Technical News Feature

The Palm Oil Research Institute of Malaysia

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Palm Oil Research Institute of Malaysia

As its name implies, the Palm Oil Research Institute of Malaysia (PORIM) is a national body entrusted with the task of researching the oil palm and its products. Malaysia is traditionally known as a major exporter and producer of rubber. The profitability of rubber estates came under severe pressure in the 1950s because of the development of synthetic rubber, which replaced the natural material in many uses. There was, therefore, a strong inducement to diversify into another major crop. In addition the Malaysian government initiated a strong drive to establish profitable plantation crops on land newly cleared of jungle. The oil palm already was grown on a limited basis in Malaysia and was chosen as one of the main crops to be planted. Consequently, the land area under oil palm increased from 90,000 hectares (ha.) in 1960 to 1 million ha. in 1980 and 1.3 million ha. in 1984.

From the first the agricultural research needs of the growing industry were met by groups within the large plantation agencies, backed up by the Ministry of Agriculture. In the 1970s a second rapid development took place when refineries were established, to enable processing of the palm oil before export. At this time the research effort of the Ministry was taken over by the new Malaysian Agriculture Research and Development Industry (MARDI). This organization, however, had the task of researching all agricultural products other than rubber, and it became evident that MARDI could not concentrate the required amount of effort on the oil palm. It was decided to form a separate, specialized institute, organized along the lines of the long established Rubber Research Institute of Malaysia. An Act of Parliament was passed in May 1979, forming the Palm Oil Research and Development Board under the Ministry of Primary Industry, to undertake the task of organizing and managing the research.

The Act sets the objectives of the board as follows:

- To conduct and promote research into the production, extraction, processing, storage, transportation, marketing, consumption and uses of palm oil and oil palm products.
- To secure, where the public interest or the interest of the oil palm industry so requires, the development and exploitation of any result of research, when it appears to the board that it is not being developed and exploited sufficiently.
- To acquire, hold, dispose of or grant rights in connection with the result of any research conducted by the board or, where the public interest or the interest of the oil palm and palm oil industries so require in connection with the result of any research undertaken by any person or organization.
- To control and coordinate the activities and policies of all research and development organizations financed wholly or mainly from the fund.
- To ensure that it is kept fully informed on the relevant activities and policies of all research and development organizations financed partly by the fund.
- To collect, collate and disseminate information relating to oil palm, palm oil, oil palm products and other vegetable and animal oils and fats, and to promote the use of palm oil and oil palm products in competition with other materials or as complementary to them.
- To coordinate activities within and outside the Federation relating to research, development, publicity and other matters affecting the oil palm and palm oil industries.
- To keep the Ministry fully informed on all matters relating to research into and the development of oil palm and palm oil industries.
- To exercise such other functions as the Minister may direct.

These objectives are purposely focused in two directions, toward the problems of growing and processing palm oil within Malaysia and toward those of marketing, consumption and use of palm oil products. Though the agricultural aspects of research were already being addressed in practical terms within the industry, the requirement to develop research to promote the use and marketability of palm oil products was new in Malaysia. It was, of course, prompted by the rapid growth in the quantity of oil available for export, and the fact that the actual products being exported were various grades of processed oil in place of crude oil.

The needs were regarded as so urgent that by May 1979 a small team already had been working for almost one year on the planning of facilities and programs, funded by voluntary subscriptions from the estate agencies. Thus, some groundwork had been done, and it was possible to start negotiations for the transfer of the existing facilities and of a nucleus of staff from MARDI. An important part of the MARDI program was the maintenance of a collection of oil palms obtained from the wild in Nigeria and forming a gene pool for use in future breeding programs.

In September 1979 it was already possible to open temporary chemical research laboratories in two buildings adapted for the purpose. These were intended to provide space for about 10 researchers and their assistants during the time required to develop permanent headquarters. Initially this was expected to be about two years; the move into the present institute took place only in February 1984. By this time a second block of temporary laboratories, including pilot plant facilities, had been brought into use, and the growing headquarters office staff was distributed among four sites in the city.

The institute is now situated on 25 acres 18 miles south of Kuala Lumpur, in an area designated for institutional development. Neighboring sites are being occupied mainly by various training institutes for bank staff, for the national electricity and highways authority and the national petroleum company. It is within a few miles of the agricultural and national universities.

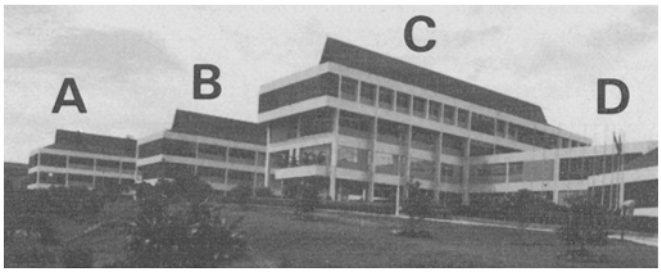
The buildings consist of three separate blocks housing the administration, chemistry and technology and biology

divisions and a link building containing library, computer and technical advisory services. There is a lecture theater seating 250, a canteen and sports block and separate workshops and pilot plant facilities. Currently the latter are being amplified, and an adjacent block of eight acres has been purchased to house a biotechnology building. In addition to the headquarters site, the needs of the biology division for land for research purposes gradually are being satisfied. This necessarily is situated in different parts of the country to include representative soil and climatic conditions, and eventually will include plots in Sabah and Sarawak, on the island of Borneo.

Organization. The Palm Oil Research and Development Board is appointed by the Minister of Primary Industries and has members representing both industry and various relevant government departments. The director general of the institute is a member of the board.

The institute has three research divisions, for biology, chemistry and technology, and techno-economics and technical advisory service. In addition, there is an administration and finance division to which the computer service, publications unit and the library are attached organizationally. Staffing at Jan. 1, 1985 is shown in Table 1.

Two important committees assist the institute in its management of research. The Technical Advisory Committee consists of senior technical staff from the Malaysian Palm Oil Industry and is involved in the selection and formulation of research projects. The Program Advisory Committee includes mainly internationally recognized experts who meet for one week each year to evaluate progress, advise on experimental approaches and provide contact with international developments. Currently members are drawn from Europe, the U.S., Japan and India.



Palm Oil Research Institute of Malaysia's new buildings at Bangi, Selangor. (A) Biology, (B) Chemistry, (C) Administration, (D) Lecture Theatre.

In addition to its in-house research, the institute sponsors a number of research projects at local and overseas universities.

The institute is funded by a statutory levy on palm oil and palm kernel oil production which currently is fixed by agreement with the industry at M$5.00 per ton of oil. The building site for the Institute was a gift from the Malaysian Oil Palm Growers Council, and the building itself was paid for largely by a government launching grant. Current income has to pay all operating expenses, capital equipment and the costs of development of experimental land and substations. Additional external funds are being provided for some projects.

The research program. The research is formalized in project statements nominating a project leader and detailing objectives, work program, time schedules and cost. These project statements are discussed in the advisory committees and approved by management before implementation. At present more than 100 projects are being carried out, and some of them are described briefly below. They have been selected to indicate the range of subjects being tackled.

PLANT BREEDING PROJECTS

Most of the major economic plants of the world are annuals which have been improved by breeding over many generations. In contrast the oil palm, which requires about eight years to go through one generation, has received relatively little attention. A great deal of genetic variability is available for exploitation, and PORIM is actively developing its germ plasm collection, the nucleus of which was formed in 1973 by MARDI together with the Nigerian Institute for Oil Palm Research (NIFOR) with Nigerian material. Prospection for *Elaeis guineensis* has since then been extended to Zaire and Cameroons, and future visits are planned to Angola and Madagascar. In each case seedlings are permanently planted and studied for desirable attributes of yield, form, disease resistance, etc., which could be bred into the commercial stock.

One possible future direction is the development of a more unsaturated palm oil based on cross breeding with the South American palm *Elaeis oleifera.* For this purpose seeds have now been collected from Panama, Colombia, Costa Rica, Honduras and Surinam. A few seedlings of other oil bearing palm species from Peru are also being grown, including Jesenia, Oenocarpus, Astrocaryum and *Euterpe oleracea.* As might be expected, PORIM is a

TABLE 1

Staffing of PORIM Divisions as of January 1985

	Biology	Chemistry & Technology	Techno Economics & Technical Advisory Service	Administration & Finance
Senior Staff—graduates	22	23	12	18
Assistant Research Officers diploma holders	23	30	4	16
Research Assistants	47	36	8	13
Clerical & Service Staff	31	16	8	120

major center of activity for the International Society for Oil Palm Breeders. An international workshop in March 1985 attracted 70 participants from nine countries to Kuala Lumpur.

FARM MECHANIZATION

The oil palm is harvested by cutting an entire fruit bunch from the tree. Because each bunch weighs about 25 kg, the cutting of the thick woody stem is a difficult operation, especially in tall, mature palms. The bunches are damaged on striking the ground, and the task of bringing them to the nearest roadway is laborious. All these aspects currently are being researched. In the main, PORIM's role is to stimulate manufacturers of tools and transport vehicles to design for these specific needs, to evaluate prototypes and to suggest suitable modifications. Collaboration with firms in Japan, Australia and Europe is proceeding along these lines.

VEGETATIVE PROPAGATION

The oil palm does not respond to the simple and widely used methods of plant propagation such as grafting and the rooting of cuttings. Research at Unilever and IRHO laboratories first succeeded in propagating the oil palm vegetatively by tissue culture, and similar results have been obtained at PORIM. The process is carried out under aseptic conditions and involves several stages.

First, samples of material from roots, leaf or the inflorescence are cultured on suitable media to produce callus. This callus can be multiplied by subculture and in due course embryoids are formed, which are capable of developing shoots. The shoots are transferred to fresh media for root development. Current research is studying the variables in these processes with a view to reducing the time required. The stage has been reached where material from selected palms with outstanding yield characteristics is being reproduced and planted out for field testing. The most important attribute of tissue culture is its ability to reproduce plants with characteristics identical to the selected plant, whereas the present commercial planting material is always obtained from seed and is therefore subject to a degree of variability in performance.

OIL PALM NUTRITION

Apart from labor, fertilizer is by far the most important cost item in the production of oil palm fruit. Consequently, estates systematically carry out soil and leaf analyses to determine the optimum local requirements. The institute is uniquely well placed to coordinate the resulting information. The available data has been put together with the results of our own long term trials on various soils to construct a series of mathematical equations. In this way it is possible to calculate the combination of fertilizers to be applied under defined conditions which will give the best financial returns.

The equations take into account soil analysis results, soil moisture conditions, the age of the trees, the type of terrain and the interactive effects on yield of the different fertilizers. The method and frequency of application has to be varied depending on the age of the palm. Other projects deal with more specific aspects of nutrition.

A large area of peat soils is still potentially available in Malaysia for the oil palm. Problems relating to their acid nature and to the deficiency of micro nutrients are under study. One of the industries being developed in Sarawak on the island of Borneo is the manufacture of urea fertilizer based on the abundant supply of natural gas at Bintulu. Urea has sometimes been found to be much less effective than conventional inorganic N fertilizers for the oil palm, and the most suitable method of applications has to be determined.

OIL COMPOSITION

One of the first tasks of the Chemistry Division was to survey the composition of processed palm oil products as a basis for quality and standards specifications. Having established data on the fatty acids and glycerides of palm oil, palm oil fractions and palm kernel oil, the interest moved to minor components.

HPLC determination of the tocopherols enabled the changes during processing of crude palm oil to be followed, and showed there was a significant concentration in the deodorizer distillate. A pilot plant is now being built with Japanese collaboration to recover this by-product. The process involves esterification of the fatty acids, followed by concentration and purification of the tocopherols. The phospholipids and glycolipids have been analyzed in collaboration with the University of Malaya.

Currently there is considerable interest in polar (often water soluble) components of the crude oil. A number of phenolic acids and alcohols have been identified in crude palm oil at the parts per million level; these may not be entirely removed in the refinery pretreatment steps.

PALM OIL QUALITY

Every step in the processing and handling of palm oil from harvesting to delivery to the end user potentially has some effect on the quality of the product. Therefore, a series of investigations of these steps is in progress. These include the assessment of ripeness of the fruit at harvesting, the introduction of microprocessor controls in the oil mills, improvement of oil recovery from the waste streams in the mill, the chemistry of the refining process and studies of storage and transport systems.

Many of these investigations are in their early stages, but some results already have been discussed, at meetings of the American Oil Chemists' Society and elsewhere. A low residual phosphorus level before (and after) the deodorizer is regarded as one useful criterion of a successful treatment of the oil. It has been established that at least some of the residual phosphorus is not derived from the phospholipids of the crude oil, but is present as phosphoglycerides resulting from the interaction of partial glycerides with the phosphoric acid used as a degumming agent. These phosphoglycerides have no adverse effect on the properties of the oil.

Palm oil is well known as a stable frying medium which may show rather rapid color development not associated with oxidation or polymerization. The hypothesis that some minor constituents are involved has been researched, and the tentative conclusions are that there is an interaction in the crude palm oil between hydroxy-

benzoic acid and other phenols (present at ppm levels) and traces of iron from the mill process. The interaction product eventually causes color formation.

Investigations into transport conditions were discussed at the AOCS world conferences in the Hague and in Kuala Lumpur and have resulted in an advisory document in which the basic principles of correct design and handling are given. It is obvious that oxidation cannot take place in the absence of oxygen. Therefore, it is surprising to find in the field that often even the simplest precautions to minimize contact between oil and oxygen are not taken.

Figure 1 shows the dissolved oxygen content of oil on its way through a refinery. Several refinery processes are carried out under vacuum and remove dissolved oxygen. Subsequently the oil is splashed, often from a height, into a storage tank, and fully oxygenated.

MARKET AND APPLICATIONS STUDIES

In view of the annual growth in supplies of palm oil there is an obvious need for a positive marketing effort by Malaysia. The institute's contribution to this effort is carried out by the Technical Advisory Service in coordination with laboratory studies on applications by the Chemistry and Technology Division. The Advisory Service is responsible for investigating oils and fats uses in the field, and for this purpose makes visits to the relevant industries in more than 30 countries. Potential applications of palm oil are discussed with the relevant laboratory specialists and investigated.

Food uses. World consumption of margarine is about 8 million tons. While the formulation and processing technology has been practiced for over 100 years in Western Europe, it is relatively unknown in a number of countries in Asia but there is a growing interest. Examination of many samples has shown that the required physical properties of margarine are similar everywhere, but formulation varies. Each country wants to use its domestic supplies of oils and, when it imports, to do so as economically as possible. Research therefore is directed to maximizing the proportion of palm oil that can be used, together with the other oils available locally, to produce the desired texture. The relatively slow crystallizing behavior of palm oil sets an upper limit in conventional blends, which can be overcome by interesterification. It has been found that the use of this technique on a blend of palm stearin together with palm kernel olein gives an economical base stock for margarine, suitable for dilution with the local liquid oil.

Palm stearin is also a very useful component of industrial pastry margarine and of bakery shortenings. For research into this type of product a full range of food technology equipment is available so that practical product evaluations can be carried out.

The "vanaspati" or "vegetable ghee" customary in the Indian sub-continent and nearby is at first sight an ideal product for the incorporation of palm oil. However, it must have a coarse, grainy texture, totally unlike bakery shortening, to melt sharply close to 37 C, and can have no supernatant oil. While palm oil meets some of these criteria, it does not crystallize in the required coarse grains. Analysis of products from the market and extensive experimentation indicated that some hydrogenated components with a relatively high *trans* acid content were required to meet the criteria. On this basis a number of formulae were developed containing high levels of palm oil.

In many countries the majority of oils consumed are used as liquid oils, and palm oil is of limited application. Palm olein meets the requirement for liquid oils in hot climates only. For temperate climates palm olein is blended with liquid oils. Practical tests have shown that for cooking and frying purposes such blends usually have better flavor and stability at high temperature than the liquid oils alone. The physical properties such as cloud point can be adjusted to suit the requirements, as can be seen from Figure 2, which shows the cloud point of blends of a typical palm olein with other vegetable oils.

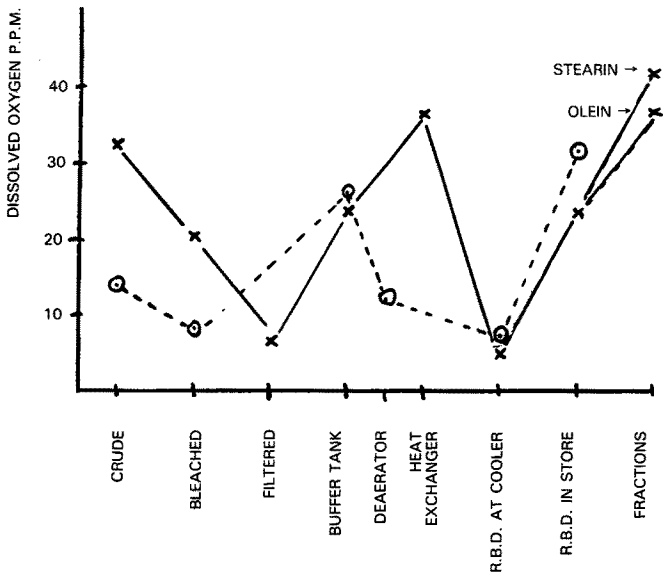


FIG. 1. Oxygen in refinery process. X—X, refinery A; ⊙- - - -⊙, refinery B.

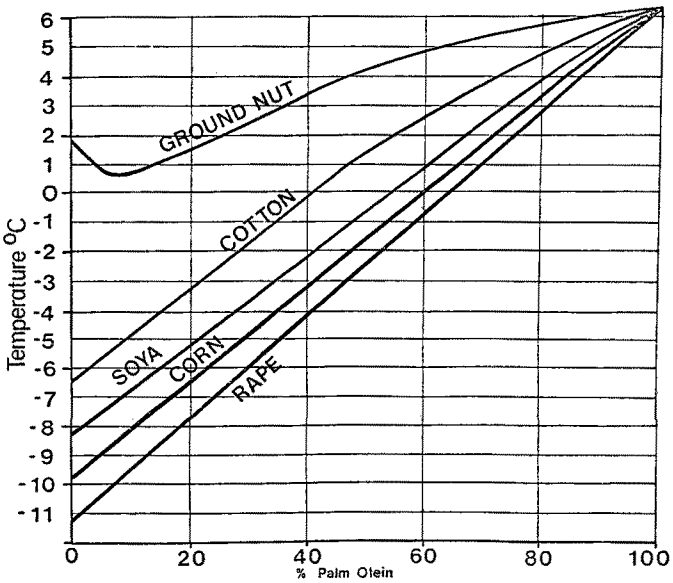


FIG. 2. Cloud point vegetable oil/palm olein mixtures.

TECHNICAL USES

By far the largest technical use of fats is in soap manufacture. The traditional raw materials are inedible grades of tallow and coconut oil. When investigating their replacement by palm products, it is found that palm kernel and coconut oil are readily interchangeable. Among the palm oil products, normally only palm stearin is competitive in price with tallow and, as one might expect, it is functionally satisfactory in soap. The only technical problem to be resolved is that palm stearin-based soaps do not generally have the completely white appearance that can be obtained with tallow. It appears that minor components and pro-oxidants may be responsible, and appropriate pretreatments are being investigated.

Technical grades of stearic acid have in the past been based mainly on tallow. The Malaysian product is derived from palm stearin or technical grades of palm oil and therefore has a different ratio of palmitic/stearic acid. This ratio affects a number of physical properties of practical importance such as titre, melting point and contraction during solidification. A survey of the relevant physical properties of palm fatty acids is being carried out.

Epoxidized soybean oil is available commercially as a plasticizer/stabilizer in polyvinyl chloride (PVC). Methods have been worked out to epoxidize various grades of palm oil using as reagent either preformed peroxy acetic acid or peroxy formic acid generated in situ. Preliminary examination of the behavior of peroxidized crude palm oil in PVC shows that the physical properties are similar to those obtained with peroxidized soybean oil. Thermal stability tests are now being carried out.

While at the present time only palm stearin and technical grades of oil are economical in chemical applications, this may not always hold in the future. The possibility exists that at some time glyceride oils will become competitive with mineral oils. This possibility already has prompted research in other countries into the use of tallow and various vegetable oils in diesel engines. PORIM, in collaboration with the national petroleum company PETRONAS, is engaged in a project to investigate the use of palm oil methyl esters. Process investigations have been completed. Transesterification with a base catalyst is suitable for palm oil grades containing less than 5% free fatty acids. For higher levels an acid catalyst is required, and a new product has been patented. Engine tests over the last two years have revealed no technical problems. For the next stage of the project a pilot plant is being built which will operate at the rate of 3000 ton/year and will enable very extensive vehicle road trials to be undertaken. The preliminary road tests have revealed an unexpected benefit, a rather appetizing odor at the exhaust end, similar to a frying pan in use.

UTILIZATION OF OIL PALM WASTE PRODUCTS

Palm oil represents approximately 20% of the harvested fruit bunch, and palm kernels are another 4%. The remaining vegetable matter is waste, much of it generated as sludge at the oil mill. Each of the 212 oil mills in operation has to treat its waste to acceptable standards before discharge. The main forms of treatment use a combination of anaerobic and aerobic fermentation. The institute provides an analytical and advisory service which ensures that the biological systems are working efficiently or that appropriate adjustments are made. Because the waste material is discharged at a high temperature, the possibility of using thermophilic bacteria is attractive. Research so far indicates that their use would result in a reduction of capital expenditure due to the smaller tank capacity required, and a reduction in corrosive by-products. Direct application of the effluent to the land with or without a partial treatment has a significant manurial value, but the risks of contamination of ground water have to be assessed.

After 25 years the oil palm has to be replanted, and the old trunks and fronds represent a large amount of biomass. The possibility of using this material in papers, fiber or particle boards and in cement roofing tiles is being investigated. During the 15 years to 2000 A.D. it is estimated that 54 million tons of trunk and 10 million tons of fronds will be available due to replanting, while normal pruning will yield 13 to 18 million tons of fronds annually. At present, pruned fronds are used as a mulch in the field, where they have useful moisture-retaining properties and slowly impart their mineral content as fertilizer. It has been found, however, that the leaves contain significant amounts of tocopherols. Availability of vitamin E from pruned fronds would be between 3,000 and 4,000 tons per year, with up to 50 tons more available from the replanting program. Extraction and purification methods are being investigated in the laboratory.

ECONOMIC EVALUATIONS

The Techno-Economics Section is carrying out projects in agricultural economics, process economics studies on the structure of the industry and the world oils and fats market, and maintaining a data bank of production and export/import statistics for countries of interest to the palm oil market.

OTHER ACTIVITIES

The above brief description of research projects indicates that many of the important opportunities and problems of the palm oil industry are being tackled. This program of research is amplified and supported by projects sponsored at a number of Malaysian and overseas universities. In addition there is a proportion of sponsored work on a confidential basis. The function of a national research institute is, however, wider than this. The institute is well placed to interpret the needs of this industry to government and vice versa, and therefore is invited to participate in a number of policy-making committees and working groups.

The Chemistry Division in particular is involved in standards formulation for oils and fats on local and international groups and in the standardization of analytical methods. It is carrying out an annual crosscheck program of the most important analytical methods, in which over 70 local laboratories now take part. The results are evaluated with methods used by the AOCS Smalley Committee.

Another program aimed at maintaining good standards is based on visits to refineries and to oil mills by a small team which carries out a technical audit. Each operation is evaluated against a standard, comprehensive check list. Marks are given and those reaching a sufficient level

receive a "Certificate of Competency." The program is in its third year for refineries and its second year for oil mills, and already is found to be effective.

INFORMATION OUTPUT

It is a commonplace that the only product of scientific research is information. Any research institute must therefore ensure that its information reaches the right people and commands their attention so that it is used. For PORIM, the communication task is particularly complicated; various methods are used.

Research reports. Written progress reports on projects are produced annually and form the basis of discussion with the advisory committees. Eventually they are available externally. Completed projects are the subject of a formal project report. This is issued to interested official bodies and the industry in Malaysia, and is in general made freely available. A restricted or confidential category is available for reports and is used occasionally. Where the work merits it, publication is sought in an international refereed journal.

Publications. The *PORIM Bulletin* is a house journal intended for the palm oil industry in Malaysia. It contains mainly technical articles written by staff on topics of local interest. They may be based on original research or on reviews.

The *PORIM Technology* series is designed to provide specific information packages for palm oil-using industries overseas. Individual booklets are devoted to basic analytical data, or to specific applications such as soap making or frying. The contents are based partly on original data from the research staff.

Occasional Papers are used as a vehicle for printing texts of visiting lecturers, research reports or surveys which do not readily fit into the other publications.

Palm Oil Developments is a recent venture intended as a twice yearly regular information package for palm oil users.

A formal Annual Report to Parliament is a statutory requirement, which includes a layman's account of significant research.

Proceedings of workshops, seminars or conferences held under PORIM auspices are published whenever possible.

Verbal communications. Several times a year the Institute organizes workshops and seminars on a local, regional or international basis to deal with specific subject areas. A prime objective is to bring to the platform both research and industrial workers to share their experiences. On a less frequent basis PORIM is involved in organizing international conferences. In recent years these have been in collaboration with the Incorporated Society of Planters, the International Trade Centre Geneva, and the American Oil Chemists' Society. Individual scientists are encouraged to contribute to international meetings in their specialized field. The Technical Advisory Service runs a number of seminars in palm oil-using countries each year. These have proved particularly useful where palm oil is still a relatively new or unknown commodity.

Training courses. The Institute has collaborated for some years in a training course for palm oil mill managers and, with the facilities now available, will take greater responsibility for its organization. Two new courses directed toward edible oil processing and product technology are being developed for the local industry this year. For overseas users of palm oil, mainly from developing countries, a familiarization program is run each year which enables key personnel to visit Malaysia, see the palm oil industry at first hand and receive a number of technical lectures.

Exhibitions. A PORIM stand is taken to a limited number of exhibitions selected because of their relevance to the oils and fats industry.

CONCLUSION

PORIM can look back at its first six years of existence with pride. It is now permanently housed in its own buildings on a site which provides pleasant working conditions. It has recruited a large, well qualified and enthusiastic staff. This rapid progress is due mainly to the unanimous support and collaboration of the industrial and government organizations involved. Significant contributions to the technology of the industry are being made, and the institute is established on the international scene. However, both individual scientists and PORIM are more interested in the future. They are confident of making continued contributions to the production and use of basic foodstuff which is economical for the world population and of major economic importance to Malaysia.