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CSD-1931
211(d) Annual Report

DATE: September 30, 1974

Title: Grain Utilization in India

Grantee: Kansas State University
Department of Grain Science and Industry
Food and Feed Grain Institute

Director: Dr. David R. Lineback

A. Statistical Summary:

Period of Grant: July 1968 to June 1973 (extended without additional funding through June 1974)

Amount of Grant:	$200,000
Accumulated:	$200,000
Expenditures for Report Year:	$46,104
Anticipated for Next Year:	None

B. Narrative Summary

One student completed his Ph.D. program involving research conducted at the Institute of Food Research and Product Development, Kasetsart University, Bangkok, Thailand. Two manuscripts concerning results obtained by two previous students at Central Food Technological Research Institute, Mysore, India, were published in a scientific journal. Contact has been maintained with directors of both research institutes with emphasis on cooperative interactions between Kansas State University and the institutes, which can continue if funding can be obtained.

The most significant accomplishments of the grant continue to be those cited in previous reports, namely relationships formed between personnel of Kansas State University and institutions in the two countries, Thailand and India, where students have conducted research under the provisions of the grant. This has increased the competence of Kansas State University to render assistance to India and other developing countries in food grain utilization and to train graduate students in food grain utilization in such nations. Relationships have been strengthened by visits of a limited number of faculty from Kansas State University to the institutions and areas where cooperative work was being done. This has stimulated and encouraged faculty involvement in international service and agriculture, thus strengthening the capability of the University to work in the area of grain utilization. Several areas of endeavor have been involved including information exchange, consultation, stimulation, and initiation of research of mutual interest. These accomplishments have significant promise for encouraging and strengthening future cooperation between Kansas State University and institutions in developing nations in areas involving grain utilization. The three students receiving Ph.D. degrees under the 211(d) program at Kansas State University are currently employed in positions involving international service.

C. Detailed Report

I. General Background and Purpose of the Grant

Kansas State University has a long history of international involvement. The University was involved in India on a University-wide basis from 1956, when it finalized a contract with the International Cooperation Administration (now USAID) to staff and operate a program to aid in the development of Andhra Pradesh Agricultural University at Hyderabad, until 1972. A large number of KSU faculty served abroad under the provisions of this program. In 1963, Kansas State University signed a contract with AID for developing Ahmadu Bello University in Nigeria. This program involves assistance in broad areas of agriculture and veterinary medicine. The agriculture portion of this program was phased out during 1974, but the veterinary medicine portion of the program continues in operation.

As soon as the 211(d) program was announced, the Council of U.S. Universities for Rural Development in India (CUSURDI), of which Kansas State University was a member, expressed a keen interest in involving its member universities in the program. In view of the heavy demands being made on university resources by their programs in India, CUSURDI and AID felt that the prime need was to use 211(d) funds to build strength around selected fields where there was interest, a potential for exceptional competence, and a need for application in India.

Kansas State University has the only Department of Grain Science and Industry in the world. The University, therefore, finds itself in a unique position: that of being able to provide services, training, and research competence of a highly specialized nature which other universities cannot

provide. This Department has an excellent international reputation for its research and training functions in the field of grain science. The graduate student body of this Department is currently about 50-60% international students. The staff and faculty of the Department of Grain Science and Industry are in almost daily contact with foreign students and visitors.

With the very heavy dependence of developing nations, such as India, on cereal grains to provide the major portion of the per capita daily intake of calories, Kansas State University with its Department of Grain Science and Industry was a logical choice for the awarding of a grant involving the area of grain utilization. The experience, knowledge, research, and training functions of this organization could be focused on the important problem of improving grain utilization in India and other developing nations, particularly increasing the capability of Kansas State University to effectively serve this area of vast need. During the period of the grant, a broad approach to several areas of grain utilization has been involved. The need for such an approach not only continues but has intensified during the period since the grant was made in 1968. Continuation of such efforts, sponsored by modest grants from AID for continuing and expanding these programs, should be of first-order priority.

II. Objectives of the Grant

A. Objectives Restated

The basic objectives, as stated in the contract, are as follows: "The basic objectives are to train graduate students in food grain utilization in India and other developing countries and to further

develop the competence of Kansas State University in these areas. The University considers international activities of this nature a legitimate concern and function. Training and research activities in this area are underway but assistance, as requested in this grant, will enable the University to engage in new endeavors and expand its research and graduate instruction program so as:

1. To increase the capability of Kansas State University to render assistance to India and other developing nations in food grain utilization.
2. To enlarge the pool of scientists trained in grain handling, processing, storage, and marketing interested in and capable of assisting India and other developing nations.
3. To increase professional awareness of the increasing importance of grain storage, handling, processing, and marketing in developing countries.
4. To encourage college students to seek careers in international service in the broad area of grain utilization.
5. To provide an opportunity for graduate students to obtain research experience on problems of particular relevance to India and other developing countries by assisting with research activities carried out fully or in part in India.
6. To stimulate and encourage faculty and other professional staff to consider careers in international service and to increase faculty interest in, and University commitment to, agricultural problems of India and other developing countries by drawing upon their special relevant competencies in training and research."

B. Review of Objectives

The basic objectives "to train graduate students in food grain utilization in India and other developing countries and to further develop the competence of Kansas State University in these areas" have received about equal emphasis during the period of the grant and have not been significantly modified. One major means for increasing the competence of a university is by training graduate students in the designated area. A second is by involvement of faculty members in programs, in an area such as grain utilization, in developing nations. Both approaches have formed the basic framework for administration of this grant. The six sub-objectives listed are interrelated and have received about equal emphasis. It was decided at the initiation of the grant that sub-objective 2 "to enlarge the pool of scientists..." would be done on the basis of quality rather than quantity. For this reason, the number of students selected was limited rather severely and those chosen were promised support to the completion of their programs, if progress was satisfactory. This has subsequently turned out to be one of the strong points of the program, since it was discovered that maximum benefits can be obtained from having one or two students at a time working in developing nations. The objectives and sub-objectives are still very consistent with needs in the area of grain utilization in developing nations and do not require further modification.

III. Accomplishments

A. The general criteria that have been used to determine satisfactory accomplishment of grant objectives are listed below as they are

applicable to the two basic objectives of the grant.

1. Training graduate students in food grain utilization in India and other developing countries.

   a. Progress of students in the 211(d) program towards meeting the Kansas State University Graduate School requirements for the Ph.D. degree.

   b. Formulation and progress of a research problem in an area of grain utilization with the research being accomplished in a developing country.

   c. Progress in the ability of the student to understand and articulate problems of developing nations, particularly those involving grain utilization.

2. Further developing the competence of Kansas State University to render assistance to India and other nations in food grain utilization.

   a. An increased number of faculty with interests in problems of international development.

   b. An increased number of faculty with knowledge of agricultural problems in India and other developing countries, particularly as evidenced by application to their special competencies in training and research.

   c. An increased effectiveness of faculty to work with international students based on knowledge, understanding, and interest in the student's country and its problems, particularly those related to grain utilization.

B. Accomplishments of the report year.

The work plan outlined in annual Technical Report No. 5 was followed and realized during this one-year extension, without additional funding, to the grant.

Mr. Alvin Siegel returned from Thailand, completed the requirements for the Ph.D. degree, and was granted the degree. His dissertation, entitled, "Development, Acceptability, and Nutritional Evaluation of New High-Protein Rice-Based Foods for Thai Children" resulted from research carried out at the Institute of Food Research and Product Development (IFRPD), Kasetsart University, Bangkok, Thailand, in collaboration with Mr. Amara Bhumiratana, Director, IFRPD. An abstract of the thesis is enclosed as Item A in the Appendix. This abstract summarizes the findings of the research and further details will not be given here, other than to say that the work was of mutual satisfaction to both institutions. Dr. Siegel will present a paper (verbal presentation) concerning the development and evaluation of a soy-supplemented dehydrated rice noodle for Thai children, resulting from the research at IFRPD, at the annual meeting of the American Association of Cereal Chemists in Montreal (October 20-24, 1974) in a symposium "Enrichment and Fortification of Cereal Products". An abstract of the presentation is enclosed as Item B in the Appendix. A manuscript covering the development and testing of the high-protein rice-noodles has been prepared and submitted for publication in a scientific journal. A second manuscript describing the development and testing of some high-protein snack foods is currently being prepared. This manuscript also will be submitted for publication in a scientific

journal following its completion. Dr. Siegel is currently employed as a project officer by the International Development Research Center, Ottawa, Ontario, Canada.

Two manuscripts were published in a scientific journal describing research accomplished at Central Food Technological Research Institute, Mysore, India, by two previous students in the 211(d) program. The results were published with the Indian scientists who acted as co-directors of the research as co-authors. Copies of the two papers "Quality of Indian Wheats" by P. L. Finney, G. S. Bains, R. C. Hoseney, and D. R. Lineback and "Degradation of Organophosphate Pesticides in Cereal Grains During Milling and Cooking in India" by L. M. Lockwood, S. K. Majumder, and D. R. Lineback are enclosed in the Appendix as Items C and D, respectively.

During the year, major items of equipment were purchased for use at Kansas State University to continue and to initiate new research in areas related to grain utilization. The purchase of the equipment was made possible by the contribution of the 211(d) professor's salary by Kansas State University. This will directly increase the research competence of Kansas State University in areas related to grain utilization in developing nations.

The 211(d) professor and Dr. David Wetzel (Associate Professor, Department of Grain Science and Industry) traveled to Thailand in May-June, 1974, to consult with Mr. Amara Bhumiratana, Director, Institute of Food Research and Product Development, concerning the results

of Mr. Siegel's research, possible commercialization or use in child feeding programs in Thailand of the products developed during the research, potential need for further development research, and the possibility of future collaboration between Kansas State University and IFRPD. The itinerary for the trip included:

May 13-14 - Food and Agricultural Organization, United Nations, Rome, Italy (to consult with Mr. Harlan Shuyler, Crop Storage Pest Control Officer, Plant Production and Protection Division, designated as correspondence liaison officer for FAO with the Kansas State 211(d) project and to consult with Dr. H. A. B. Parpia, Director, CFTRI, Mysore, India, concerning future means of collaboration between Kansas State University and CFTRI).

May 15-18 - Vienna, Austria (to attend Working and Discussion Meetings of the International Association of Cereal Chemistry where international research relative to grain utilization was discussed).

May 20-27 - Institute of Food Research and Product Development, Bangkok, Thailand.

May 29 - National Food Research Institute, Ministry of Agriculture and Forestry, Tokyo, Japan (to consult with Japanese colleagues and scientists on research related to grain utilization and cereal chemistry).

May 31 - Kyoto University and the Research Institute for Food Science, Kyoto University, Kyoto, Japan (to consult with

Japanese colleagues and scientists on research related to cereal chemistry).

C. A summary of the accumulated accomplishments during the period of the grant can best be done as follows:

1. Relationships have been established with Central Food Technological Research Institute (CFTRI), Mysore, India, and with the Institute of Food Research and Product Development (IFRPD), Bangkok, Thailand. Collaborative research of interest to the above two institutions and to Kansas State University has been accomplished at CFTRI and IFRPD by three 211(d) students. Results of this collaborative research have been published in a scientific journal with personnel at the two institutes and KSU as co-authors. Research, resulting from these relationships, is currently being continued at Kansas State University. Personal relationships have been established between personnel of CFTRI and IFRPD and faculty of Kansas State University.

2. Three students have completed their Ph.D. degrees under the 211(d) program with research problems in areas related to grain utilization in India or other developing nations. Two of the students completed research projects in India and one in Thailand. The three individuals are currently employed in positions involving international service; a very important direct result of the 211(d) program and one of the objectives of the grant.

3. Increased faculty interest at Kansas State University in agricultural problems of India and other developing nations has occurred due to direct involvement of faculty from the Department of Grain

Science and Industry in the 211(d) program.

4. The basis and desire for collaborative research between Kansas State University and institutions in developing nations in areas related to grain utilization have been developed during the current 211(d) program. These involve collaborative research on problems of mutual interest to scientists in both institutions and have great potential for future development to the benefit of both Kansas State University and institutions in developing countries.

D. The proportion of each year's expenditures that was used for each objective or area of activity is estimated as follows:

Activity	Proportion of Expenditures
Research and training of graduate students	64%
Teaching	12%
Consultation	24%

IV. Impact of Grant Supported Activities in Developing Institutional Capabilities

The capabilities of an academic institution may best be evaluated in terms of its areas of responsibility. These include teaching, research, and consultation.

A. Development of Teaching Competence

The 211(d) program has been used to enrich the teaching program of this department, and the services of those involved in the 211(d) program have been made available to other departments of Kansas State University for use in their teaching programs. It is strongly

believed that this approach is of more value to this University and its students than the creation of new courses specifically dealing with international agriculture. This is due to the heavy international commitment that Kansas State University has had for many years. As the experiences of students and staff involved in the 211(d) program are incorporated into their various teaching assignments, many more students will benefit from these experiences than would the few enrolling in any one new course.

The 211(d) professor has incorporated experiences from the 211(d) program into the two courses he teaches related to food science and into his involvement in the food science interdepartmental program at Kansas State University. After his return from Thailand, Mr. Siegel presented a seminar concerning his research and experiences in Thailand. The seminar was attended by interested students and faculty from this and other departments within the University. Mr. Siegel was also invited to present a lecture concerning current food problems in Thailand to approximately 150 undergraduate students enrolled in a class "Food For Man". This enabled him to present some of his experiences in Thailand and some of his research results.

The three staff members who have accompanied the 211(d) professor on trips to India or Thailand have increased their teaching effectiveness and competence as a result of involvement in the 211(d) program. All three indicated they were aware of some of the problems faced by developing nations but lacked real understanding of them until exposed to experiences encountered during the trip with the 211(d)

professor; a "realization aspect" which comes only with personal experience. Such understanding and realization have definitely increased the interests of the three professors in international agriculture, have increased their ability to advise and work with international students, and have increased their teaching competence as a result of an increased understanding of international students and agricultural problems.

Development and improvement of teaching competence occurs as the experiences and competence of teaching faculty are increased. As noted above, this is certainly being accomplished via the 211(d) grant by exposing more personnel to problems of grain utilization, production, storage, and distribution in developing nations.

B. Development of Research Competence

Relationships between Kansas State University and both the Central Food Technological Research Institute, Mysore, India, and the Institute of Food Research and Product Development, Bangkok, Thailand, have been developed and strengthened during the period of the 211(d) grant. Considerable exchange of technical information and experience has occurred between individuals in the institutions via the 211(d) program. A former staff member at CFTRI who co-directed one 211(d) student's research is now Head of the Department of Food Science and Technology, Punjab Agricultural University, Ludhiana, India. Information exchange has continued with this individual in areas which were first developed when he was at CFTRI. New areas of mutual research interests are becoming apparent which are increasing the

research competence of scientists at Kansas State University by opening new or expanded areas of research. As noted in annual Technical Report No. 5, Dr. R. Carl Hoseney initiated research concerning the use of sorghum in food products as a result of discussions held during his trip to India with the 211(d) professor. This research has involved a Sudanese graduate student and has been supported by non-211(d) funds. This research is continuing and has been expanded to include studies on millets. This activity is the direct result of the 211(d) program and the involvement of a faculty member; also of importance is its support with non-211(d) funds.

Investigations in the 211(d) professor's laboratory concerning starch structure and functionality continue and involve starches isolated from some of the wheats studied in India under the 211(d) program. This is being done to determine whether there are structural differences between starches from Indian wheats and U.S. wheats which can be related to differences in baking quality. This interest is a result of the 211(d) program.

During the visit to Thailand in 1974, the 211(d) professor and personnel at the Institute of Food Research and Product Development (including an Australian scientist working there under the Colombo Plan) discussed the production of mung bean protein used in the Kaset protein prepared at IFRPD for child feeding programs in Thailand. The Institute currently is interested in obtaining larger quantities of mung bean protein and has turned to mung bean starch (noodle) manufacturers as a possible source since the protein is discarded as an

effluent by these processors. During a visit to the processor's facilities, the 211(d) professor was made aware of low starch recovery during the process. This is of considerable concern to the processor and if it can be increased would give added economic incentive to the processor to also recover protein from the effluent. After discussions with personnel in Thailand, the 211(d) professor has initiated limited research on mung bean processing in his laboratory. Initial studies have attempted to explain the low starch recovery by investigating possible starch damage and subsequent loss under conditions similar to those used in Thailand to process mung beans. Research is also being initiated on dry milling mung beans to yield a flour from which protein and starch could be isolated more readily without interference from hulls. This research will continue on a limited scale and will be expanded if financial support can be obtained. This is a direct result of the 211(d) program and illustrates the mutual stimulation of research interests between an institution in a developing nation and Kansas State University. Personnel in Thailand are being furnished the research results as they become available at KSU.

The research competence of a university is increased as the interests, knowledge, and experiences of faculty are increased. Such enrichment enables new applications, new problems, and different views to be formulated by research personnel of the University. Scientists from Kansas State University and the two institutions at which 211(d) students have been situated have exchanged information and ideas on potential areas for collaborative research, for information exchange,

and for consultation. If the relationship between Kansas State University and these institutions and their staff is allowed to continue to develop, significant areas of mutual cooperation will emerge. During discussions in 1974 with the directors of both institutes, the mutual benefits of associations initiated during the 211(d) grant were mentioned many times and the need for such associations to continue was emphasized by both directors and the 211(d) professor. During the term of the present grant, these associations and relationships have just been initiated and now need time, encouragement, and direction to reach fruition. Many areas of mutual interest may be incorporated into existing research programs at Kansas State University, such as the development of protein-enriched cereal-based foods and problems of grain storage, while others will require initiation of new research programs, enriching the research efforts of Kansas State University. All of these will increase the research competence of the scientists involved, particularly in areas of food grain production, storage, and utilization in developing nations.

C. Development of Competence for Consultation and Service

As indicated in the last three annual technical reports and again reemphasized in this report, experiences gained in India and Thailand by students and staff participating in the 211(d) program increase their competence for consultation and service in the following ways:

1. Information and knowledge gained from these experiences constitute a pool of knowledge and information concerning international agriculture, particularly grain utilization in developing nations, and food problems which can be made available to the University

community and other interested individuals.

During discussions with Mr. Harlan Shuyler, Crop Storage Pest Control Officer, Plant Production and Protection Division, FAO, experience and research at Kansas State University in grain processing, grain storage, and baking were considered. As a result, Mr. Shuyler spent two days at Kansas State University consulting with faculty members and acquiring data for use in an international conference held in London, England, during September, 1974.

As a result of collaboration with the Institute of Food Research and Product Development, Bangkok, one of their staff members is currently studying for a Ph.D. degree in the Department of Grain Science and Industry. The project being formulated for her dissertation research is in an area of mutual interest to the two institutions. Her graduate work at Kansas State University is supported by non-211(d) funds.

2. The most unique concept of the 211(d) program is the ability to formulate a research project in an area of mutual interests through direct cooperation with colleagues in developing countries. This observation has been voiced on several occasions by personnel involved in the program, including directors of both institutions involved with Kansas State University, and cannot be stressed enough. The experiences gained through such a venture are not available in the University other than through the 211(d) program. As administered by this University, this program has been based on

personal contact by scientists, devoid of political overtones. It has been indicated that we can continue to place students in India under the provisions of the program because of the mutual benefits derived from personal associations between scientists. It will be most regretful if those efforts and programs are lost through lack of foresight in arranging the modest amount of funding required for their continuation and expansion. It is still firmly believed that the 211(d) concept will, in the long run, prove to be the most viable, least expensive vehicle to foster establishment of significant long-term relationships between institutions and scientists in developing nations and their counterparts in the U.S., without the political implications of technical assistance teams. It has been shown that such programs can operate on the local economy without need for large support organizations, other than the sister institution in the developing nation. The experiences gained by Kansas State University during the duration of the present 211(d) grant can be extended in much the same form to developing nations in Africa, Central and South America and can be expected to function effectively.

Personnel at the Institute of Food Research and Product Development, Bangkok, have suggested possible research projects, in areas of mutual interest, in which they would like to see further collaboration continued. These are areas, such as extrusion processing of cereal-based foods, in which considerable interest and research are in progress at Kansas State University. This institute has suggested specific areas for future collaboration if

funds can be obtained to support such collaborative efforts. Personnel at CFTRI have designated broad areas of mutual interest for consideration but have not yet attempted to develop specific projects until some hope for further continuation exists.

3. Experiences of those involved in the 211(d) program are daily utilized through lectures, seminars, contact with international students, and discussions with other faculty members having interests in India and other developing nations.

The 211(d) professor and Dr. Siegel presented an evening program to the Kansas State Chapter of the American Association of University Women concerning food problems in Thailand and the work that had been done there under the 211(d) program. This presented an excellent opportunity to discuss agricultural problems in developing countries utilizing experiences derived from the 211(d) program. Considerable interest was evidenced by this group as indicated by a number of excellent questions.

The 211(d) professor was also interviewed for a radio program, Agriculture Today, produced by the Kansas State University Extension Division and distributed to radio stations throughout the State of Kansas. Emphasis was placed on agricultural problems in developing countries and some of the experiences encountered during the 211(d) program. Such information is of considerable interest to Kansas grain producers as we illustrate how knowledge gained from grain production in the U.S. can be brought to bear on problems in developing nations and also how research programs

at Kansas State University are stimulated by problems of developing nations.

As a result of the visit by the 211(d) professor to the National Food Research Institute, Ministry of Agriculture and Forestry, Tokyo, and through previous personal friendship, Dr. Keiji Kainuma of that Institute visited Kansas State University in October, 1973, under non-211(d) sponsorship. He presented a seminar concerning his research on enzymes active on cereal starches. The seminar was attended by students and staff with interests in this area of grain science. This is an excellent example of the relationships that can be formed from activities occurring during the 211(d) program which hold promise for mutual benefits to both institutions in years to come.

Dr. David Wetzel accompanied the 211(d) professor to Thailand in May-June, 1974. Dr. Wetzel is an analytical chemist with interests in analytical methodology used in cereal chemistry and grain processing. Dr. Wetzel had detailed discussions relative to analytical methodology with scientists at the International Association of Cereal Chemistry meeting in Vienna, with scientists at the University of Kyoto and the Research Institute for Food Science, University of Kyoto, and with personnel in Thailand. One visit of particular significance and importance was to a large feed milling company in Bangkok where Dr. Wetzel spent time with personnel in the quality control laboratory. While there, he was not only able to familiarize himself with techniques used in that

laboratory, compared to techniques used in similar laboratories in the U.S., but was also able to give information and advice in response to questions by laboratory personnel. This was his first involvement in international agriculture, and he returned much better qualified to work in this area and with more interests in doing so. The need for analytical methodology yielding rapid, accurate, and precise results at minimal cost is great in the area of cereal processing and cereal chemistry. This is again one of the finest examples of the use of the 211(d) program to increase the teaching, research, and consulting competence of Kansas State University by increasing the capabilities of individual faculty members, already involved in teaching and advising international students. Dr. Watzel greatly benefited from the trip, his discussions with personnel at various locations visited during the trip, and the experiences he had with analytical methodology used in Thailand in the area of grain processing and utilization. This has increased the competence of Kansas State University to assist with food grain utilization in developing nations by more effectively equipping one of its faculty members to work in this area. This is one aspect of the 211(d) program which should be encouraged and used, for it truly achieves the objectives of the grant and will have a lasting impact.

V. Utilization of Institutional Resources in Development

There is no way that all of the contributions in the area of grain utilization made by Kansas State University to developmental activities and programs in less developed countries can be adequately cited in the scope

of this report. The Department of Grain Science and Industry has a long history of international involvement. This Department has an excellent international reputation for its research and training functions in the field of grain science. For many years, foreign students have selected Kansas State University for training in grain science and utilization, usually leading to advanced degrees in these areas. No figure is known to the 211(d) professor to reflect the actual numbers of international students trained here in grain science. Currently, approximately 50-60% of the graduate student enrollment in the Department of Grain Science and Industry is international, i.e. 35-40 international students. International wheat teams visit this Department regularly throughout the year to learn of grain utilization and research concerning cereal grains. During the report period, individuals, milling groups, and wheat teams visited the Department of Grain Science and Industry for one-day briefings from Peru, Japan, Brazil, Norway, South Africa, Korea, Indonesia, and Ecuador. These briefings are sponsored by Great Plains Wheat Inc. and Foreign Agricultural Service of the U.S.A. Individuals from several countries, including Japan, New Zealand, England, Iran, Saudi Arabia, Finland, Mexico, Poland, and France have also visited the Department to consult with faculty concerning mutual interests in grain processing, cereal chemistry, and grain utilization.

Kansas State University is committed to the concept that international activities are a legitimate concern and function of the University. It has a long history of involvement in international agriculture and continues its high degree of interest and involvement in international programs of this nature. These programs are diverse in nature, and it must

be realized that a commitment to teaching and training foreign graduate students represents a major commitment of the resources of a university. Kansas State University has been a center for such activity, and it has only recently become necessary to place limitations upon the number of international students enrolled in the graduate programs of this University. This was necessitated by current economic conditions in the United States as reflected by decreasing financial support for graduate education and research.

The University was involved in India on a University-wide basis from 1956 until 1972. The University staffed and operated a program to aid in the development of Andhra Pradesh Agricultural University at Hyderabad. A large number of KSU faculty served abroad under the provisions of this program, representing approximately 61 man years of involvement.

Kansas State University has been involved in developing Ahmadu Bello University in Nigeria since 1963 under a contract with AID. The program involves assistance in broad areas of agriculture and veterinary medicine. The agricultural portion of the program was phased out during 1974, while the veterinary medicine portion of the program currently continues. Numerous KSU faculty members have served there on two-year or short-time assignments.

Due to the international reputation that Kansas State University has in the area of grain processing, it has been asked to train fifteen Saudi Arabians in wheat milling and six Saudi Arabians for M.S. degrees in grain science. The latter six individuals will have positions as mill superintendents and quality assurance supervisors in new milling facilities

being constructed in Saudi Arabia. This is being done under contract to a commercial firm in the U.S. The students plan to begin their studies at Kansas State University in January, 1975. These students will be financially supported by the Saudi Arabian government.

Training and research programs in grain handling and processing have been continued on an international basis by the Department of Grain Science and Industry under contracts with AID. A short course in Grain Storage and Marketing was again offered at Kansas State University during July-August, 1974, under provisions of Contract AID/csd-1588. The short course was attended by 23 individuals from Bolivia, El Salvador, Ethiopia, Honduras, Indonesia, Nepal, Nigeria, Paraguay, Peru, South Viet Nam, and Sri Lanka. Under this same contract, programs involving grain storage, transportation, and processing were continued and staff members from this Department and the Department of Economics traveled to Indonesia, Phillipines, Haiti, Tunisia, Korea, South Viet Nam, and Venezuela to consult on problems pertinent to these areas. During this same period, the Department of Grain Science and Industry continued its extensive research program concerning nutritional improvement of cereal-based foods under provisions of Contract AID/csd-1586. Faculty members have traveled to Iran, Turkey, El Salvador, Colombia, and Brazil in relation to potential use of protein-enriched cereal-based food products in these countries.

Professor Arlin Ward, Department of Grain Science and Industry, and Dr. Floyd Smith, Director, Kansas Agricultural Experiment Station, made an extensive visit to Europe during September, 1974, sponsored by Great Plains Wheat Inc. During the trip, problems of cereal grain processing

were discussed with different mill organizations.

As a result of the work of the Department in grain storage, transportation, and processing, an invitation has been received to present a working paper on Fundamentals of Village-Level Grain Storage at a seminar on Village-Level Grain Storage to be held at the Codiam Training Centre, Cotonou, Dahomey, in December, 1974. One or two staff members will be involved in this seminar.

VI. Other Resources for Grant-Related Activities

Many divisions of Kansas State University provide either direct or indirect support to the 211(d) program. The University contributed the salary of the 211(d) professor. This enabled substantial amounts of equipment to be purchased with grant funds during the report year. This equipment is to be used to continue and initiate research projects related to grain utilization. Administrative services are provided by various offices within the University. Advice is provided by various international programs' offices that have extensive overseas projects. In addition, the over-all staff of the Department of Grain Science and Industry contributes in innumerable ways to support of the 211(d) project by providing office space and library facilities as well as giving advice and encouragement to 211(d) students. Table I reflects the distribution of 211(d) grant funds.

VII. Next Year's Plan of Work and Anticipated Expenditures

Since the current report year is the terminal year of the grant, no expenditures will be made in the coming year. Efforts will be made to obtain a minimal level of funding to allow efforts initiated under the current 211(d) grant to be continued and strengthened.

VIII. Other

Experiences gained by Kansas State University during the duration of the present grant indicate that programs of this type deserve very high priority for continuation and expansion. It has been found that these programs can be effectively administered with a modest level of funding in such a way that the University is able to continually expand its capability to serve developing nations in the area of grain utilization and to increase the effectiveness and interests of faculty members in international agriculture, particularly in the area cited which represents a vast problem on a world-wide basis. It is our opinion that a program such as the current 211(d) program at Kansas State University can be effectively continued at a level of funding of approximately $50,000-$60,000 per year and could be expanded to include developing nations other than India. This latter facet would be most desirable to allow maximum benefits to be realized from such involvement. The program should continue to be centered around the training of one to four graduate students at any one time and the involvement of a limited number of faculty members from the University. Such a program would allow maximum benefit to be derived from the grant. The desirability and benefits derived from such a program have been reflected and emphasized by the directors of the two institutes in developing nations with which Kansas State has been associated during the current 211(d) program. AID is strongly urged to give priority consideration to the continuation of this program so that the relationships now initiated can be strengthened and enlarged.

IX. Report of Expenditures

See Tables I and II.

Table I

Distribution of 211(d) Grant Funds and Contributions From Other Sources of Funding*

Review Period July 1, 1973, to June 30, 1974

	211(d) Expenditures				Non 211(d) Funding Amount
	Period Under Review	Cumulative Total	Projected New Year	Projected to end of Grant	
Research	$29,507	$128,000	None	$128,000	1. Salary of 211(d) professor ($22,095 including benefits) by Kansas State University.
Teaching	5,532	24,000	None	24,000	
Consultation	11,065	48,000	None	48,000	2. There is no way to estimate in any reasonable accurateness the remaining contribution of non-211(d) funding.
TOTAL	$46,104	$200,000	None	$200,000	

*These figures are best estimates

Table II

Expenditure Report

(Actual and Projected)

Under Institutional Grant AID/csd-1931

Review Period July 1, 1973, to June 30, 1974

	Expenditures to Date		Projected Expenditures	Total
	Period Under Review[1]	Cumulative Total		
Salaries	$ 4,626	$ 61,719	None	$ 61,719
Travel	10,062[2]	34,856	None	34,856
Graduate stipends	4,940[3]	54,687	None	54,687
Exchange professor	-0-	1,068	None	1,068
Equipment, supplies, and other	26,476	47,670	None	47,670
TOTAL	$46,104	$200,000	None	$200,000

[1]One-year extension of grant without additional funding.

[2]1973-74 Travel includes expenses of:

a) Dr. Lineback's travel to 58th Annual Meeting American Association of Cereal Chemists (St. Louis, Missouri).
b) Mr. Siegel's travel in Thailand on grant-related business.
c) Mr. Siegel's travel to Laos on grant-related business.
d) Mr. Siegel's return to U.S. from Thailand.
e) Dr. Lineback's and Dr. Seib's air fare for 1973 trip to Thailand.
f) Dr. Lineback's and Dr. Wetzel's 1974 trip to Thailand.

[3]Graduate stipend to Mr. Alvin Siegel.

[4]The following items of equipment costing in excess of $100 were purchased from U.S. manufacturers for use at Kansas State University to continue and initiate research related to grain utilization.

Table II

Item	Cost	Supplier
pH meter	$ 375	Beckman Instruments
Centrifuge	2,495	Sharples
Shaker	285	Scientific Products
Mixer with stainless-steel bowl	272	Peerless Supply
Oven	435	Scientific Products
Rotary evaporator (2)	500	Scientific Products
Centrifuge and accessories	1,592	Fisher Scientific
Analytical balances (2)	998	Curtin-Matheson
Micro-mixograph	393	National Mfg. Co.
Spectrophotometer	3,948	Varian Instruments
Strip chart recorder (2)	1,073	Adelphi, Inc.
High-pressure liquid chromatograph	5,958	Waters Associates

[5] Included in this value is $6,370 paid to WARF, Madison, Wisconsin, for analytical evaluations of products developed during Mr. Siegel's research in Thailand.

APPENDIX

Appendix

Item A

Abstract of a dissertation entitled, "Development, Acceptability, and Nutritional Evaluation of New High-protein Rice-based Foods for Thai Children" submitted by Alvin Siegel to the Graduate School, Kansas State University, in partial fulfillment of requirements for the Ph.D. degree, 1974 (research done at Institute of Food Research and Product Development, Bangkok, Thailand, under 211(d) grant).

Soy-supplemented rice noodles and rice-based snacks were developed for use in supplementary feeding programs at Child Nutrition Centers in Thailand. Acceptability studies were conducted with preschool and elementary school children in rural and urban localities. Nutritional evaluations of the products were determined using chemical and biological testing procedures.

Dehydrated rice noodles, protein-supplemented with 20 and 30% full-fat soy flour, with and without methionine fortification at respective levels of 0.2 and 0.3%, were prepared in the same manner as traditional rice noodles. Acceptability studies were held with 197 preschool children for five and three months at two rural Child Nutrition Centers and at a Bangkok nursery school, respectively. Each sample was given as the mid-day meal once a week on a rotating schedule. Regular rice and whe[illegible] noodles served as controls. Initial amounts of each dish served and additi[illegible] [illegible]tions requested were recorded. Proximate, vitamin, mineral, and amino acid analyses, in addition to rat growth studies, determined nutrient content and protein quality.

Soy-rice noodle consumption was not significantly different ($P < 0.01$) from

that for regular rice noodles at all testing localities. No significant differences in preference for noodles at the two amounts of either soy supplementation or methionine fortification were found. Other control dishes were eaten equally in most feeding situations. The 20 and 30% soy noodles contained 15.0 and 18.0% protein (dry basis), respectively; the control contained 7.8% protein. Additions of full-fat soy flour to rice increased the amount of vitamin E- and B-complex vitamins found in soy-rice noodles compared to regular ones. Marked increases in mineral content were found in soy-supplemented noodles as compared to regular noodles as follows: calcium, four times; iron, two times; magnesium, twelve times; and phosphorus, three times. Chemical scores for regular, 20% and 30% soy-rice noodles were 40, 60, and 76, respectively. Protein efficiency ratios (PER) using laboratory animals were 2.16, 2.56, 2.58, 2.69, and 3.00 for regular, 20% soy, 30% soy, 20% soy plus methionine, and 30% soy plus methionine noodles, respectively, corrected to 2.50 for standard casein. Net protein utilization (NPU) values for the 20% soy plus methionine and 30% soy noodles, with and without methionine, were significantly higher ($P < 0.05$) than the control sample, and not different from the NPU for casein.

Snacks were prepared containing additions of protein-supplements to a 70% rice base (dry basis) as follows: 30% soy, 25% soy plus 5% ground sesame, 25% soy plus 5% fish protein concentrate (FPC), and 30% soy protein concentrate. The latter product was an extrusion-cooked puffed curl. The remaining products were dehydrated pieces deep-fat fried into edible chips. Acceptability studies with 198 children at two schools employed a five-point hedonic scale corresponding to facial expressions (very happy to very sad). Scores for extruded curls were 3.44-4.81 on a 5.0 scale, while rice chips had scores ranging from 3.82-4.92. New rice snacks contained 17.2 to 24.6% protein (dry basis). New rice snacks had

scores significantly higher ($P < 0.01$) than one regular commercial (control) snack food and comparable with two others.

Chemical and subjective studies on changes in products (noodles and snacks) during storage (five and six months) showed no detrimental changes in quality factors. Protein costs of the new foods were substantially lower than those for regular products. A mixture, primarily of soy and rice flours, enabled the introduction of acceptable animal-quality protein foods suitable for improving the protein status of Thai children.

Appendix

Item B

A. Siegel, D. R. Lineback, and A. Bhumiratana "Development, Acceptability, and Nutritional Evaluation of High-protein Soy-supplemented Rice Noodles for Thai Children," 59th Annual Meeting of the American Association of Cereal Chemists, Abstract 18, Montreal, Quebec, Canada (October 20-24, 1974).

Dehydrated rice noodles, supplemented with 20 and 30% full-fat soy flour (dry basis), were developed for potential use in feeding programs at Child Nutrition Centers in Thailand. Methionine-fortified samples were also prepared. Acceptability studies were conducted with 197 preschool children at two rural centers and a Bangkok nursery school. Nutritional evaluation was based on chemical and biological tests to determine nutrient content and protein quality. Soy-rice noodle consumption was not significantly different from that for regular (control) rice noodles. Additions of soy flour to rice more than doubled the protein content and increased the vitamin and mineral content in soy-rice noodles compared to regular noodles. PER and NPU values for soy-rice noodles, determined from rat growth studies, were, in most cases, equal to or greater than those for casein. Regular rice noodles had substantially lower values. Protein costs for soy-rice noodles were lower than those for unsupplemented rice noodles.

APPENDIX
ITEM C

PN-AAA-516

QUALITY OF INDIAN WHEATS[1]

P. L. Finney[2], G. S. Bains[3], R. C. Hoseney[2], and D. R. Lineback[2]

Summary

Analytical, physical, chemical, and baking studies were performed on 43 samples, representing 30 spring wheat varieties harvested in India. Some high-yielding wheats and wheats recently introduced from Mexico were excellent bread wheats compared with a typical composite bread flour (RBS-70A) from wheats grown in the U.S. Water absorptions of India's wheats averaged materially above those of U.S.-grown varieties. Water absorptions of some of the semidwarf Mexican varieties were as high as 75 to 78%, and many indigenous Indian varieties had water absorptions above those of average U.S. wheats. Bread-baking quality of both Mexican and Indian varieties varied from excellent to poor; however, the Mexican varieties generally were better bread wheats.

THE INTRODUCTION IN 1966 of high-yielding spring wheats in India from the Centro Internacional de Mejoramiento de Maiz Y Trigo (CIMMYT) greatly changed the quantity and quality of Indian wheats. In 1971 one of those varieties, Kalyan Sona (known as Siete Cerros in Mexico) was planted on 75% of the Punjab, an important wheat-growing region of India. That variety has contributed most to India's increase in total wheat production, from about 12 to nearly 25 million metric tons between 1966 and 1971 (Fig. 1). During the last three years Modern Bakeries of India, Ltd., a government organization producing white pan bread, expanded at an estimated rate of 15% each year. The Indian milling industries are expanding and attempting to meet the quality needs of the breadmaking and biscuit (cookie) industries, while also satisfying traditional food needs.

With more than 550 million people to feed, India's national commitments to food production remain paramount. Thus production of wheat—second only to rice—is a primary commitment. Secondary wheat quality commitments are concerned with producing wheats that: a) have higher protein content, b) satisfy traditional food requirements (e.g., chapatties, puris, and paratas), c) satisfy the expanding breadmaking industry, and d) satisfy the expanding biscuit (cookie) industry.

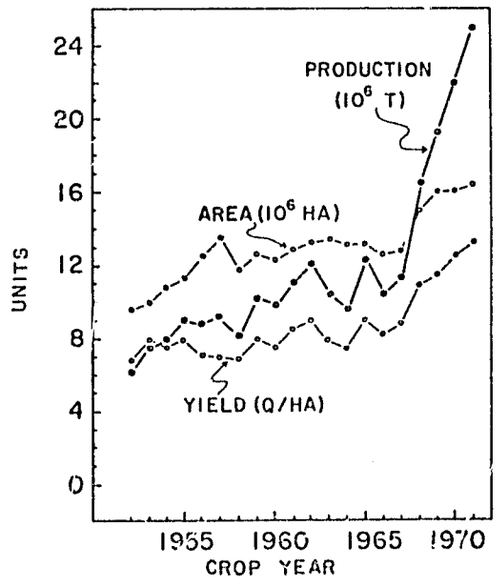

Fig. 1. Production (million tons, -o-o-), area sown (million hectares, upper -o-o-), and yield (quintals per hectare, lower -o-o-) of wheat in India from 1952 through 1971.

India's dependence on the quality characteristics introduced by those high-yielding, semidwarf, spring wheats was studied, using samples from two crop years and three breeding stations, at the Central Food Technological Research Institute, Mysore, India.

In the first detailed study of Indian wheat quality in 1940, Singh and Bailey (1) found high bushel and

[1]Contribution No. 817, Dept. of Grain Science and Industry, Kansas Agricultural Experiment Station, Manhattan 66506. Presented at the 57th Annual Meeting, Miami Beach, Oct./Nov. 1972.

[2]Respectively: Research Associate, Associate Professor, and Associate Professor, Kansas State University.

[3]Head, Milling and Baking Discipline, CFTRI, Mysore, India. Present address: Head, Department of Food Science and Technology, Punjab Agricultural University, Ludhiana, India.

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1,000-kernel weights, compared with spring and winter wheats grown in Minnesota. Average protein content of flours milled from the 1940 Indian wheats was only 9.6% (13.5% m.b.); but water absorptions were high, average of 31 samples, 72.6%.

From 1942 to 1947 studies on the quality of Indian wheats were conducted at the Punjab Agricultural College, Lyallpur, now in Pakistan. Those studies mainly involved assessing milling and baking quality and surveying protein contents. Many of the varieties had water absorptions of 75.0 to 82.0%, although average flour protein was comparatively low (2).

Bains and Irvine (3), more recently, reported that several Indian varieties yielded high percentages of straight-grade flour. However, their farinograph water absorptions were not exceptionally high.

Tara and Bains (4), studying the relation of starch damage and protein content to water absorption, found that starch damage contributed to high water absorptions of commercial Indian samples.

Sadisivan et al. (5), in taste panel tests, found no significant difference between chapattis made from wheats of Mexican (Sherbati Sonora and Sonalika) or Indian (K65 and C-306) parentage.

Materials and Methods

Forty-three samples, representing 30 wheat varieties, were harvested in India at three breeding stations (Ludhiana, Karnal, and Niphad). A composite flour used as a standard, RBS-70A, represented several hard winter wheat varieties harvested at many locations throughout the Great Plains of the U.S. in 1969. That standard flour had a protein content of 12.3% (14% m.b.), a good loaf volume potential, and a medium-long mixing time of 4.25 min. Wheats were tempered to 13.5 to 15% moisture, depending on pearling value (hardness) and protein content, for 48 hr. before milling on a Buhler mill.

Hectoliter and 1,000-kernel weights were determined by standard methods (6). Protein, moisture, and ash contents were determined as described in AACC Methods (6). A straight-dough experimental baking procedure described by Finney and Barmore (7-10) was used. The method employed optimum mixing time and water absorption, and a formula that included: flour, 100 g.; sugar, 6 g.; salt, 1.5 g.; shortening, 3 g.; fresh baker's yeast, 2.25 g.; dry buffalo milk (whole), 4 g.; 60°L. malt syrup (Fleischmann's, U.S.A.), 0.5 g.; and $KBrO_3$, 4 mg.

The response of Indian varieties to potassium bromate was determined by a baking test using the AACC lean-baking formula (6) with and without 1 mg. potassium bromate.

Sedimentation tests were determined by the standard procedure (6). Mixograms were determined on 35 g. flour using farinograph water absorptions. Farinograms were obtained on 50 g. of flour and sufficient distilled water to be centered on the 500 B.U. line.

Hectoliter and 1,000-Kernel Weights. The 43 samples were conveniently divided into two groups, traditional Indian varieties or newly developed Mexican varieties.

TABLE I. MILLING, PHYSICAL, CHEMICAL, AND RHEOLOGICAL DATA FOR INDIAN WHEAT VARIETIES HARVESTED AT ONE OF THREE LOCATIONS IN 1970 AND/OR 1971[a]

		Wheat				Flour				
Variety	Location[b]	1000-Kernel Wt. g.	Hectoliter Wt. kg.	Protein %	Ash %	Yield %	Protein %	Ash %	Sedimentation	Farinograph Absorp. %
NI-917	N	47.1	81.8	11.9	1.33	60.7	11.1	0.51	29.0	66.4
NI-917	N	44.3	81.3	13.9	1.44	65.2	12.7	0.48	29.0	68.5
NI-5643	N	38.7	80.8	12.1	1.31	65.4	11.1	0.41	33.5	64.1
NI-5643	N	36.6	83.5	14.5	1.25	68.6	13.1	0.39	32.5	66.9
NI-5644	N	28.0	78.0	12.8	1.98	63.7	12.4	0.57	30.5	66.1
NI-5644	N	39.0	82.0	13.8	1.35	74.0	12.6	0.47	31.0	67.6
NI-5439	N	38.8	79.5	11.1	1.34	71.4	10.3	0.48	35.5	60.8
NI-5439	N	39.3	81.8	12.9	1.26	73.9	12.8	0.45	34.5	60.9
NI-747-19	N	37.8	79.3	11.3	1.36	69.0	10.4	0.51	36.5	62.0
NI-747-19	N	33.0	78.3	13.1	1.37	73.6	12.1	0.48	36.5	59.5
NI-7010	N	41.5	79.5	13.4	1.34	71.7	12.7	...	31.0	67.6
NI-7176	N	44.4	84.0	9.7	1.21	66.6	9.2	...	29.0	69.7
NI-7008	N	52.3	81.7	12.6	1.32	74.6	11.1	...	24.0	61.9
NI-5645	N	36.1	82.0	13.3	1.16	70.7	12.1	0.59	31.0	67.6
NI-5642	N	38.0	83.7	13.4	1.24	66.4	12.6	...	31.0	68.5
NI-5641	N	40.3	81.7	13.6	1.28	74.2	12.9	0.47	31.0	69.7
C-273	L	42.9	82.1	12.5	1.68	65.7	11.3	0.47	24.0	60.3
C-306	L	42.2	80.9	10.9	1.45	66.4	9.8	0.45	25.0	65.1
C-306	L	43.7	78.7	8.3	1.47	68.4	8.0	...	20.0	61.1
HD-1734	K	44.2	81.7	9.0	1.50	71.3	8.0	0.63	20.0	62.6
NP-824	K	40.9	74.7	10.2	1.93	76.0	9.4	0.72	23.5	58.4
NP-830	K	43.7	74.7	12.0	1.44	74.5	11.0	0.61	29.0	59.1
NP-980	K	44.6	76.3	9.6	1.59	71.7	8.7	0.74	20.0	59.1
NP-890	K	48.7	81.0	9.5	1.46	74.6	8.7	0.58	24.0	60.2
RBS-70A							12.3	0.39	46.0	60.1

[a]All data expressed on a 14% m.b.

[b]Locations: N = Niphad; L = Ludhiana; K = Karnal.

TABLE II. MILLING, PHYSICAL, CHEMICAL, AND RHEOLOGICAL DATA FOR MEXICAN WHEAT VARIETIES HARVESTED AT ONE OF THREE LOCATIONS IN 1970 AND/OR 1971[a]

		Wheat				Flour				
Variety	Location[b]	1000-Kernel Wt. g.	Hecto-liter Wt. kg.	Protein %	Ash %	Yield %	Protein %	Ash %	Sedimentation	Farinograph Absorp. %
S-308	N	36.8	81.0	11.2	1.45	70.6	9.8	...	26.5	54.3
S-308	K	40.6	71.7	12.4	1.72	74.8	11.2	0.68	31.5	59.0
S-308	L	44.5	78.7	11.3	1.56	71.6	9.4	0.40	21.0	59.6
PV-18	L	36.6	80.1	10.4	1.45	70.7	9.2	0.39	24.5	61.9
S-307	N	38.4	77.5	10.4	1.27	70.0	9.3	0.39	20.5	49.0
S-307	N	38.1	80.0	12.1	1.34	69.0	10.3	0.36	24.0	53.6
S-331	N	36.2	80.5	12.5	1.34	66.9	11.1	0.42	26.0	54.8
S-331	N	33.4	82.0	12.8	1.45	68.2	11.1	0.34	24.0	55.1
HD-1941	L	38.6	77.2	11.7	1.62	68.6	10.3	0.49	28.0	59.8
HD-1941	K	31.9	71.0	11.8	1.72	74.1	10.8	...	28.5	56.9
WL-212	L	33.3	74.7	12.2	1.70	67.4	10.6	0.44	32.0	61.0
UP-301	L	40.8	76.6	11.7	1.52	68.2	10.2	0.50	25.0	57.9
WG-377	L	35.6	77.7	11.2	1.47	67.8	10.1	0.50	25.0	63.5
WG-357	L	40.5	79.1	12.2	1.52	69.2	11.0	0.46	26.5	61.0
Pusa Lerma	K	33.6	75.3	9.5	1.72	70.7	8.3	...	23.0	48.0
Sharbati Sonora	K	29.0	75.0	11.1	1.77	75.1	10.2	...	27.5	54.2
Kalyan Sona	L	29.5	73.6	12.3	1.75	68.7	11.1	0.47	31.0	63.8
Kalyan Sona	N	37.8	82.0	11.5	1.23	68.1	10.4	0.35	30.0	68.6
Kalyan Sona	K	36.1	77.7	9.4	1.69	74.7	8.3	0.70	24.5	63.3
RBS-70A							12.3	0.39	46.0	60.1

[a]All data expressed on a 14% m.b.
[b]Locations: N = Niphad; L = Ludhiana; K = Karnal.

Hectoliter weights of the Indian wheats were approximately the same as average hard winter and spring wheat varieties grown in the U.S. (Tables I and II). The Indian wheats averaged 79.0 kg. per hectoliter (63.2 lb. per bu.) and ranged from 73.6 to 83.3 kg. per hectoliter (59.0 to 67.5 lb. per bu.). Their 1,000-kernel weights ranged from 28.0 to 52.3 g. and averaged 39.3 g., considerably higher than the average of hard winter and spring wheats grown in the U.S.

Wheat and Flour Protein. Flour protein ranged from 8.0 to 13.3%; average for the 43 samples was 10.7% (Tables I and II). Average flour protein content was 1.03% less than the average of the corresponding wheats (Tables I and II).

Buhler-Milling Properties. Despite large differences in hardness and milling characteristics, reasonable flour yields were obtained from most of the wheats (Tables I and II). Certain samples from Niphad were extremely hard and tended to stay in the form of "semolina" during milling. With the limited reduction capacity of the mill, the flow was altered to reduce those varieties to traditional flour size of 10XX. That was accomplished by removing the 46SS and 72SS fine bran and shorts sieves on the reduction side, thereby increasing the number of reductions to which the granular material was subjected. As flour yield increased, however, so did flour ash content.

Sedimentation Values. Sedimentation values for the Indian wheats varied from 20.5 to 36.5 cc., and averaged a relatively low 27.5 cc. (Tables I and II). Despite the good-to-excellent loaf-volume potential of certain Indian wheat flours, sedimentation values failed to reflect that potential. Average bread wheat flours in U.S. would be expected to have sedimentation values comparable to the 46.0 cc. of the RBS-70A. The correlation coefficients for sedimentation value versus loaf volume and for sedimentation value versus flour protein were r=0.568 and r=0.548 ($p<0.001$), respectively.

Wheat and Flour Ash. Wheat ash content varied from 1.16 to 1.93%, and averaged 1.46% for the 43 samples tested. Flour ash varied greatly, as might be expected, because the study included soft, medium, and hard wheat varieties (Tables I and II).

Rheological Properties. Selected mixograms from both the Indian and the Mexican varieties are reproduced in Figs. 2 and 3, respectively (except that S-331 in Fig. 2 is Mexican). Kalyan Sona, the most important commerical variety in India, is pictured with the other varieties of Mexican background. Note the low mixing tolerance of all the Indian varieties, except for NP-830 (Fig. 2). In contrast, most the Mexican varieties (Fig. 3) have mixing tolerances comparable to that of the standard flour RBS-70A.

Particularly noteworthy are the water absorption and flour protein data for all 43 samples (Fig. 4). The regression line for RBS-70A represents the breadmaking absorption level of hard winter wheat varieties grown in the U.S. Seventy-four percent of the Mexican varieties (●) and 96% of the Indian varieties (o) had absorptions above the RBS-70A regression line. Water absorptions of the Mexican Kalyan Sona samples (x) exceed water absorptions of most of the varieties tested, especially when considered on a constant protein basis. Mean water absorption values were in decreasing order: Kalyan Sona (73.2%), Indian varieties (70.3%, Table III), Mexican varieties (62.5%, Table IV). On

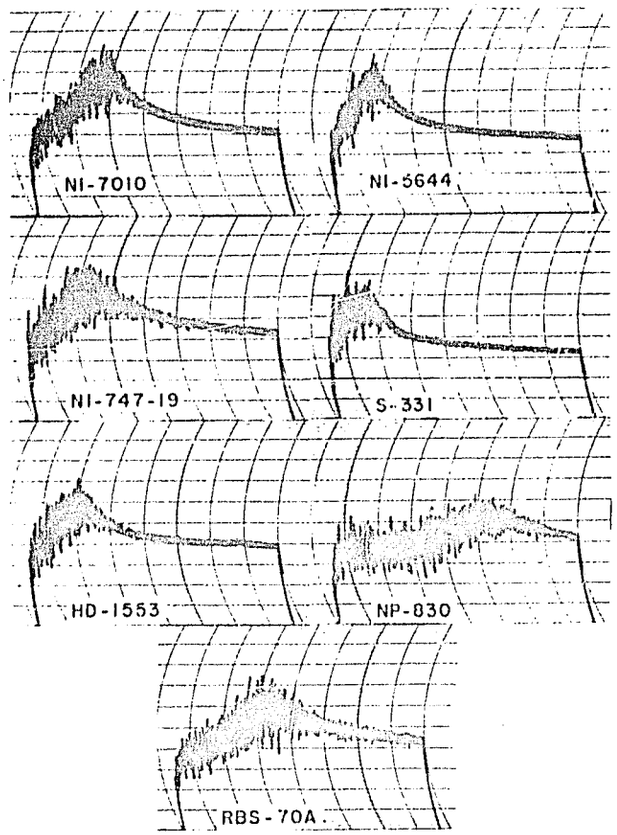

Fig.2. Mixograms of Indian wheat varieties.

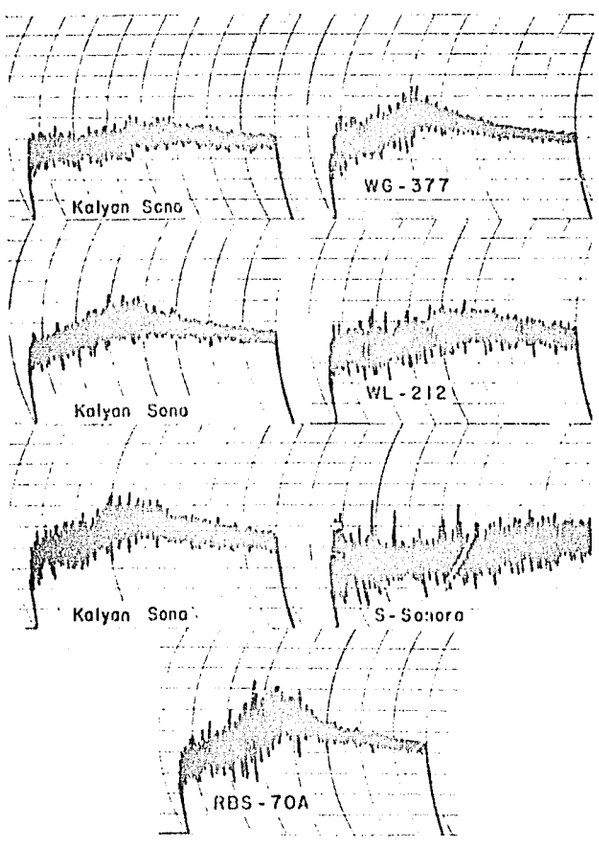

Fig. 3. Mixograms of Mexican wheat varieties grown in India. The three mixograms for Kalyan Sona are for samples grown in three different locations.

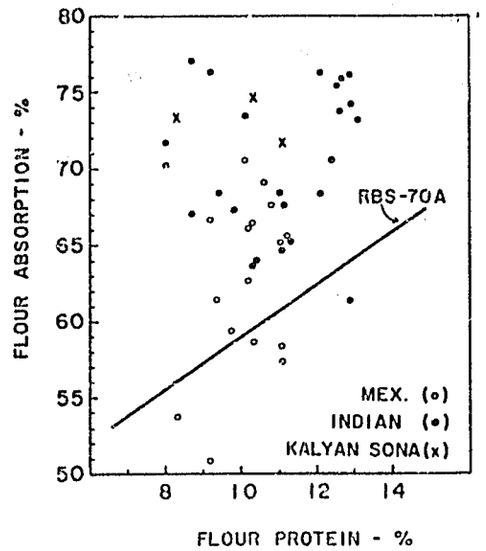

Fig. 4. Flour protein versus baking absorption. The line for RBS-70A represents the flour protein versus baking absorption regression line for an average of U.S.-grown bread wheats.

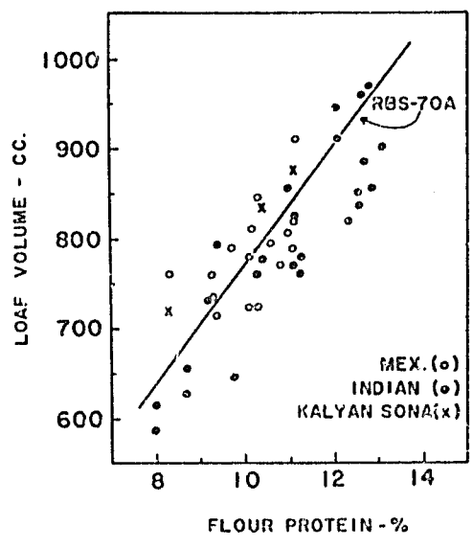

Fig. 5. Flour protein versus loaf volume. The line for RBS-70A represents the flour protein versus loaf volume (regression line) for an average of U.S.-grown bread wheats.

a constant protein basis, however, even the mean absorption of the Mexican varieties would appreciably exceed that of RBS-70A. Although Kalyan Sona had the highest average water absorption, it also had the lowest average protein content, 9.9%.

Those high water absorptions of most varieties deserve further investigation. It may be that the varieties are genetically so constituted, or it may be that Indian growing conditions contribute to producing kernel endosperms that are more susceptible to starch damage during milling. The relation of starch damage and protein content to water absorption of those samples has been published elsewhere (11). Most of the varieties tested were exceptionally hard. Earlier work by Tara and Bains (4) indicated that starch damage contributed to high water absorptions of the Indian commercial samples tested.

TABLE III. BREADMAKING DATA FOR INDIAN WHEAT VARIETIES HARVESTED AT ONE OF THREE LOCATIONS IN 1970 AND/OR 1971[a]

Variety	Location[b]	Flour Protein %	Breadmaking Absorption %	Mixing Time min.	Loaf Volume cc.	Regr. Coeff.[c]
NI-917	N	11.1	73.4	4.375	770	58.0
NI-917	N	12.7	74.9	2.500	885	60.5
NI-5643	N	11.1	67.6	5.375	770	58.0
NI-5643	N	13.1	73.1	3.375	900	59.5
NI-5644	N	12.4	70.6	4.000	820	55.0
NI-5644	N	12.6	72.7	2.375	835	55.5
NI-5439	N	10.3	63.7	6.000	760	63.0
NI-5439	N	12.8	61.3	3.875	970	68.0
NI-747-19	N	10.4	64.0	4.875	775	64.0
NI-747-19	N	12.1	68.3	4.250	945	71.0
NI-7010	N	12.7	75.7	3.875	960	68.0
NI-7176	N	9.2	76.3	5.500	730	68.0
NI-7008	N	11.1	64.7	1.500	825	65.0
NI-5645	N	12.1	76.2	4.750	910	67.0
NI-5642	N	12.6	74.7	3.000	850	57.0
NI-5641	N	12.9	74.1	2.125	855	56.0
C-273	L	11.3	65.3	4.000	760	55.0
C-306	L	9.8	67.3	3.500	645	49.5
C-306	L	8.0	70.1	5.875	585	53.0
HD-1734	K	8.0	71.6	4.750	615	59.0
NP-824	K	9.4	68.4	14.250	790	74.0
NP-830	K	11.0	68.3	9.000	855	69.5
NP-880	K	8.7	67.1	7.000	625	56.0
NP-890	K	8.7	77.0	26.500	655	61.5
Mean (All Indian Samples)		11.0	70.3			61.3
RBS-70A		12.3	63.2	4.250	925	67.5

[a]Data expressed on a 14% m.b.
[b]Locations: N = Niphad; L = Ludhiana; K = Karnal.
[c]Loaf volume vs. flour protein content.

TABLE IV. BREADMAKING DATA FOR MEXICAN WHEAT VARIETIES HARVESTED AT ONE OF THREE LOCATIONS IN 1970 AND/OR 1971[a]

Variety	Location[b]	Flour Protein %	Breadmaking Absorption %	Mixing Time min.	Loaf Volume cc.	Regr. Coeff.[c]
S-308	N	9.8	59.4	3.500	790	71.0
S-308	K	11.2	65.6	4.750	910	74.0
S-308	L	9.4	61.4	2.000	715	63.0
PV-18	L	9.2	66.7	4.250	730	68.0
S-307	N	9.3	50.2	2.625	760	71.0
S-307	N	10.3	58.7	1.875	845	74.0
S-331	N	11.1	57.4	2.125	820	64.0
S-331	N	11.1	58.3	1.750	790	60.5
HD-1941	L	10.3	66.4	4.875	725	58.0
HD-1941	K	10.8	67.7	11.500	770	60.0
WL-212	L	10.6	69.0	5.875	759	65.0
UP-301	L	10.2	62.7	4.250	725	59.0
WG-377	L	10.1	70.5	4.875	780	68.0
WG-357	L	11.0	65.2	4.500	805	63.0
Pusa Lerma	K	8.3	53.9	4.125	760	81.0
Sharbati Sonora	K	10.2	66.2	20.000	810	70.5
Kalyan Sona	L	11.1	71.6	4.750	875	71.0
Kalyan Sona	N	10.4	74.6	3.125	835	72.0
Kalyan Sona	K	8.3	73.3	7.000	725	76.0
Mean (Kalyan Sona only)		9.9	73.2			73.0
Mean (All Mexican Samples)		10.1	62.5			67.9
RBS-70A		12.3	63.2	4.250	925	67.5

[a]All data expressed on a 14% m.b.
[b]Locations: N = Niphad; L = Ludhiana; K = Karnal.
[c]Loaf volume vs. flour protein content.

Breadmaking Quality. Loaf volume potential (protein quality) of wheat varieties can be evaluated after plotting their protein contents and bread loaf volumes. When using an optimized bake test, the relation between flour protein content and loaf volume is essentially linear within a variety. Because the slopes of their loaf volume-protein content regression lines represent differences in loaf volume per unit of protein, quality differences between wheat varieties can be assessed simply by referring to the regression coefficients.

Experimental Baking. The mean regression coefficient for loaf volume and flour protein content of the Mexican varieties grown in India equals that of RBS-70A (Table IV). It is most significant that the samples of Kalyan Sona (r=73.0), presently grown on more than 75% of an important wheat-growing region, significantly outperformed RBS-70A (r=67.5). Kalyan Sona is equally desirable from the point of view of milling characteristics, dough-handling properties, and machinability.

The RBS-70A regression line for loaf volume and flour protein (Fig. 5) divides the Mexican varieties into two groups, with eight varieties above the line and eight below. All three samples of Kalyan Sona (x) lie above the RBS-70A line; while 18 of 24 Indian varieties lie below the RBS-70A regression line.

New High-Yielding Varieties Not Yet Released. Among the new, unreleased, high-yielding, spring wheat varieties tested, WG-377, WL-212, and WG-357 were the most promising bread varieties. Their loaf volume-protein content regression coefficients were 68.0, 65.0, and 63.0, respectively. Two of those varieties (WG-377 and WL-212) had above-average water absorptions of 70.5 and 69.0%. All three varieties had excellent dough-handling properties and were easily machined.

Those varieties have been released to Indian farmers for cultivation. It is, of course, highly important that high-yielding varieties other than Kalyan Sona be commercially planted. If the rust resistance of Kalyan Sona should fail sometime in the future, before other desirable varieties were introduced, the annual production of wheat could be drastically reduced.

Potassium Bromate Response. Earlier work in India indicated that some Indian varieties did not respond to potassium bromate[4]. Potassium bromate responses varied from negligible to extremely high among the 43 samples.

In 1971, varieties C-273 and Kalyan Sona (S-227) from Ludhiana, and Kalyan Sona (S-227) from Niphad, responded moderately to potassium bromate-approximately

[4]Personal communication from G. S. Bains, CFTRI, Mysore, India.

35 cc. per loaf. The same year NI-5644, S-308, and NI-5642 from Niphad, and Kalyan Sona (HD-1593) from Karnal, had medium responses of 50, 60, 40, and 45 cc., respectively. Varieties NI-5645 and NI-5641 from Niphad, and WG-377 from Ludhiana, had high-bromate responses of 90, 115, and 80 cc., respectively. In all cases the response to potassium bromate was measured by the AACC (6) lean-baking formula with and without 1 mg. potassium bromate.

Future of Bread Wheats in India. It appears that the primary commitment to produce more wheat and the secondary commitment to produce wheats of desirable quality characteristics (functional properties) that satisfy traditional as well as more recent food requirements are being met by concerned Indians. Studies in New Delhi indicate that the recently introduced Mexican varieties are suitable for traditional food products such as chapatties, puris, and paratas (5). Thus, with wheat production in India approaching self-sufficiency and with bread and cookie wheat flours more available, it appears that the commitment to increase the percentage of protein in the major commercial wheat varieties is now as important as continuing to meet total wheat production needs. Even a modest increase of 0.5 to 1% in protein (raising the average from about 10 to 10.5 or 11%) would make available an additional 125 to 250 thousand metric tons of that body-building material so vital to physical and mental health.

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Literature Cited

1. SINGH, R., and BAILEY, C. H. A biochemical and technological study of Punjab wheat varieties. Cereal Chem. 17: 169 (1940).
2. ANONYMOUS. Progress report of the schemes for wheat milling and baking tests and appointment of (an assistant) cereal technologist for wheat work in India. Superintendent, Government Printing, Punjab, Lahore (1943, 1944, 1945, and 1946).
3. BAINS, G. S., and IRVINE, G. N. Studies on the quality of some improved varieties of Indian wheats. J. Sci. Food Agr. 16: 526 (1956).
4. TARA, K. A., and BAINS, G. S. Starch damage, amylase activity and protein content of commercial flours in relation to water absorption and maltose values. J. Food Sci. Technol. (Mysore) 8: 105 (1971).
5. SADISIVAN, G., RAI, S. C., and AUSTIN, A. Fractional pairs for the evaluation of palatability of chapaties made from bread wheats. J. Food Sci. Technol. (Mysore) 8: 7 (1971).
6. AMERICAN ASSOCIATION OF CEREAL CHEMISTS. AACC Approved methods. The Association: St. Paul, Minn. (1962).
7. FINNEY, K. F. Methods of estimating and the effect of variety and protein level on the baking absorption of flour. Cereal Chem. 22: 149 (1945).
8. FINNEY, K. F., and BARMORE, M. A. Yeast variability in wheat variety test baking. Cereal Chem. 20: 194 (1943).
9. FINNEY, K. F., and BARMORE, M. A. Varietal responses to certain baking ingredients essential in evaluating the protein quality of hard winter wheats. Cereal Chem. 22: 225 (1945).
10. FINNEY, K. F. and BARMORE, M. A. Optimum vs. fixed mixing time at various potassium bromate levels in experimental bread baking. Cereal Chem. 22: 244 (1945).
11. TARA, K. A. FINNEY, P. L., and BAINS, G. S. Damaged starch and protein contents in relation to water absorption of flours of Indian wheats. Staerke 24: 342 (1972).

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APPENDIX
ITEM D

Degradation of Organophosphate Pesticides in Cereal Grains during Milling and Cooking in India[1]

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Summary

Samples of paddy (rough rice), wheat, and sorghum were treated with different concentrations of malathion, Gardona, and Sumithion for protection against insect infestation during storage. Subsequently, samples were milled, cooked, and analyzed by gas-liquid chromatography to determine residues remaining in the final products. Malathion and Gardona treatments ranged from 10 to 80 p.p.m.; Sumithion treatments, from 2 to 16 p.p.m. During machine milling, residues in wheat and sorghum were decreased from 30 to 70%. Because residues were concentrated in the hull and bran of the paddy, relatively little remained on polished rice after milling. Even with treatments of 80 p.p.m. residues on polished rice were never more than 4 p.p.m. Milled products from each grain were cooked using traditional Indian methods. Preparations involving boiling or steaming (wet cooking) resulted in complete degradation (loss) of residues of all three protectants so far as detectable with methods sensitive to less than 0.1 p.p.m. Dry cooking methods, used in preparing chapatties from wheat and sorghum, resulted in average losses of 43 to 75% of residues.

The Indian Government's Prevention of Food Adulteration rules (P.F.A.) now forbid admixture of any insecticide with food materials. Consequently, grain cannot legally be treated with pesticides for protection during storage, although use of fumigants is permitted (1). That contrasts with regulations in many other countries, including the U.S., where treatment with malathion up to 8 p.p.m. on stored grain is allowed (2). Part of the rationale behind the P.F.A. regulations against the use of pesticides on stored products was that sufficient data from pesticides use in India were not available. Meanwhile, various insecticides have been misused in India as grain protectants. In 1967 a government commission recommended that, to combat indiscriminate use of persistent organochlorine pesticides on stored grain, the use of malathion and pyrethrums should be encouraged after suitable studies had been carried out (3). Several studies conducted in India indicate that malathion can protect stored grain while residues are kept acceptably safe for human consumption as determined by the Codex Alimentarius Commission (4–6). The study (in India) reported here was to determine how much of the residue from storage treatments with malathion, Gardona, or Sumithion is degraded while the grain is being prepared for human consumption by milling and cooking.

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Materials and Methods

Grain. The variety of paddy (rough rice) used was Bangalore Sanna, grown locally in Mysore State, South India. The IS 0-40 sorghum also was obtained locally. The wheat was a hard amber variety from Maharashtra. Care was taken to avoid grain that had been treated with pesticide. Both bioassay and residue tests were performed on samples to be certain of no effects from previous, undocumented treatments.

Treatment with Protectants. Five-kilogram samples of each grain were treated with three different amounts of each of the three protectants: 10, 40, and 80 p.p.m. for malathion[4] and Gardona,[5] 2, 8, and 16 p.p.m. for Sumithion.[6] Protectants were freshly prepared emulsions of primary (analytical) grade pesticide applied to the grain as it was tumbled in a mixer.

Bioassay. Cultures of red flour beetles (*Tribolium castaneum* Herbst.) and rice weevils (*Sitophilus oryzae* L.) were used for bioassay tests. Each batch of treated grain was sampled after 24 hr., 1 month, and 2 months. In each instance, 20 adults of each species were exposed to the treated grain after samples had been partially ground and placed into a vial. Each test was replicated three times. After 7 days, dead insects were counted.

Milling. Sorghum and wheat were milled using an electrically powered disc mill, a type common in cities and villages throughout India. The grain sample (500 g.) was ground until 90% passed through a 32-mesh sieve. Paddy was milled by hulling 1-kg. samples in a McGill Sheller and polishing 700 g. of the resulting brown rice in a McGill No. 3 polisher for 2 min. to give a 4% polish.

Cooking. Chapatties were prepared from 50 g. of flour. Distilled water was added to give a suitable dough, which was formed into a thin chapatti and cooked on a griddle without oil. Besides chapatties, sorghum dough was formed into balls and cooked by boiling. Rice was prepared both by boiling and as a gruel (rice water), which was fermented, formed into balls, and steamed (a South Indian preparation called *iddli*). All cooking trials were conducted in duplicate and results were averaged.

Extraction and Cleanup. Methanol is an efficient solvent to extract malathion from grain (7). Residues were extracted for gas-liquid chromatographic analyses by agitating 5 g. of each sample with 10 ml. of methanol for 2 hr. The residue, after being filtered, was washed twice with 5-ml. aliquots of methanol and the washings were combined with the original filtrate. Cooked samples were dried and ground to pass through a 32-mesh sieve before extraction. Cleanup of the methanol extracts was accomplished by agitating the filtrate with 1 g. of Nuchar activated clay for 2 hr. After filtering, the volume was adjusted to 25 ml. with methanol and internal standard was added. The samples were then analyzed by gas-liquid chromatography.

Analysis. A Varian Aerograph Model 1400 gas-liquid chromatograph equipped with an alkali flame ionization detector with cesium bromide salt tip was used for analyses. The Pyrex glass column (6 ft. × 0.25 in. o.d., 2 mm. i.d.) was packed with 1.5% OV-225 on high-performance Chrom W, 80/100 mesh. The column oven was operated at 210°C., the injection port at 230°C., and the detector at 240°C. Hydrogen flow was adjusted to 30 ml. per min. at the detector. Flow rates of air and nitrogen were adjusted over ranges of 200 to 300 ml. per min. and 15 to 40 ml. per min., respectively, as required to adjust the detector for satisfactory response. A 5-µl. Hamilton syringe was used to inject 2-µl. samples of the methanol extract into the chromatograph. Amounts of residue in each sample were determined by comparing the area of the peak produced by the residue to the area of the peak resulting from the internal standard. That ratio indicated the concentration of residue when compared with a calibration curve prepared from different concentrations.

TABLE I. RESULTS OF PERIODIC BIOASSAY TESTS FOR RESIDUES OF INDICATED INSECTICIDES USED TO CONTROL RED FLOUR BEETLES AND RICE WEEVILS IN PADDY (ROUGH RICE)

Insecticide	Treatment Amount p.p.m.	Test Insect	% Mortality at[1] 0 Month	1 Month	2 Months
Malathion	10	RFB[2]	97	90	10
		RW[3]	100	100	97
	40	RFB	100	100	97
		RW	100	100	100
	80	RFB	100	100	100
		RW	100	100	100
Gardona	10	RFB	100	97	73
		RW	100	100	97
	40	RFB	100	100	100
		RW	100	100	100
	80	RFB	100	100	100
		RW	100	100	100
Sumithion	2	RFB	27	10	3
		RW	97	83	13
	8	RFB	100	100	23
		RW	100	100	90
	16	RFB	100	100	100
		RW	100	100	100

[1]0% mortality in control vials.
[2]Red flour beetles (*Tribolium castaneum*).
[3]Rice weevils (*Sitophilus oryzae*).

TABLE II. RESULTS OF PERIODIC BIOASSAY TESTS FOR RESIDUES OF INDICATED INSECTICIDES USED TO CONTROL RED FLOUR BEETLES AND RICE WEEVILS IN WHEAT

Insecticide	Treatment Amount p.p.m.	Test Insect	% Mortality at[1] 0 Month	1 Month	2 Months
Malathion	10	RFB[2]	100	97	70
		RW[3]	100	100	100
	40	RFB	100	100	100
		RW	100	100	100
	80	RFB	100	100	100
		RW	100	100	100
Gardona	10	RFB	100	100	90
		RW	100	100	100
	40	RFB	100	100	100
		RW	100	100	100
	80	RFB	100	100	100
		RW	100	100	100
Sumithion	2	RFB	60	7	3
		RW	100	40	7
	8	RFB	100	100	100
		RW	100	100	100
	16	RFB	100	100	100
		RW	100	100	100

[1]0% mortality in control vials.
[2]Red flour beetles (*Tribolium castaneum*).
[3]Rice weevils (*Sitophilus oryzae*).

[4]S-(1,2-Diethoxycarbethoxyethyl) O,O-dimethyldithiophosphate; phosphothion; donated by Agricultural Division, American Cyanamid Co., Princeton, N. J.

[5]O,O-Dimethyl 2-chloro-1-(2,4,5-trichlorophenyl) vinyl phosphate; Shell SD 8447; donated by Woodstock Agricultural Research Centre (Shell), Sittingbourne, Kent, England.

[6]Fenitrothion; O,O-dimethyl O-(4-nitro-m-tolyl) phosphorothioate; Bayer 41801; donated by Sumitomo Chemical Co., Osaka, Japan.

of the pesticide being assayed plus a constant amount of internal standard. Malathion was used as an internal standard for samples containing Gardona. Gardona was used as an internal standard for samples containing malathion or Sumithion.

Results and Discussion

Bioassay Tests. Tables I and II give mortality at 0, 1, and 2 months for rice weevils and red flour beetles exposed to paddy and wheat treated with each of the three levels of the three pesticides. Table III gives similar information for sorghum at 0 and 1 month. Highest concentrations of the three pesticides killed 100% of the insects. Intermediate concentrations of all three pesticides were completely effective in sorghum and wheat, but Sumithion at 8 p.p.m. in paddy had begun to lose effectiveness after 2 months, particularly to red flour beetles. At the lowest concentration, Sumithion was relatively ineffective in controlling paddy infestation. By the end of the test periods Sumithion at 2 p.p.m. lost effectiveness with the other grains, too. At lowest concentration, malathion and Gardona also began to lose effectiveness at the end of the test. In general, treatments of paddy were less effective than equivalent treatments of the other two grains. This probably was due in part to the method of application and mixing. Because rice hull is rougher than sorghum or wheat, more chemical presumably wore off (dusted off) as paddy was tumbled.

Loss of Residues during Milling. Tables IV and V show residues detected in whole and milled grains (wheat and sorghum). The average residue losses during grinding were:

Wheat treated with	Malathion	71%
	Gardona	30%
	Sumithion	62%
Sorghum treated with	Malathion	40%
	Gardona	39%
	Sumithion	28%

Minor adjustments in the clearance of the grinding discs made a noticeable difference in heating of the grain during grinding. Variation in residue loss (breakdown) may have partially resulted from that. Milling (wheat) with a hand-operated grinding stone (chakki) resulted in a much lower loss of malathion and Sumithion.

Table VI shows the amounts of malathion, Gardona, and Sumithion applied to paddy and residues remaining in the polished rice, from the protectant migrating through the hull and bran into the endosperm. However, even 80 p.p.m. of malathion left less than 4 p.p.m. residue in the polished rice – less than 50% of the 8 p.p.m. authorized by many countries (2).

TABLE III. RESULTS OF PERIODIC BIOASSAY TESTS FOR RESIDUES OF INDICATED INSECTICIDES USED TO CONTROL RED FLOUR BEETLES AND RICE WEEVILS IN SORGHUM

Insecticide	Treatment Amount p.p.m.	Test Insect	% Mortality at[1] 0 Month	1 Month
Malathion	10	RFB[2]	100	93
		RW[3]	100	100
	40	RFB	100	100
		RW	100	100
	80	RFB	100	100
		RW	100	100
Gardona	10	RFB	100	97
		RW	100	100
	40	RFB	100	100
		RW	100	100
	80	RFB	100	100
		RW	100	100
Sumithion	2	RFB	97	13
		RW	100	60
	8	RFB	100	100
		RW	100	100
	16	RFB	100	100
		RW	100	100

[1]0% mortality in control vials.
[2]Red flour beetles (*Tribolium castaneum*).
[3]Rice weevils (*Sitophilus oryzae*).

TABLE VI. RESIDUES OF MALATHION, GARDONA, AND SUMITHION DETECTED IN POLISHED RICE 0, 1, AND 2 MONTHS AFTER APPLICATION TO PADDY

Insecticide	Treatment Amount p.p.m.	Residue in Paddy at 0 Months p.p.m.	Residue Detected in Polished Rice at: 0 Month p.p.m.	1 Month p.p.m.	2 Months p.p.m.
Malathion	10	3.5	b.d.[a]	0.16	1.66
	40	9.5	0.19	n.d.[b]	3.0
	80	37.6	0.38	0.75	3.24
Gardona	10	6	b.d.	b.d.	b.d.
	40	26.6	0.6	1	b.d.
	80	52.5	2.3	1.6	1.65
Sumithion	2	1.2	b.d.	b.d.	b.d.
	8	3.4	0.22	b.d.	0.21
	16	9.6	0.49	0.4	0.26

[a]b.d. = below detectability.
[b]n.d. = not determined.

Degradation of Residues during Cooking

Chapatti-Making. Table VII shows losses of pesticide residues during preparation of chapatties from wheat flour. Average losses varied from 51 to 75% (Table VII), and 43 to 74% for sorghum flour (data not shown). However, breakdown of residues varied widely during preparation of chapatties, as shown by large standard deviations. Preparation of chapatties varies considerably from household to household and from one part of India to another, so the variation we noted may be typical.

Boiling and Steaming. Within detectable units (less than 0.1 p.p.m.) of the methods we used, residues of all three protectants were completely broken down during the wet-cooking methods. Peaks due to protectants were not present in gas-liquid chromatograms of samples extracted from boiled rice, iddli (steamed, fermented rice), and boiled sorghum balls.

Conclusions

The bioassay tests indicated that 10 p.p.m. of malathion or Gardona, or 8 p.p.m. of Sumithion, when applied and for a period of approximately 2 months afterwards, killed the stored products insects tested. Sumithion at 2 p.p.m. killed rice weevils in wheat and sorghum at the time of application, but its effectiveness began to decrease in less than 2 months. When applied at 2 p.p.m. it did not eliminate all red flour beetles even at the time of application. For longer periods of protection, more Sumithion probably should be applied.

Residue losses during power grinding ranged from 30 to 70%. That, combined with losses of 40 to 75% during the

TABLE IV. LOSSES OF INDICATED INSECTICIDE RESIDUES DURING MACHINE GRINDING OF WHEAT

Insecticide	Treatment Amount p.p.m.	Insecticide Residue Recovered from: Whole grain p.p.m.	Machine-ground grain p.p.m.	Loss of Residue: p.p.m.	%	Avg. %	Std. Dev. %
Malathion	10	5.8	2.2	3.6	62		
	40	31.9	9.3	22.6	71	71	8.5
	80	77.1	16.5	60.6	79		
Gardona	10	18	13.5	5.5	31		
	40	39	27.5	11.5	29	30	1.2
	80	65	45	20	31		
Sumithion	2	2	1	1	50		
	8	8.3	3	5.25	64	62	11.6
	16	15.5	4.2	11.3	73		

TABLE V. LOSSES OF INDICATED INSECTICIDE RESIDUES DURING MACHINE GRINDING OF SORGHUM

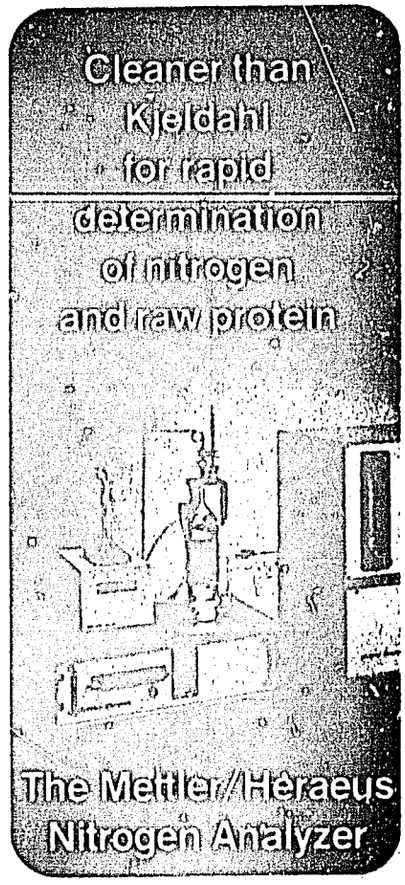
Insecticide	Treatment Amount p.p.m.	Insecticide Residue Recovered from: Whole Grain p.p.m.	Machine-ground grain p.p.m.	Loss of Residue: p.p.m.	%	Avg. %	Std. Dev. %
Malathion	10	5.76	3.4	2.23	41		
	40	22.4	13.5	8.9	40	40	1.5
	80	53.3	33	20.3	38		
Gardona	10	6.5	2.75	3.75	58		
	40	32.5	25.5	7	22	39	17.5
	80	85	53	32	38		
Sumithion	2	2.5	1.8	0.7	28		
	8	9.25	6.5	2.75	30	28	2.0
	16	15.5	11.5	4	26		

TABLE VII. LOSS OF INDICATED INSECTICIDE RESIDUES DURING THE PREPARATION OF CHAPATTIES FROM *WHEAT FLOUR*

Insecticide	Treatment Amount p.p.m.	Months after Treatment	Insecticide Residue Recovered from: Machine-ground grain p.p.m.	Chapatti p.p.m.	Loss during Cooking: p.p.m.	%	Avg. %	Std. Dev. %
Malathion	10	0	2.2	1.5	0.7	32		
		1	0.8	0.23	0.57	71		
		2	0.53	0.23	0.3	57		
	40	0	9.3	5.8	3.5	38		
		1	3.5	1.3	2.2	63	61	24.0
		2	1.85	0.95	0.9	49		
	80	0	16.5	16	0.5	3		
		1	12	3.5	8.5	71		
		2	7.5	1.6	5.9	79		
Gardona	10	0	13.5	b.d.[a]	13.5	100		
		1	5	2.85	2.15	43		
		2	2.35	0.65	1.70	72		
	40	0	27.5	1.7	25.8	94		
		1	27.5	7.5	20	73	75	18.3
		2	8	3	5	63		
	80	0	45	3	42	93		
		1	50	12.5	37.5	75		
		2	18	6.5	11.5	64		
Sumithion	2	0	1	0.53	0.47	47		
		1	0.2	b.d.	0.2	100		
		2	0.13	0.13	0	0		
	8	0	3	1.5	1.5	50		
		1	1.1	0.09	1.01	92	52	35.1
		2	0.58	0.38	0.2	34		
	16	0	4.2	3.6	0.6	14		
		1	1.9	0.23	1.67	88		
		2	1.08	0.65	0.43	40		

[a]b.d. = below detectability.

(Cont. on page 346)



The Mettler/Heraeus nitrogen analyzer eliminates two common yet fundamental nitrogen analysis errors. Too low values from incomplete decomposition. Too high values from formation of volatile cracked gases which do not oxidize completely. Additionally, results are equal to, if not better than the Kjeldahl method, with a wide variety of materials and without special techniques. You also receive these features:

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MIXOGRAM CHARACTERISTICS

(Cont. from page 324)

Discussion

During mixing, the ingredients are thoroughly incorporated to form a homogeneous mass, followed by development of the gluten structure. Mixing, however, also incorporates air into the dough. This air is introduced into the dough as a given volume and not as a given weight. The volume of air incorporated into a dough depends on the mixing procedure and on the mixing speed both of which are fixed in the operation of the mixograph.

The volume of gas is inversely proportional to the pressure as stated by Boyle's law. As atmospheric pressure is reduced, the volume of the incorporated air becomes greater placing a greater stress on the dough system which shows up as a greater maximum curve height, a longer time to maximum height, and, consequently, as a larger area under the curve.

Conclusions

The operation of the mixograph is affected by changes in atmospheric pressure. Maximum curve height, the length of the curve to maximum height, the time to maximum height, and the area under the curve increase as elevation increases. The percent increase of the values for these characteristics varies slightly depending on the kind of flour. Weakening angle is not affected by changes in elevation. Treated and untreated flours behave similarly. Many cereal laboratories and flour mills are located at elevations of up to 5,000 ft. and should take this into consideration when examining or reporting mixograph data.

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Literature Cited

1. SWANSON, C. O., and WORKING, E. B. Testing the quality of flour by the recording dough mixer. Cereal Chem. 10: 1 (1933).
2. LARMOUR, R. K., WORKING, E. B., and OFELT, C. W. Quality tests on hard red winter wheats. Cereal Chem. 16: 733 (1939).
3. FINNEY, K. F., and YAMAZAKI, W. T. Quality of hard, soft, and durum wheats. In: Wheat and wheat improvement. Agronomy Monograph No. 13, chapt. 14. Amer. Soc. Agron.: Madison, Wis. (1967)
4. POMERANZ, Y., and SHELLENBERGER, J. A. Bread science and technology, p. 146. Avi Pub. Co.: Westport, Conn. (1971).
5. MILLER, B. S., and JOHNSON, J. A. A review of methods for determining the quality of wheat and flour for breadmaking. Kansas Agr. Exp. Sta. Bull. No. 76 (April 1954).
6. JOHNSON, J. A., SWANSON, C. O., and BAYFIELD, E. G. The correlation of mixograms with baking results. Cereal Chem. 20: 625 (1943).
7. HARRIS, R. H., and SIBBITT, L. D. Comparative effects of absorption and temperature on mixogram patterns on different wheat varieties. Baker's Dig. 19: 5 (1945).
8. PYLER, E. J. Baking science and technology, p. 510. Siebel Pub. Co.: Chicago, Ill. (1952).
9. SHUEY, W. C., and GILLES, K. A. Effect of spring settings and absorption on mixograms for measuring dough characteristics. Cereal Chem. 43: 94 (1966).
10. MORRIS, V. H., BODE, C. E., and HEIZER, H. K. The use of the mixogram in evaluating quality of soft wheat varieties. Cereal Chem. 21: 49 (1944).
11. LORENZ, K. A note on the effect of varying atmospheric pressures on amylograph viscosity. Cereal Chem. 50: 576 (1973).
12. LORENZ, K., BOWMAN, F., and MAGA, J. High altitude baking. Baker's Dig. 45(2): 39 (1971).

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PESTICIDES IN CEREAL GRAINS

(Cont. from page 333)

preparation of chapatties from wheat and sorghum flour, made total residue losses range from 59 to 93% for whole grain (wheat and sorghum) processed to chapatties. With rice products, wet cooked, all three protectants were totally degraded, except that metabolites, undetected with the equipment we used, may have formed. In India, steam cooking of rice has been reported to almost completely (>95%) destroy malathion (8). Large (75 to 78%) losses of malathion were observed during preparation of chapatties from wheat or wheat flour (5, 9).

Recommendations now being advanced to amend the P.F.A. rules to allow at least 8 p.p.m. of malathion as a grain protectant in India seem to be justified - particularly when one considers the hazards presently posed by misuse of such other pesticides as DDT, BHC, endrin, lindane, and others to control insect infestation in stored grain. Pesticides often are misused because of lack of proper guidance in their use by the farmer.

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Literature Cited

1. TRIVEDI, R. C., ed. A. P. Mathur's Commentaries in the Prevention of Food Adulteration Act 1954 (6th ed.). Eastern Book Co.: Lucknow, India (1970).
2. FAO/WHO. Evaluation of some pesticides residues in food. FAO, PL: CP/15; WHO/Food Add. 67: 32 (1966).
3. INDIAN COUNCIL OF AGRICULTURE RESEARCH. Report of the special committee on harmful effects of pesticides. ICAR: New Delhi, India (August 1967).
4. FAO/WHO. Recommended international tolerances for pesticide residues. Joint FAO/WHO Food Standards Programme-Codex Alimentarius Commission, CAC/RS 2-1969 Rome (1969).
5. UDEAAN, A. S., and BINDRA, O. S. Malathion residues in wheat grains in relation to dosages applied, storage period and receptacles used for storage. Bull. Grain Technol. 9: 13 (1971).
6. BINDRA, O. S., and SIDHU, T. S. Dissipation of malathion residues on maize grain in relation to dosage, storage conditions and baking. J. Food Sci. Technol. 9: 29 (1972).
7. CRISP, S., and TARRANT, K. R. The determination of residues of dichlorvos and malathion in wheat grain by gas-liquid chromatography. Analyst (London) 96: 310 (1971).
8. GODAVARI BAI, S. Persistence of malathion residues on treated food-grains under different conditions of storage and processing. In: Pesticides, ed. by S. K. Majumder. Academy of Pest Control Sciences: India (1968).
9. GODAVARI BAI, S., KRISHNAMURTHY K., and MAJUMDER, S. K. Studies on malathion for stored grain product insect control. Pest Technol. 2(7): 12 (1960).

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