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Food research and development in South East Asia

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The CSIRO Division of Food Research recognizes an obligation to share its accumulated knowledge and experience in food science and technology with the nations that are neighbours to Australia.

The Division has established particular relations with Indonesia, Malaysia, the Philippines, Singapore and Thailand, which are the member nations of the Association of South East Asian Nations (ASEAN), where it is involved in a number of projects funded by the ASEAN-Australia Economic Cooperation Program through the Australian Development Assistance Bureau (ADAB). An officer of the Division, Dr R. A. Buchanan, has been seconded to serve as Australian Scientific Liaison Officer for the Protein Project, the Food Handling Project, and the Food Waste Materials Project. In addition, the Division has close contacts with Bhutan, Sri Lanka and Papua New Guinea.

During 1980, three senior officers of the Division, as part of general overseas visits, made independent visits to the ASEAN and neighbouring countries, in order to initiate and renew contacts with institutes and laboratories where there were research programs in Food Science and Technology. When research workers from these countries are accepted into the Division for training, it is important that the Division should know something of the background of problems and resources in the trainee's home country. Further, it has become apparent that when these young ASEAN research workers return to their countries they benefit greatly from regular follow-up visits by more experienced scientists.

In the countries that were visited, as in Australia, food-related research is undertaken in government laboratories with a specific mission, in laboratories associated with Departments of Agriculture, in university laboratories and, to a minor extent so far, in the food industry.

Only the laboratories recently visited are described in this article, and it is hoped that in the future the Division will be able to widen its contacts to a number of food research laboratories in South East Asia that are not mentioned.

Indonesia

The Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia, LIPI) is a government research organisation broadly analogous to CSIRO, which carries out its functions through a number of institutes. One of these is the National Institute of Chemistry (Lembaga Kimia Nasional, LKN) within which the research programs are almost entirely concerned with food.

LKN shares a LIPI campus (full addresses are given in the Appendix) with several other national institutes in the city of Bandung which is in Western Java about 30 minutes flight from Jakarta and at an elevation of about 750 m. so that it enjoys a fairly equable climate. It is likely however that in the next 5–10 years LKN together with other institutes will be moved to a LIPI research centre at Serpong closer to Jakarta.

The Director of LKN is Ir. I. Suharto who holds the Graduate Diploma in Food Technology from the University of New South Wales; a number of the other professional staff have also had postgraduate training in Australia.

Mr Suharto is Leader of the ASEAN Protein Project and LKN has a number of research programs within the framework of

this Project and also the ASEAN Food Waste Materials Project.

The Institute is organized in three Divisions:

- Analysis, where automatic amino acid and atomic absorption analyses are being applied to Indonesian foods
- Applied Microbiology, where the programs are concerned particularly with low-cost fermented protein foods peculiar to Indonesia, such as *tempe* from soybeans and *oncom* from peanuts, and with biogas from cassava processing wastes
- Chemical Engineering, where there are projects on dehydration, including solar drying, extrusion technology, and membrane technology for treatment of wastes.

An interesting recent development is the establishment by Presidential Decree of 'field stations for rural people's food processing' through which LKN researchers will pass on information about improved procedures for indigenous foods.

Research in Indonesia on postharvest handling and storage is undertaken by the Agency for Agricultural Research and Development (AARD) of the Ministry for Agriculture, which maintains Horticultural Research Institutes for fruit at Pasarminggu, a suburb of Jakarta, and for vegetables at Lembang, near Bandung. In the 1960s Australia provided controlled temperature rooms and some fruit and vegetable processing equipment for the Pasarminggu laboratories. Currently research programs are being supported by the ASEAN Food Handling Project at Pasarminggu and at Medan in North Sumatra.

Three university laboratories in Indonesia are participating in the ASEAN Protein Project: Institut Technologi Bandung (ITB), Faculty of Technology (Professor Oei Ban Liang); Universitas Gadjah Mada (UGM), Jogjakarta, Faculties of Engineering (Professor Winoto Martoadiprawito) and Agriculture (Dr Kamariani); and Institut Pertanian Bogor (IPB), Faculty of Agricultural Products Technology (Prof. F. G. Winarno). A new facility, the Food Technology Development Centre, has been established at the IPB with a brief to develop village-scale processes and equipment for food preservation.

Malaysia

The Agricultural University (Universiti Pertanian Malaysia, UPM) established a Department of Food Science and Technology in 1976. This Department offers a 4-year course leading to the degree of Bachelor of Food Science and Technology, and also postgraduate degrees in the fields of Food Chemistry and Biochemistry, Food Microbiology, Food Processing and Preservation and Food Engineering.

To celebrate the graduation of the first batch (21) of students at the UPM convocation on 6 September 1980, the Department organized a highly successful symposium on Food Technology in Developing Countries which was attended by 200 delegates from 30 countries.

The Head of the Department of Food Science and Technology is Mrs Asiah M. Zain, and she is supported by 17 academic staff who, in addition to teaching duties, conduct and supervise research with emphasis on relevance to national needs in such areas as:

- Low-cost high protein foods from fish and legumes
- Utilization and nutritive value of indigenous foods
- Improved processing of traditional foods
- Solar energy for drying and fermentation processes
- Microbiology of fish, meat and poultry.

UPM is located at Serdang, Selangor, about 30 km from Kuala Lumpur on a 1200-h campus which includes rubber, oil palm, and fruit plantations, farm units producing poultry, eggs, milk, beef, and fish, and pasture land. A spacious and handsome new building on this campus to house the Department of Food Science and Technology was occupied in 1981.

Adjacent to the UPM campus at Serdang is the Malaysian Agricultural Research and Development Institute (MARDI) (see Fig. 1.) of which the Director General is Dato Mohd Tamin bin Yeop. The research functions of MARDI are carried out through a series of Divisions concerned with agricultural production, and also an Agricultural Products Utilization (APU) Division of which the Director is En. Mohd Hashim Hassan. Food investigations make up a major part of the research programs in APU, but there are also programs concerned with non-food products such as tobacco.

APU has substantial laboratories based on a nucleus originally provided by FAO, and

Fig. 1. Malaysian Agricultural Research and Development Institute, Agricultural Products Utilization Division, Serdang, Selangor, Malaysia.

they are well equipped with a pilot plant for food processing and advanced facilities for food analysis. In October 1980, Mr Reg Adams and Mr Glenn Ford of the Food Research Laboratory conducted a 2-week course at APU on instrumentation techniques in gas chromatography and high performance liquid chromatography.

Research programs under the ASEAN Protein Project and Food Handling Project are being undertaken at APU on food legumes, traditional fermented foods such as soy sauce and belacan (prawn paste), and the handling, storage and processing of fruits and vegetables. Other investigations are directed towards assisting the important indigenous industries processing prawns, cocoa, coffee, coconut, and essential oils and spices.

In addition to the main laboratories in Serdang, APU operates several research stations strategically located for research on specific commodities, e.g., for fish processing at Kuala Trengganu, for rice processing at Alor Setar, and for fruit and vegetable processing at Tampoi.

The major plant crops in Malaysia, rubber and oil palm, are served by their own research institutes. The Rubber Research Institute has been in existence for many years and provides acknowledged world leadership in this field. The Palm Oil Research Institute of Malaysia (PORIM) was established in 1979 in temporary quarters in Kuala Lumpur but will later move to new laboratories at Bangi just outside the capital. The Director-General is Tan Sri Datuk Dr Anuwar bin Mahmud and the institute is comprised of five divisions each headed by a Director: Administration and Finance, Biology, Techno-Economic and Information, Chemistry and Technology, End-Use and Technical Advisory. Recently, Dr R. E. Timms, DRL, spent two months at PORIM working in the last two divisions. Standards for foods, and other products, are the responsibility of the Standards and Industrial Research Institute of Malaysia (SIRIM).

The University of Science (Universiti Sains Malaysia, USM) is located on the island of Penang where it occupies the attractive Minden campus formerly the site of British Army barracks. This University has a School of Applied Sciences with five specialisations: Polymers, Minerals, Electronics, Computers, and Food Science and Technology. The Food Science and Technology specialist course has a professional staff of six under the leadership of Associate Professor Lim Chin Lam who was a visiting worker in the CSIRO Food Research Laboratory in 1980, while one of

the lecturers, Dr Seow Chee Choon, spent a sabbatical period in FRL from March to September 1981.

The Food Science and Technology laboratories in a new Applied Sciences building are well equipped with instrumental and pilot plant facilities, and the library and information services on the USM campus are outstanding. Areas of active research in the sub-department include the composition and properties, e.g. water relations, of indigenous Malaysian foods, the extraction of carotenoids from palm oil, and disposal of effluents from palm oil processing.

Singapore

Food investigations are included in the programs of the Singapore Institute of Standards and Industrial Research which is an organization strongly oriented towards research and development of immediate relevance to Singapore's special needs as a nation without natural resources, dependent upon importing raw materials and adding value, especially technological value, for export. The Chairman of SISIR, Dr Lee Kum Tatt, expressed interest in assisting Australian companies who wished to enter into joint ventures with Singapore companies using Australian raw materials to make foods for Asian markets.

SISIR receives some government funding but it is expected to maintain itself by contract research and development, of which one example is the supply of standard microbial cultures to soy sauce manufacturers. Food research and development projects are directed by Mrs Soon-Ong, M.W., a graduate in Food Technology from the University of Reading. A project on flexible film packaging has recently commenced under Dr Lien Wen Sze who visited Australia for training in this area at the Food Research Laboratory and at Kraft Foods.

In addition to research and development programs, particularly engineering development, SISIR is involved in the writing of standards for manufactured products, and awards a Mark of Approval to products, including foods, which meet its standards.

The laboratories of SISIR in River Valley Road are congested but well equipped with instrumentation and a pilot plant. Facilities include an experimental kitchen for food product development. SISIR expects to be relocated in due course in the Science and Technology Park that is being developed adjacent to the new campus of the National University of Singapore at Kent Ridge.

Research facilities in postharvest horticulture have recently been set up in Singapore at the Sembawang Field Station of the Department of Primary Production under the Ministry of National Development. Here, Australian funds allocated by the ASEAN Food Handling Project have provided four controlled temperature rooms, very well designed and maintained, and ancillary laboratory space and equipment. Under the direction of Dr Leong Poo Chow, research is in progress on the handling and storage of fresh fruits, particularly mangoes and rambutans, and vegetables. Singapore imports most of its requirements of fruits and vegetables from Malaysia and Thailand, and some of this produce is exported after processing. In cooperation with Indonesian postharvest workers and Associate Professor R. B. H. Wills (University of New South Wales) experimental shipments of cabbages have been made from North Sumatra.

Education in Food Technology is available in Singapore only at the Singapore Polytechnic which occupies an impressive new campus in Dover Road with colourful modernistic concrete buildings. The Division of Chemical Process Technology (Headed by Mr Poh Hee Seng) offers a 3-year, full time course, or a 5-year, part time day release course, in Food Technology.

Thailand

Since 1966 a Food Science and Technology Training Program has been available at Kasetsart University in the Faculty of Agriculture on the Bangkhen campus near Bangkok International Airport. In 1980 a Faculty of Agro-Industry was established, made up of four departments: Food Science and Technology (Professor Narudom Boonlong), Packaging Technology, Product Development, and Biotechnology.

Within Kasetsart University, as an autonomous body, is the Institute of Food Research and Product Development (IFRPD) which was originally set up 25 years ago under the Ministry of Defence. The Director, Professor Amara Bhumiratana, spent a year of research experience in the Division of Food Research in the 1950s. He is supported by a staff of approximately 200,

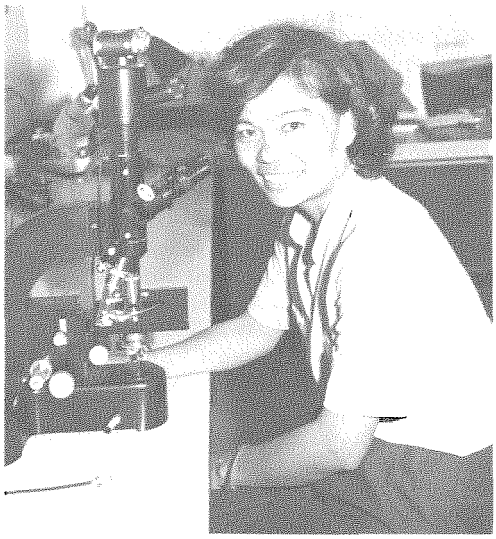

Fig. 2. Mrs Sing Ching Tongdee, visiting worker at FRL from the Thailand Institute for Scientific and Industrial Research.

including 40 professional officers.
The purpose of the Institute is to do research contributing to the welfare of the food industry in Thailand and the nutritional status of the Thai people. Particular attention is devoted to improving the nutritive value of foods by supplementation and fortification. Thus in addition to chemical and microbiological laboratories and an animal house for nutritional studies, IFRPD has a plant for the production of a number of processed foods in quantities sufficient for distribution in school lunches and other institutional feeding programs. Such foods include Kaset infant food, based on indigenous raw materials, biscuits, snack foods and rice noodles incorporating proteins from soy bean, mung bean, and fish.

In the Horticulture Department (Chairman, Professor Suraphong Kosiyachinda) of Kasetsart University, the ASEAN Food Handling Project has provided a small laboratory with controlled temperature facilities for postharvest studies, presently on mangoes and rambutans.

Adjacent to the Bangkhen campus of Kasetsart University is the Thailand Institute of Scientific and Technological Research (TISTR), an organization broadly modelled on CSIRO when Mr F. G. Nicholls, a former officer, assisted in its establishment about 20 years ago. The Governor is Dr Smith Kampempool, and he controls eight Divisions covering different fields of technology. The Division of Agricultural Products Development, directed by Mrs Pivan Varangoon, includes in its research programs many concerned with food, in such areas as vegetable and coconut oils, food microbiology, winged bean processing, and extraction of papain. Research is also in progress on the postharvest handling of fruits and vegetables and is receiving some support from the ASEAN Food Handling Project. Mrs Sing Ching Tongdee (Fig. 2.) from TISTR recently spent a training period in the Plant Physiology Group at FRL under a fellowship from the International Development Research Centre, Canada.

The Division has well-equipped laboratories in an Industrial Research Building funded by UNIDO, and a useful range of pilot plant equipment largely provided from the ASEAN Protein Project.

The Philippines

The Division's involvement with food research and development in the Philippines has been largely confined to the University of the Philippines, College of Agriculture, at Los Baños (UPLB).

Following a visit to the ASEAN countries by Mr E. G. Hall (FRL, retired) and Mr D. Lyons of the National Materials Handling Bureau, the ASEAN Food Handling Project provided funds for a Postharvest Horticulture Training and Research Centre (PHTRC) at UPLB (see Fig. 3). It was built in 1977 to a design prepared by an Australian Steering Committee and commissioned by Dr W. B. McGlasson and the late Mr M. Franklin of FRL.

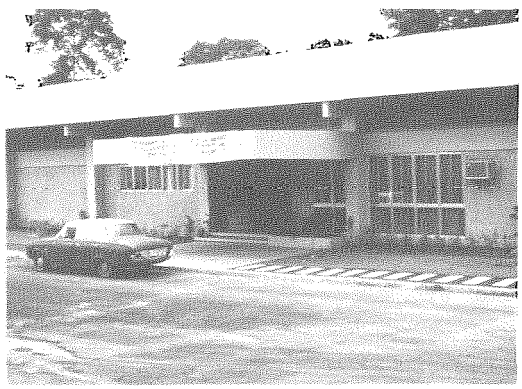

Fig. 3. Postharvest Training and Research Centre, University of the Philippines at Los Baños.

The Director is Associate Professor Er. B. Pantastico who is assisted by Dr D. B. Mendoza as Head of Research and Dr O. Bautista as Head of Training. It comprises teaching and research facilities, including cold-rooms and an experimental packing shed. Initially, the major role has been in training graduates in the postharvest technology of fruits and vegetables, and some 60 ASEAN nationals have graduated from its courses. Emphasis is now being placed on the research role since there are many avenues for new research in the relatively untouched field of postharvest physiology and technology of tropical fruits and vegetables in which scientists from all the ASEAN countries, and Australia also, might profitably collaborate.

Bhutan

To many Australians Bhutan is an unknown country, yet Australia is the second largest aid contributor to that country. ADAB is funding an aid project on postharvest handling of fruit and vegetables, for which CSIRO Food Research Laboratory is the operating agency and its Officer-in-Charge, Dr A. R. Johnson, is the Project Manager.

Bhutan is a small landlocked country, the size of Tasmania, with a population of about 1.4 million people. It is sandwiched between Tibet to the north, and India to the south. The Bhutanese have many local dialects but the common national language is Dzongka. They are a very religious people adhering to Mahayana Buddhism. Bhutan is a monarchy and King Jigme Singye Wangchuk has followed the tradition of his father by encouraging Bhutan to adopt modern technology. Bhutan has a subsistence economy with more than 90% of the workforce involved in agriculture.

The fourth 5-year plan of the Royal Government of Bhutan has given emphasis to the production of cash crops by both extensive and intensive cultivation (see Fig. 4). The marketing of the agricultural surplus is organised by the Food Corporation of Bhutan, a government enterprise under its Managing Director, Mr Hardi Ali. The main cash crops with the marketable surplus in tonnes are: potatoes (15 000), apples (2000), oranges (8000), and ginger (1000). About 75% of the potatoes are grown in Western Bhutan and enter the Indian market from Phuntsholing, the southern border town with

Fig. 4. Terraced cultivation around a village in Bhutan.

India. Transport of the potatoes for long distances over mountainous roads and at high temperatures, together with the lack of cool storage facilities at Phuntsholing, results in considerable deterioration and wastage with consequent loss of produce and profits.

The aid project resulted from a request in 1974 by the Bhutanese Government for an Australian to undertake a feasibility study to develop the horticultural industry. Mr E. G. Hall, then in charge of the Fruit Storage Section at FRL but now retired, spent one week in Bhutan in 1974 and prepared a report on which the aid program has subsequently been based. Subsequent visits by Mr Hall, Mr G. B. Morgan (Assistant to the Engineer), Dr W. B. McGlasson (postharvest horticulturist), and Dr A. R. Johnson resulted in the implementation of the first phase of the project which commenced in April 1979 and cost approximately $390 000. This phase included the training of five Bhutanese in Australia, and the purchase and delivery of equipment including forklift trucks, and instrumentation and accessories to construct small cool stores.

The five Bhutanese trainees spent 12 months in Australia based at FRL and, through the goodwill and considerable help of many people in Australia, commercial firms and State Departments of Agriculture, returned to Bhutan experienced in various aspects of the handling of fruit and vegetables. Mr Roop Narayan Sharma and Mr Kezang Thinley are now postharvest extension officers, and Mr Sherub Gyaltshen is an agricultural engineer with experience in refrigeration systems, cool store design and the operation of refrigerated transport vehicles and packing house machinery. These three are officers of the Department of Agriculture under the Director, Dasho Pema Wangchuk. Mr Zeko Dorji is a marketing officer with experience in the handling of perishables, and Mr Kezang Namjey is the technical cool store manager, both with the Food Corporation of Bhutan at Phuntsholing.

Phase II of the project, which is about to commence, is the establishment of a 1000-tonne cold store complex at Phuntsholing which will be used for the storage of potatoes, for the marketing of apples and oranges as their production increases, and for the storage of imported fish, meat, and dairy products.

In addition to the Food Corporation of Bhutan's operation at Phuntsholing, there is a canning industry at Samchi in Eastern Bhutan and a small food processing operation at Bondey Farm in the centre of Bhutan. The Farm is also responsible for the production of seed material for distribution to farmers and for extension work. The main canned products are jams, asparagus, and fruit juices.

Sri Lanka

The Ceylon Institute of Scientific and Industrial Research (CISIR) was set up in 1955 to serve industry by providing research and development, training, analytical, quality control, and information services. The Director, Mr Mervyn Wijeratne, a rubber scientist, and Deputy Director Mr E. E. JeyaRaj, an applied microbiologist, lead a research staff of 75 together with ancillary workers. Food-related research is conducted in a number of the sections of the Institute:

- Food Technology: dehydrated foods, low cost infant foods, composite flours for bread, and coconut and manioc (cassava) products
- Industrial Microbiology: microbiology of food spoilage, fermented foods, and industrial enzymes
- Fats and oils: indigenous vegetable and fish oils
- Agro-Industries: tea, natural food colours, and waste disposal
- Natural Products: essential oils and spices; Sri Lanka produces 90% of the world's cinnamon. A strong team working on essential oils is led by Dr E. R. Jansz and includes Dr U. M. Senanayake, who carried out his postgraduate work at the University of New South Wales.

Particular attention is paid to raising the levels of quality and efficiency in village industries by the use of simple equipment.

A private autonomous research foundation, the Marga Institute, has been established in Sri Lanka, with support from the Ford Foundation. It is a member institute of the International Federation of Institutes of Advanced Studies, and has a staff of 120 together with a changing group of attached consultants. The Marga Institute has in the past undertaken mainly socio-economic development studies but has recently created a Science and Technology Division in the

charge of Mr L. A. C. Alles, a food technologist who acquired early experience as a Colombo Plan Fellow in the Division of Food Research in 1952–53. Subsequently he set up the Government Canning Factory in Colombo as a production and research development unit, and was responsible for instituting a fruit processing industry in Sri Lanka notably for passionfruit but also for mango, guava, and less-known fruits such as wood apple and beli.

The Department of Agriculture in Sri Lanka, under the Ministry of Agricultural Development and Research, maintains a Central Agricultural Research Institute at Peradeniya near Kandy about 120 km from Colombo. Within this Institute, the Sri Lankan Soya Bean Development Program has set up a pilot soya bean processing plant. In an attractively renovated 100-year old building a wide range of equipment is available for diversified food processing, under the capable management of Mr W. B. Wijeratne who is a graduate of the M.Sc. course at the International Food Technology Training Centre, University of Mysore.

Papua New Guinea

Among the countries discussed in this article, Papua New Guinea is particularly deserving of future aid. The other countries have a core of their own nationals trained both at home and overseas as technicians and researchers, but this is not the case in Papua New Guinea. Although they have several overseas experts in various areas related to food and agriculture, Papua New Guinea lacks the infrastructure for the highly specialized training which is required, and there are few nationals with any training in food technology. The reasons for this are partly the lack of facilities, but also the lack of tradition in any form of food processing. All staple foods are either eaten raw or simply cooked. Because of the ready availability of foodstuffs in the past, stored and fermented foods have not been utilized, as they have in many Asian countries. It is Government policy to make Papua New Guinea largely self-sufficient in its food needs. To achieve this, the need for increased local food production is recognized and a majority of the Department of Primary Industry programs have this aim. An increased volume of production of fresh produce for urban population necessitates the application of postharvest handling methods which minimize wastage, ensure maintenance of quality, and are economical.

The Government is also encouraging the development of food processing industries as the processing of local raw materials for food would reduce the need to import foods, stimulate local agriculture and fisheries, and raise the nutritional status of the people.

The Government is attempting to rectify the shortage of locally trained nationals by establishing in the Papua New Guinea University of Technology at Lae, a Department of Chemical Technology which includes a 4- or 5-year course in food technology. A joint research unit in food technology has been set up embracing university staff and research students and some staff from the Department of Primary Industry. The Head of the Department is Professor D. F. Stewart who is an Australian and he is supported by Dr M. R. Baqar who did his postgraduate work in food technology at the University of New South Wales.

The Division of Food Research is assisting Papua New Guinea to develop its food industry in two ways. There is a collaborative research program between Dr A. K. Sharp of FRL and Mr J. van S. Greve of the Department of Primary Industry on the shipment of cocoa and coffee in intermodal containers (Fig. 5).*

In 1979, the Government of Papua New Guinea invited Australia to send a team to investigate the postharvest handling of fruits and vegetables and to make recommendations to the Minister for Primary Industry. The team consisted of Dr W. B. McGlasson and Mr G. R. Chaplin of FRL, and Dr B. S. Harrap of the CSIRO Centre for International Research Cooperation. Their major conclusion was that 'a severe shortage of skilled and experienced manpower at all levels of food production through to the postharvest handling systems is a major factor limiting the Government's efforts towards self-sufficiency in food.' The Department of Primary Industry has appointed Sister Mary Drum, a graduate of the Royal Melbourne Institute of Technology, as a food technologist, and established a small postharvest laboratory at Port Moresby.

*Information about this project is available in *CSIRO Food Research Report* No. 148. The transport of cocoa and coffee in freight containers. A. K. Sharp and J. van S. Greve, March 1981.

Fig. 5. Mr J. van S. Greve with an experimental shipment of cocoa beans from Papua New Guinea.

Sister Drum recently spent four weeks undergoing training at FRL. The Department of Primary Industry has also appointed Mr G. Thomas, a food technologist from the United Kingdom, and located him with the Department of Chemical Technology at Lae. Plans have been drawn up and funds are available for the construction of a pilot plant which would be used for research, for training undergraduates from the university, and as a demonstration plant for the food industry. There is active collaboration between this unit and the university department.

Professional Associations

Vigorous professional associations in food science and technology can contribute greatly to the technical and economic welfare of the food industry. It is encouraging therefore to report that professional associations are actively functioning in several of the Asian countries visited: the Malaysian Institute of Food Technology (MIFT), the Philippine Association of Food Technologists (PAFT), the Singapore Institute of Food Science and Technology (SIFST), and in Indonesia two societies — the Indonesian Association of Food Technologists and the Indonesian Association of Nutritionists and Food Technologists.

In 1982 (16–20 May) there will be held in Singapore, *Food Conference 1982*, a major international food conference that is being organized jointly by MIFT, SIFST, and AIFST (the Australian Institute of Food Science and Technology). Invited speakers from at least ten countries will focus on food commodities which are of interest to both Australia and South East Asia and are traded internationally. Details may be obtained from the Conference Secretariat, Singapore Professional Center, Block 23, 129-B, Outram Park, Singapore 0316 or, in Australia, by telephoning Mr David Vernon on (03) 51 8721.

Appendix — Addresses

Indonesia

Lembaga Kimia Nasional (LKN, National Institute of Chemistry),
LIPI Kompleks,
Jalan Cisitu, Sangkuriang,
Bandung, Indonesia.

Institut Technologi Bandung (ITB),
Faculty of Technology,
Ganesha 10, Bandung, Indonesia.

Institut Pertanian Bogor (IPB),
Faculty of Agricultural Products Technology (FATEMETA).
Jalan Gunung Gede, Bogor, Indonesia.

Food Technology Development Center (FTDC),
P.O. Box 61, Bogor, Indonesia.

Universitas Gadjah Mada,
Department of Chemical Engineering,
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Department of Horticulture,
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Malaysia

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Ministry of National Development,
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Field Station, Sembawang.

Singapore Polytechnic,
Division of Chemical Process Technology,
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Department of Primary Industry,
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Thailand Institute of Scientific and
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196 Phahonyothin Road,
Bangkhen, Bangkok 9, Thailand.

The Philippines

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(UPLB),
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College, Laguna, The Philippines.
(ASEAN Postharvest Horticulture
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(PHTRC),
and Department of Food Science and
Technology).

Sri Lanka

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(P.O. Box 787),
Colombo 7, Sri Lanka.

Marga Institute,
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Colombo, Sri Lanka.

Sri Lanka Soyabean Development
Program,
Central Agricultural Research Institute,
Gannoruwa, Peradeniya, Sri Lanka.

Bhutan

Food Corporation of Bhutan,
Thimphu, Bhutan.

Postharvest storage and handling of sweet potatoes

By S. C. Morris

Horticultural Postharvest Laboratory, N.S.W. Department of Agriculture, Gosford.

Sweet potatoes (*Ipomea batatas* (L.) Lam.) are thought to have originated in the tropical regions of South America (Cooley 1951) and in their natural habitat presented no storage or handling problems, being simply dug as required. Because this crop is sensitive to chilling, year-round production in temperate regions is not possible. This may necessitate storage of up to nine months.

Introduction

To achieve long storage, careful handling and storage are necessary. The main requirements for successful storage of sweet potatoes are gentle harvesting, followed by holding at high temperature and high humidity to allow healing of damaged skin (curing) and then storage at temperatures above 12 °C. These requirements have been determined by trial and error in New Zealand, where, in association with elaborate religious ceremonies, for many centuries the Maoris have successfully stored potatoes (Cooley 1951). The importance of curing was also appreciated by Spanish explorers of the 16th Century, who brought the sweet potato to Europe more than half a century before the common potato (Cooley 1951).

Handling

For correct postharvest handling, the first aim should be to avoid damaging the roots. Such damage results in the removal of the protective skin, but allowing the potatoes to cure leads to natural healing of injuries. Although the optimum environmental conditions necessary for curing and its physiology are well known, correct curing of sweet potatoes often is still not carried out.

Curing conditions

Curing results in the formation of a protective layer of periderm over areas of broken skin (Fig. 1). This acts as a barrier to prevent fungal infection. Curing also reduces skin permeability, resulting in lower weight

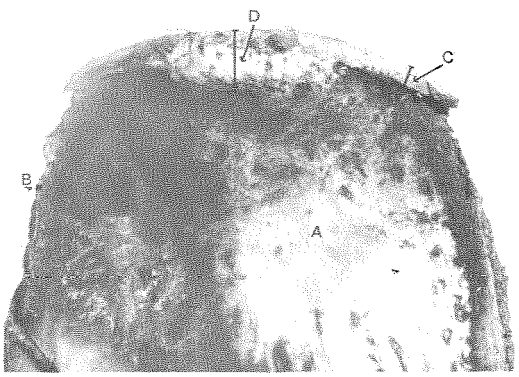

Fig. 1. Formation of wound periderm in sweet potatoes. (A) Cross section of cured sweet potato (the end was broken off during harvest) (B) Normal skin thickness. (C) Layer of wound periderm over wounded end of the root. (D) Greatly thickened wound periderm due to additional wounding.

loss during storage (Kushman and Pope 1972). The formation of periderm occurs within the temperature range of 15–37 °C with an optimum at 33 °C; below 25 °C the process is slow (Kushman and Deonier 1958; Tereshkovich and Newson 1964). Periderm formation is also affected by humidity, with optimum formation above 85% R.H. and much slower formation at lower humidities. The duration of curing is also important; good disease control has been reported with curing periods as short as four days (McCombs and Pope 1958), although some authors recommend 10–14 days (Cooley and Kushman 1951). The optimum curing conditions would seem to be 30–33 °C and 85–95% R.H. for 5–7 days (Kushman and Pope 1972).

Handling and environmental effects

Adverse conditions at harvest such as cold wet soils, often experienced with late season crops, can cause increased postharvest rotting of sweet potatoes (Kushman and Deonier 1958). Increased rotting may also be caused by exposure to chilling temperatures (<10 °C) for only a few hours (McClure 1959; Neilsen and Johnson 1974). The greater breakdown under these conditions is due to a reduced rate of periderm formation, allowing fungal infection into the unprotected flesh.

Exposure to excessively high temperatures can also result in increased breakdown. This especially occurs when the roots are left in the hot sun after harvest.

Large losses are experienced when tubers are injured by rough handling during harvest. Gentler handling, such as by eliminating brushes from packing lines, can greatly improve the storage life of roots (Paterson *et al.* 1967).

During packing after removal from storage, the roots are unavoidably bruised and the skin broken, providing a further opportunity for fungal infection. It has been shown that infection is prevented by another two days curing at 30 °C and 85–95% R.H. during transit to market (Tereshkovich and Newson 1964). Hydrowarming by washing or dipping in water at 46 °C for 15 minutes shortens the required re-curing period and increases its effectiveness (McClure 1959).

Storage

For long storage, the cured roots should be held under carefully controlled conditions. Short exposures to temperatures of 10 °C or less may cause chilling injury. Symptoms are internal breakdown, development of 'off' flavours and greatly increased rotting (Daines 1970). Chilling can also result in 'hardcore', which appears after cooking as hardened areas in the centre of roots (Buescher 1977). The severity of hardcore increases with the duration of exposure to chilling temperature (Daines *et al.* 1976).

Freshly harvested roots may recover from hardcore after two weeks or more at non-chilling temperatures, while roots stored for several months do not (Daines *et al.* 1976). Curing can increase the susceptibility of roots to hardcore, while ethylene can cause a decrease in the size of the affected area (Buescher 1977). Susceptibility among cultivars varies widely (Buescher 1977).

Storing at too high a temperature results in excessive dehydration and sprouting. At high temperatures the development of pithiness or internal cavities in the stored roots may also be a problem. Originally this was thought to be due to a virus (Kushman and Deonier 1952), but it has not been confirmed (Kushman and Pope 1972). The severity of pithiness has been correlated with a high percentage of intercellular spaces in the roots at harvest and with increased storage time and increased temperatures above 15 °C (Kushman and Pope 1972). Cultivars differ widely in susceptibility to pithiness (Kushman and Pope 1972).

The best storage temperatures are 13–16 °C. These temperatures are high enough to avoid chilling injury, but low enough to prevent excessive weight loss, sprouting and development of pithiness.

Pathogens

Postharvest breakdown is caused by a range of organisms. The relative importance of the major pathogens can differ considerably between different localities and with time of year. In the U.S.A. the two most important diseases have been found to be soft rot (*Rhizopus stolonifera*) and black rot (*Ceratocystis fimbriata*), while surface rot (*Fusarium oxysporum*) is also of major importance. Other diseases occasionally causing large postharvest losses are scurf (*Monilochaetes infuscans*), dry rot (*Diaporthe theobromae*) and charcoal rot (*Macrophomina phaseoli*) (Elmer 1960; USDA 1971).

In Australia, the major postharvest pathogens are *Diaporthe phaseolum* (dry rot), *Pythium ultimum* (pythium rot), *Fusarium* spp (surface rot) and *Rhizopus* spp (soft rot) (Morris 1978*b*). Both *Monilochaetes infuscans* (scurf) and *Botryodiplodia theobromae* (Java black rot) also occur as minor pathogens. Several regional differences occur; thus *Pythium ultimum* causes major losses in eastern Australia, but has not been detected in Western Australia; while *Monilochaetes infuscans* has caused some major losses in Western Australia, but is only a minor pathogen in eastern Australia (Morris 1978*b*). The major differences between the reported pathogens in the United States and Australia (the only countries for which adequate information is available) are that black rot (*Ceratocystis fimbriata*), a major rot in the U.S.A., is not found in Australia and *Pythium* rot, a major rot in Australia, is not found in the U.S.A.

Pathogen control

The control of postharvest pathogens depends firstly on using the natural defence mechanism of periderm formation and suberization. Further postharvest treatments are necessary if more than a few days elapse between harvest and sale. A number of postharvest treatments have been investigated with the aim of controlling specific pathogens, but none is capable of controlling all major pathogens.

Postharvest treatments

Soft rot. — Curing both before and after storage is effective in reducing soft rot (McClure 1959). It was controlled by dichloran dips at 500–1000 ppm (Welch *et al.* 1966; Paterson *et al.* 1967); SOPP (sodium-ortho-phenylphenate) at 0.5 to 1% also gave good control but can be phytotoxic (Welch *et al.* 1966; Paterson *et al.* 1967).

Black rot. — Black rot is reduced by normal curing, although better control is possible by pasteurizing the roots at 48 °C for 16 hours, 45 °C for 24 hours or curing at 35 °C (Cooley and Kushman 1951). However, it is not advisable to cure for too long at 35 °C as weight losses, sprouting and losses due to other rots may be increased (Kushman 1973). Dipping in TBZ (thiabendazole) and benomyl for one minute, especially in hot water at 43–53 °C, controlled black rot (Daines 1971), but hot water dips alone may also give control (Neilsen 1977).

Surface rot. — This is exacerbated by cold conditions or exposure of the roots to long periods in the hot sun and is partially controlled by captan (2500 ppm) and SOPP (10 000 ppm) (Neilsen 1969).

Scurf. — As well as being an important postharvest disorder, scurf affects the establishment of young plants. Much of the economically important damage is done in the field, therefore it is important to plant only roots free from infection (Wood 1976). Almost total control of this pathogen can be achieved by a 15-minute dip at 40 °C in ferbam (6000 ppm) and captan (12 000 ppm) (Daines 1970). Dipping in benomyl or TBZ for 1–5 minutes at temperatures of 50–60 °C (Daines 1972), or hot water (50–54 °C) for 2 minutes (Neilsen 1977) can also control scurf.

Java Black Rot. — This can be controlled (along with soft rot) by SOPP and dichloran (Paterson *et al.* 1967).

Cultivar resistance

Selection of cultivars for genetic resistance to pathogens can also provide a useful and inexpensive way of avoiding postharvest spoilage. Generally, information about cultivar resistance is based only on casual observations and is available mainly for older cultivars, which are tending to lose popularity. Of the more important modern cultivars, information is available only for Centennial, Goldrush and Nemagold. Centennial and Goldrush are reported to store well, while Nemagold is more susceptible to postharvest pathogens (USDA 1971). All these varieties are susceptible to black rot, with Nemagold having slight resistance to soft rot (USDA 1971). Centennial and Goldrush have some resistance to surface rot, although the literature is somewhat contradictory (Neilsen 1969; Neilsen and Johnson 1974).

The keeping quality of several cultivars has been studied recently in Australia (Morris 1978*a*; Morris and Huett 1979). The best cultivar by far was Jewel (Fig. 2). It had a very low incidence of soft rots (*Diaporthe phaseolum, Pythium* spp and *Rhizopus* spp) and surface rots (*Fusarium* spp and *Monilochaetes infuscans*). Redmar also kept well but was more susceptible to soft rots. Copperskin, Goldrush, White Maltese, Centennial and Nemagold were moderately resistant to postharvest rots, the latter two cultivars being more susceptible to surface rots. The most susceptible cultivar was Sweetgold (L8-92), which was especially susceptible to soft rots.

Conclusion

There is still a need for considerable postharvest research on sweet potatoes. The optimum storage and curing temperatures and the physiological processes involved have been defined and a considerable amount of information is available concerning control of individual postharvest pathogens. However, no postharvest treatment has yet

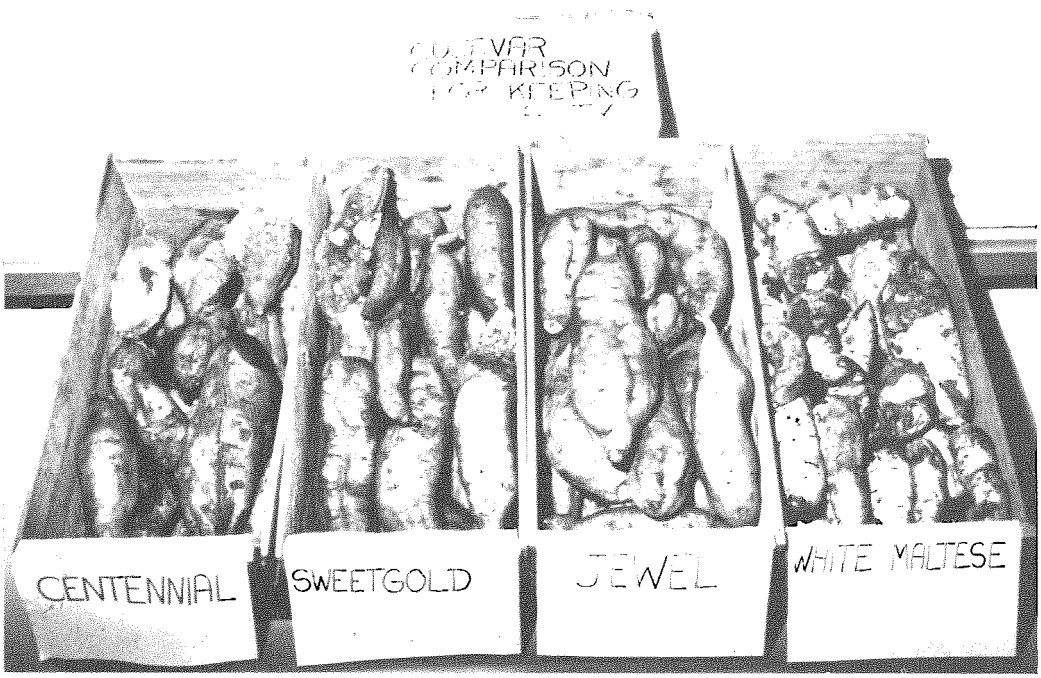

Fig. 2. Cultivar comparison for keeping quality. The roots were stored after harvest for 6 weeks at 20 °C.

been developed that is capable of controlling all major pathogens. Further work on this problem is required, especially since the actual pathogens and their relative importance may vary considerably between countries and even localities.

Postharvest breakdown can be greatly reduced by using genetically resistant cultivars (Morris and Huett 1979), but no accurate assessments of storage abilities have been published by sweet potato breeders, or in any assessment of sweet potato cultivars (USDA 1971; Wood 1976). The concentration on preharvest performance and yield is unfortunate because achieving a high yield is quite useless, if the crop is unmarketable owing to excessive postharvest breakdown.

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Protein functionality in fabricated foods

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Today, more than ever before, cost *and* convenience are important factors determining the acceptability of a particular food product in the market place. The demand for fabricated foods and, consequently, the range of such foods available is growing rapidly. Continuing growth will depend on manufacturers being able to obtain adequate supplies of ingredients having the required functionality at an affordable price.

Introduction

By 'fabricated food' is meant a product which has been manufactured from substantial proportions of ingredients from a variety of natural sources. 'Functionality' is here defined as 'the set of properties that contributes to the desired colour, flavour, texture and nutritive value of a product'. Although the inclusion of 'nutritive value' in this definition may be arguable, the extensive possibilities for the diminution of nutritive value during food fabrication justifies its inclusion.

A strong impetus to study functionality, particularly of proteins, has come recently from the need to utilize by-products from the processing of raw food materials in order to prevent waste and pollution and to minimize costs.

The objectives of studies of protein functionality in fabricated foods may be summarized:

- to find applications for proteins which are both abundant and nutritionally adequate
- to reduce the need for proteins used currently which are both expensive and in short supply
- to extend knowledge of the functional role of a particular protein in a fabricated food, the specific aspects of its composition and structure which determine that role and the interactions it makes with other ingredients in the formulation.

An approach to protein functionality elucidation

As fabricated foods are complex systems, their study necessitates examination of both the micro- and macro-states of each of the system's components individually before a detailed explanation of the properties of the whole food system is possible. In broad terms, the question 'what is the role of a certain protein in a fabricated food system?' is posed. More specifically this may be reduced to 'what are the specific elements of protein composition and structure which contribute to protein functionality?'. However, there is no direct solution to either of these questions; several indirect approaches must be made.

A thorough characterization of the protein is essential, but this can only be done after isolation and fractionation procedures have been established. In parallel, it is necessary to develop procedures for qualitative and quantitative analysis of the protein and its substructural elements.

Clearly, methods need to be established for functionality testing of the protein in a food system. The question is 'what food system?'. Examination of proteins in a simple system, for example, in aqueous solution or in an oil/water dispersion, may yield valuable information about the protein but little about its potential for interaction with other food components (Kinsella 1976). For example, the volume and stability of a foam generated in a protein solution may bear

little relation to the behaviour of the protein when included with fat, sucrose and stabilizers in a whipped dessert. While functionality data may be more significant when the protein is included in a model food system which closely resembles the final product, the number of components and the interactions between them make interpretation of results difficult (Harper *et al.* 1980).

To investigate the role of protein in such a system, a functional response must be defined in terms of a quantitatively measurable, significant parameter. Product formulation must be ascertained for optimized functional response or for optimum sensitivity to variation in protein quality or quantity. It is difficult to describe the experimental investigation except in terms of a specific example. Therefore some studies of functional properties of soy bean protein isolates that were undertaken in conjunction with Professor W. J. Harper at the Ohio State University, Department of Food Science and Nutrition will be used as an illustration. The series of steps involved in these studies is depicted in Fig. 1.

Protein isolation and fractionation

Soy bean protein was isolated from defatted flour by the traditional, commercial procedure of isoelectric precipitation of the protein from an aqueous extract, and also by an alternative method employing the extremely low solubility of soy bean protein in dilute calcium ion solution to precipitate the protein from the aqueous extract. The calcium precipitation procedure was almost as effective as precipitation at the isoelectric point (78% versus 83% respectively of the aqueous extractable nitrogen), and avoided treatment at low pH which was possibly detrimental to the functionality of the protein.

Both isolates were fractionated into the two major soy bean proteins, glycinin and conglycinin, by fractional precipitation under controlled conditions of pH, electrolyte concentration and temperature.

Protein characterization

To examine the quaternary structure and the composition of the two isolates and their subfractions, their sedimentation characteristics were observed in an analytical ultracentrifuge. Both isolates displayed the 15, 11, 7 and 2S peaks characteristic of soy bean protein isolate on the Schlieren optic profile; however, the proportion of 11S to 7S was increased after calcium precipitation, this being due to the higher solubility of conglycinin (7S) in dilute calcium solution.

None of the subfractions was pure, however, 'glycinin' (11S) fractions contained only little conglycinin whereas 'conglycinin' fractions were more heavily contaminated with glycinin.

To examine the subunit structure and

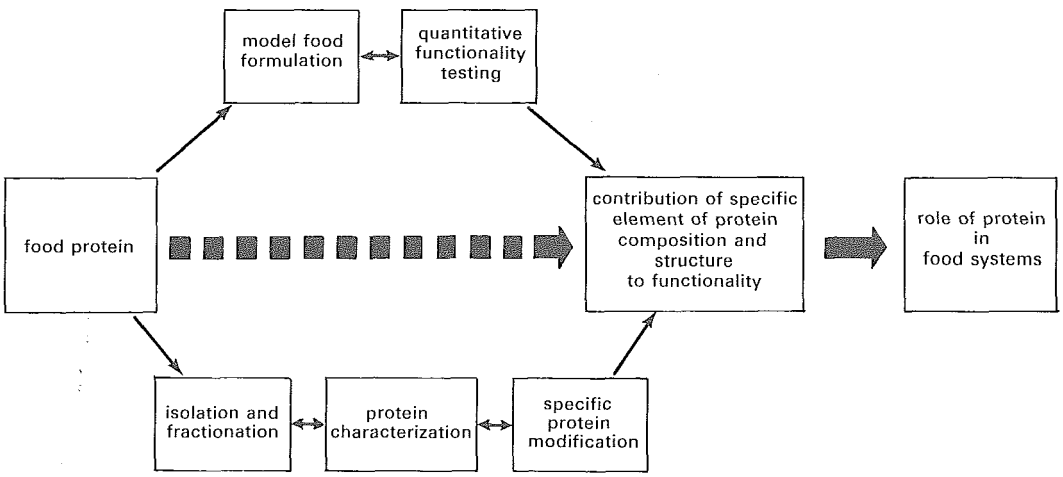

Fig. 1. Schematic depiction of an empirical approach to protein functionality elucidation.

molecular size characteristics of the isolates and subfractions, electrophoresis in polyacrylamide gel using sodium dodecyl sulphate (SDS) and urea as denaturants was employed. Glycinin subunits migrated principally as three bands exhibiting molecular weights of 37 000, 21 000 and 19 000 daltons. Conglycinin also migrated as three bands exhibiting molecular weights of 60 000, 80 000 and 90 000 daltons, considerably greater than previously published values (Thanh and Shibasaki, 1977) but recently confirmed (McDermott, 1980 — personal communication).

Quantitative functionality testing

To investigate the emulsifying ability of the soy bean protein isolates and their subfractions, liquid coffee whitener was selected as a model fabricated food system.

Emulsion stability may be assessed by, for example, observing the resistance to phase separation under accelerated conditions of centrifugation or repeated freeze/thaw cycles. However, if the emulsion is used as a coffee whitener the destabilizing conditions are more severe viz. high temperature ($\sim 90\,^{\circ}C$) and pH close to the isoelectric point of the protein. Consequently, an appropriate quantitative test was required.

Destabilization of the coffee whitener emulsion in hot coffee manifests itself in the appearance of a buoyant, lipid-protein aggregate called 'feathering'. A method was devised whereby the amount of aggregate could be measured as an indicator of the extent of emulsion destabilization (Pearce and Harper, 1981*a*). An aliquot of coffee whitener was added to hot coffee in a flask fitted with a graduated capillary tube at the top. After feathering, the aggregate on the surface of the coffee was compacted into the capillary and the length of compacted material measured.

Model food formulation

The liquid coffee whitener, selected as a model fabricated food system was formulated from hydrogenated coconut oil, corn syrup solids, dipotassium phosphate, soy bean protein, sodium stearoyl lactolate (SSL), mono- and di-glyceride (MDG), polysorbate (PS) and water. The first three were held constant to maintain the body, sweetness and pH. The ratio of MDG to PS was held constant to maintain hydrophilic/lipophilic balance (HLB). Because of the many variables in this system and the many possible interactions between them, the statistical technique known as Response Surface Methodology was applied in the design of the experiments, and the further technique known as Path of Steepest Ascent was applied to optimize the variables (Lah *et al.* 1980). Thus, the levels of three independent variables, soy bean protein, SSL and MDG/PS, with water as dependent variable, were examined in a Path of Steepest Ascent approach to determine the range of levels within which optimum sensitivity of the formulation to protein level could be determined. Using a 3^3 factorial design, a formulation was determined which would permit a positive or negative change in functionality to be observed.

Emulsifying ability of soy bean protein isolate

The calcium and isoelectric isolates and their subfractions were incorporated into the standard liquid coffee whitener formulation. The results are shown in Table 1. Conglycinin was found to have greater emulsifying ability than glycinin, the natural mixture showing intermediate behaviour.

Table 1. Emulsion stabilizing ability of soy bean protein isolates and subfractions determined in liquid coffee whitener

Sample	Observations	Extent of emulsion destabilization[A]
Isoelectric isolate	Light feathering	11[B]
Glycinin fraction	Heavy feathering	>50
Conglycinin fraction	Very light feathering	5
Calcium isolate	No feathering	0
Glycinin fraction	No feathering	0
Conglycinin fraction	No feathering	0
Acid precipitable residue[C]	Very light feathering	6

A 0–50 measurable scale, zero value represents an emulsion stable to the test conditions. Formulation: 9.5% hydrogenated coconut oil, 12.4% corn syrup, 0.1% K_2HPO_4, 0.25% SSL, 0.31% MDG, 0.5% PS, 0.70% soy bean protein isolate, 76.24% water (Pearce and Harper 1981*a*).

B Isoelectric isolate used as 'control' in standard formulation at a level to yield 12 ± 1 on emulsion stability scale.

C Soluble protein remaining after calcium precipitation recovered by subsequent addition of acid as in isoelectric precipitation.

Isolation of the soy bean protein using calcium as precipitant produced an isolate having superior emulsifying ability. The standard formulation did not permit discrimination between the relative emulsifying ability of the derived glycinin and conglycinin fractions. However, it may be seen that the acid-precipitated residue, which was predominantly conglycinin, showed emulsifying ability comparable to the conglycinin from the isoelectric isolate. The question of whether the difference in emulsifying ability shown after acid and calcium precipitation is due to a deleterious effect of acid or an advantageous effect of bound calcium has not been resolved.

Role of amide groups

It is well established that the presence of amide groups on the side chain carboxyl groups of polymers dramatically affects the physical properties of the polymer. It was suggested that conversion of the natural protein amides, asparagine and glutamine, to their free carboxyl forms, aspartic acid and glutamic acid, might similarly affect the physical and chemical properties of a protein, which may be observed as changes in protein functionality in a fabricated food. This conversion might then be used as a probe for the role of free acid/amide functions in functionality and in determining ingredient interactions.

A method was developed for the deamidation of soy bean protein (Pearce and Harper, unpublished data). Isolates were modified to different extents of deamidation between 5 and 80% of the total amide

Table 2. Emulsion stabilizing ability of unmodified and deamidated soy bean protein isolates at different levels of emulsion determined in liquid coffee whitener.

Extent of protein deamidation (%)	Observations	Extent of emulsion destabilizationA
0 (control)	Light feathering, unstable cream on standing	13
12	(as for control)	8
26	Very light feathering	6
37	Stable cream	3
43	Completely stable	0
66	Completely stable	0
79	Completely stable	0

A See Table 1

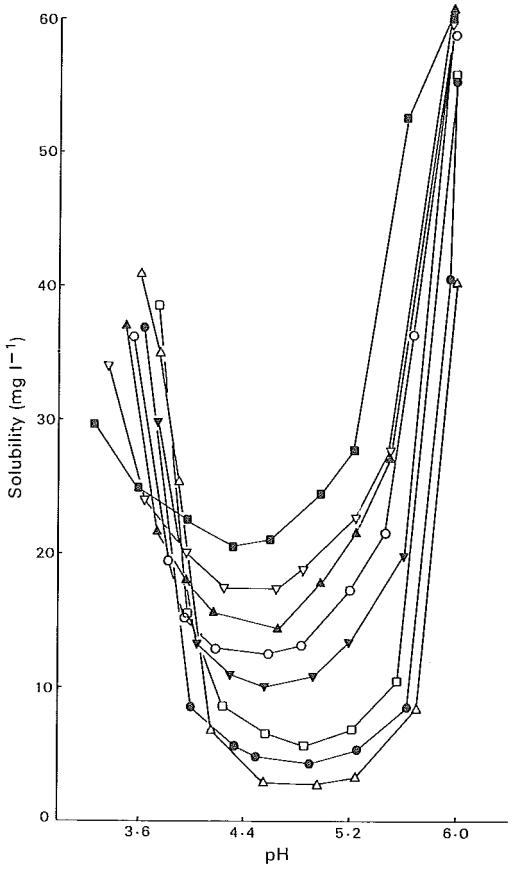

Fig. 2. Solubilities of unmodified and deamidated soy bean protein isolates at different levels of deamidation: △ 0%, ● 5%, □ 12%, ▼ 26%, ○ 37%, ▲ 43%, ▽ 59%, ■ 79%.

content. Solubilities of the modified soy bean isolates were determined in the pH range 3.5 to 6.0, results are shown in Fig. 2. As anticipated, the solubility in the vicinity of the isoelectric point increased with increasing deamidation.

The emulsifying abilities of deamidated soy bean protein isolates are shown in Table 2. Unmodified isoelectric isolate was used in the standard liquid coffee whitener formulation as in Table 1. Deamidation resulted in improvement of emulsifying ability as shown by the greater resistance to emulsion destabilization on addition to hot coffee. Extensive deamidation (43%) resulted in complete stabilization of the standard formulation, hence further improvement in emulsifying ability at greater levels of amide removal could not be discerned.

It remains to establish the mechanism whereby the amide content affects functional properties. Improved solubility of the protein may provide for more rapid migration of the protein to the oil/water interface but almost certainly the modification to the protein has affected the secondary, tertiary and quaternary structures of the protein and thus its interactive properties in the fabricated food system.

Conclusion

The approach to protein functionality elucidation in fabricated foods adopted in this study yielded valuable data concerning the role of the protein but also demonstrated some important factors to be considered.

Clearly, the protein source and the method of isolation and fractionation can significantly affect its functionality in a fabricated food and must therefore be carefully defined and described.

For a full understanding of the behaviour of the protein in a simple system or a fabricated food, a thorough characterization of the composition and structure of the protein is necessary. Soy bean proteins are not yet sufficiently characterized.

Food formulations for test purposes must be clearly defined and described for results to be comparable.

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A temperature indicator for meatworks use.

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Introduction

A recent survey (Cain 1979) has shown that bimetallic strip thermometers (e.g. TelTru PT50), widely used in abattoirs, are sufficiently accurate for measurements of steady-state temperatures. However, their long response times, the size of the thermally-active zone, and their susceptibility to stem conduction errors make them unsatisfactory for many meatworks applications. For example, European Economic Community regulations require that all meat in a carcass must be at 7 °C or below before boning, proposed hot-boning regulations require that the centre temperature of a carton of meat pieces be reduced to 8 °C or lower in a certain time, and a proposed check on effectiveness of electrical stimulation relies on the fact that stimulated sides have deep butt temperatures above 40.5 °C, while unstimulated sides have deep butt temperatures below 40.5 °C. In all these cases, the temperature of a small zone of meat at the centre of a mass of cooler meat must be accurately determined. The bimetallic strip thermometer, and many other commercially available thermometers, are not capable of giving fast, accurate

readings under such conditions. It is sometimes difficult, if not impossible, to read a thermometer under conditions of poor lighting or difficult access. In many meatworks applications, the actual value of temperature is of little interest. All that is required is to know whether or not the temperature is above or below a value specified by regulation or process requirements.

Our objective was to design and construct a prototype, thermometric device which indicates whether temperature at a given point in a meat mass is above or below a specified value. Accuracy, quick response, simplicity in use, cheapness, robustness and reliability were aimed for in the design.

Technical aspects of design and operation

The electronic circuitry utilizes a Schmitt trigger in a Motorola integrated circuit chip MC14583CP, chosen because of the small amount of switching hysteresis. Other components which have recently become available commercially in miniaturized form are:

- 8 × Single-Pole, Single-Throw Switch Bank (Dual In-line Package)
- Dual Red/Green Light Emitting Diode in a single housing

These components have been incorporated into the circuit diagram in Fig. 1. The temperature detector is a thermistor, which forms the lower leg of a voltage divider. The upper leg of the voltage divider consists of one of seven variable resistors which have been preset to desired values of resistance. Any one of these resistors may be selected by manual operation of a switch in the 8 × Single-Pole, Single-Throw bank. The eighth switch is to turn power on/off to the device.

The junction of the upper and lower legs of the voltage divider is connected to the A input of the chip while the A and $\bar{A}$ outputs are connected to the LED (Light-Emitting Diode) drive transistors. The 120 ohm resistor limits the LED current to about 5 mA.

When the thermistor is at a temperature below set point, the A input of the Schmitt Trigger will be above the switch point. The truth table for the MC14583CP indicates that above the switch point, $\bar{A}$ output will be low, turning on the green LED, and A output will be high, turning off the red LED. When the thermistor is above set point temperature, A input is below the switch point, and the outputs switch off the green LED and switch on the red LED.

The chip and switch socket are mounted on one Printed Circuit Board (PCB), which is backed up to two more PCBs carrying the seven variable resistors, and the LED drive transistors. The PCB battery, switch bank, and LED are housed in a die-cast metal box (length 90 mm, height 30 mm and width 40 mm). Also fitted to this box is the stainless steel tube, 4.8 mm diameter, 0.4 mm wall thickness, and 175 mm long, at the end of which is sealed the thermistor. The design of the top of the probe, showing location and

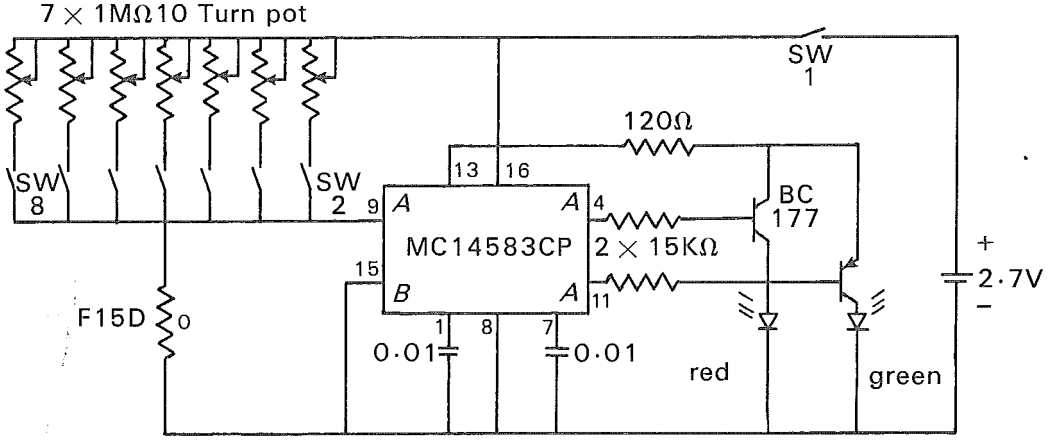

Fig. 1. Circuit diagram

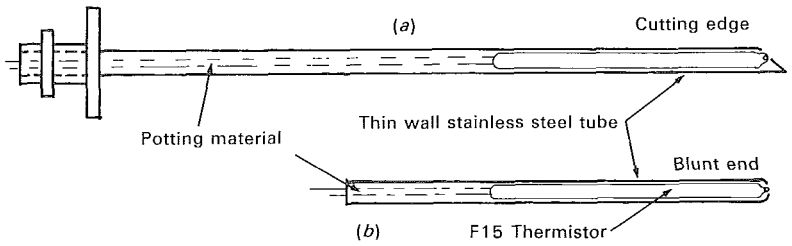

Fig. 2(a). Probe designed for use in meat, **(b)** Probe designed for clinical use

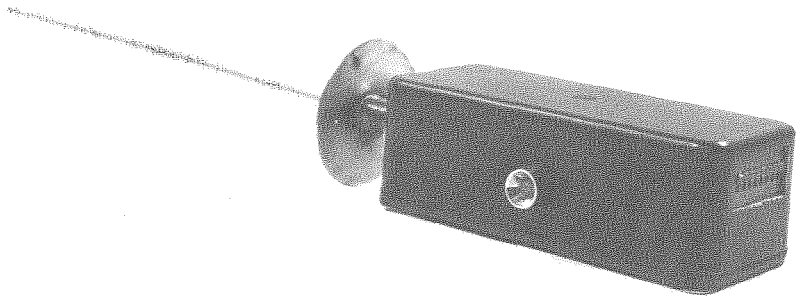

Fig. 3. Assembled temperature indicator

method of sealing of the thermistor, is shown in Fig. 2 for a probe designed for use in meat (Fig. 2*a*) and for clinical use (Fig. 2*b*). Total weight of the complete device is 200 g. The battery is a Mallory TR232R mercury cell, capacity 2200 mA hours, voltage 2.7V, capable of operating the device 8 hours a day for 2 months. The upper limit of operating temperature is set by PVC insulation, and the lower limit by the Araldite Type D potting compound used to seal the thermistor into the probe. A suggested range is therefore minus 20 °C to 80 °C. A photograph of the complete device is given in Fig 3.

Calibration

The device is adjusted to a given set point temperature as follows:

A constant temperature glycol/water bath is set to the desired temperature and the stem of the device immersed to about half its length in the bath. The device is turned on and a switch position selected. The potentiometer associated with that switch position is then adjusted so that the green LED comes on when the bath temperature drops 0.2 ° below, and the red LED comes on when it rises 0.2 ° above, the set-point temperature. Potentiometers for other switch positions are similarly adjusted to desired set-point temperatures.

Testing

The device was tested for accuracy and speed of response when only the tip and a short length of stem were immersed in water at test temperature. The rest of the stem was in air at ambient temperature giving rise to stem conduction effects. Times of response given below are averages for several tests at the given test conditions.

a) Ambient 25 °C. Device set to change at 10 °C. Tip + 5 mm stem immersed in ice/water slurry. Time to change from red to green: 4 s (∼60% of step change). Time constant is approximately 4 s.

b) Ambient 25 °C. Device set to change at 1 °C. Tip + 5 mm stem immersed in ice/water slurry. Time to change from red to green: 16 s (∼96% of step change).

c) Ambient 25 °C. Device set to change at 69 °C. Tip + 5 mm stem immersed in water at 70 °C. Time to change from green to red: 22 s (∼98% of step change).

The time of response was also checked when the stem of the device was inserted in a partly-chilled side of beef to a depth of 100 mm, ambient air temperature 7 °C. Thermocouple measurements had shown surface meat temperature 15 °C and *deep meat* temperature 31 °C. The device was set to change at 30 °C. Time to change from green to red was about 27 s (96% of step change).

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Effect of harvesting procedures on measurement of maturity in peas

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The method of harvesting pea crops in Australia changed greatly some 15 years ago. Young (1978) described how the stationary viners, which had been used for many years, were replaced by mobile viners. These evolved through the tractor-drawn, self-driven and pod-stripper models and resulted in economies in the industry. Instead of transporting vines to the viners, with the need to transport the trash away after vining, the processor now transports only the vined peas from the field. Handling has been facilitated by replacing bins with bulk systems, thereby reducing the labour content in the processing line.

Peas harvested by stationary viners suffered damage at a relatively constant rate because the vines were fed to the viners at a regulated rate and the beaters were run at a set speed. Bin capacities were usually less than 1 t and hence mechanical damage during handling after vining was minimal. However, the feed rate to mobile viners depends upon their ground speed, and beater speed is often varied depending upon field conditions. The peas are now transported from the field in loads of 8 to 10 t and tipped from the truck into a hopper feeding the production line. This system causes additional damage to the peas. Thus peas now received for processing may have more variable and greater amounts of damage than peas vined and tranported by earlier methods.

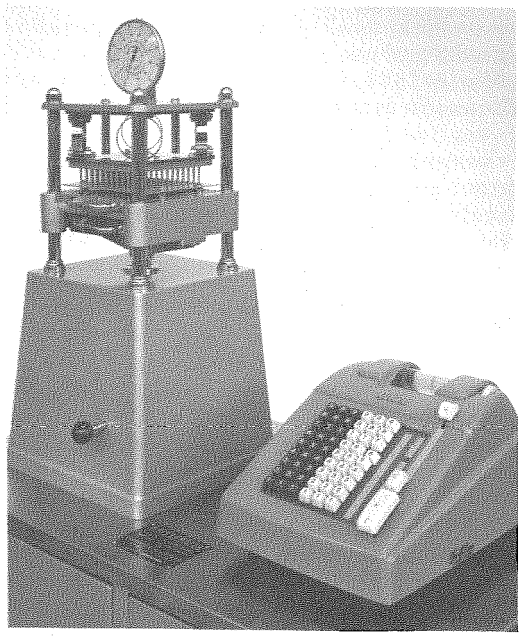

Fig. 1. Maturometer

Pea crops are harvested at a point in the growing period when the highest yield of peas of requisite maturity will be obtained. This point is known as the optimum harvest time and it will vary according to the intended method of preservation and the standards of the individual manufacturer. The accepted standard for measuring pea maturity, which has been used by many research workers, is the alcohol-insoluble solids content (AIS%) of the peas. The determination of AIS% requires 3 h and is too slow for production control. Some instruments which measure the textural quality of peas give results which correlate closely with AIS%. Accordingly, they are used by the factory to measure pea maturity.

Maturometer

In many Australian pea-processing plants a maturometer is used to measure the maturity of peas for quality assessment and for determining the payment to growers. This instrument, described by Mitchell *et al.* (1961), measures the force required to

puncture 143 peas with blunt steel pins 3.175 mm in diam. (Fig 1). The maturometer was originally designed as a portable instrument for use by field staff to predict the optimum time to harvest pea crops. Lynch *et al.* (1959) reported that the maturometer was easily calibrated and gave readings that correlated well with other measurements of maturity. These factors led to the wide use of the instrument for quality assessment and for determining payments to growers on the broad basis that more tender peas commanded a higher price.

The effect of vining is to lower maturometer readings, the decrease being greater as the beater speed of the viner increases (Moyer *et al.* 1954). Casimir *et al.* (1967) confirmed this observation and found that 'more mature peas suffer less damage than immature peas during the vining process'. Nortje *et al.* (1963) obtained different relationships between AIS% and maturometer reading depending upon the method used to shell the peas. Clearly, maturometer readings are affected by damage to the peas. Moreover, the method now used for harvesting peas in Australia subjects them to variable amounts of damage.

Four studies have been carried out by workers from the Food Research Laboratory on the relationship of AIS% and maturometer readings that are relevant to the changes brought about by the continuous development of the viner. Mitchell *et al.* (1961) quote a relationship for peas from the 1958 season in Tasmania, when a commercial stationary viner was used and AIS% was determined on canned peas. Scheltema *et al.* (1961), using a stationary viner, determined a relationship between the AIS% of frozen peas and maturometer reading. Mitchell and Rutledge (1972) compiled a three-season correlation between AIS% and maturometer reading for peas that had been vined by tractor-drawn and self-driven mobile viners. Rutledge and Willcox (1978) used peas from the peapod-picker mobile viners to determine a relationship in that year. Values for the maturometer reading at various values of AIS% for frozen peas from the four CSIRO studies are shown in Table 1.

Table 1. AIS% and maturometer values of frozen peas

AIS%	Year of determination 1958[A]	1961	1972	1978
10	162	183	150	138
12	230	252	210	201
14	298	321	269	263
16	366	389	328	326
n[B]	50	151	233	77
r[C]	—	0.97	0.92	0.96

[A] Data converted from canned to frozen AIS% using the conversion factor from Sykes *et al.* (1957)
[B] n = number of pairs
[C] r = correlation coefficient

The data in Table 1 are inadequate to establish significant differences. However, there appear to be large differences between the values for peas vined in stationary viners (1958 and 1961 crops) and those of peas from mobile viners.

Factors affecting AIS%

The measurement of AIS% is an empirical determination and the resultant value depends upon the processing given to the peas before the determination. Originally, the determination was carried out mainly on canned peas but as some of the industry changed from canning to freezing the AIS% was determined on frozen and fresh peas more frequently. Kramer (1948) showed that, for a given sample, the AIS% of frozen peas could be 3% AIS higher than that for canned peas. Anthistle (1961) demonstrated the same type of relationship by correlating AIS% of canned and raw peas with tenderometer (Martin 1937) readings. She obtained two linear relationships about 2% AIS apart. Sykes *et al.* (1957) investigated the relationship between the AIS% of canned and frozen peas and determined that, for the conditions used in the Australian industry, the mean AIS% of frozen peas was 0.65% greater than for canned peas.

Tenderometer

Other mechanical instruments are also used for assessing pea quality. The tenderometer (Fig. 2), manufactured by Food Machinery Corporation, is used in most pea-growing countries for measuring the maturity of pea crops. The measuring system of the tenderometer comprises two stainless steel grids, the upper one being driven in a rotating motion to compress and extrude the sample of peas through the lower grid which is free moving and attached to a pendulum that lifts in reaction to the peas being crushed

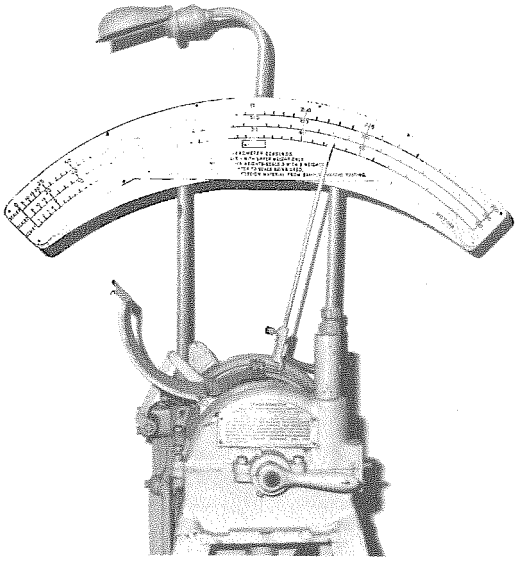

Fig. 2. Tenderometer.

and extruded. This in turn moves a pointer on a scale to give the reading. Moyer *et al.* (1954) showed that tenderometer values were not affected by changes in the beater speed of the viner. In every country using the tenderometer, however, there are difficulties in standardizing the instruments to ensure that consistent values are maintained. This problem was investigated in Canada by Voisey and Nonnecke (1971) who suggested the use of wax test blocks to standardize factory machines from a laboratory master tenderometer. Voisey (1971) attempted to overcome the problem by developing a new instrument called the Ottawa Texture Measuring System.

Ottawa pea tenderometer

The Ottawa Pea Tenderometer (OPT) shown in Fig. 3 and described by Voisey and Nonnecke (1973) is a modification of the Ottawa Texture Measuring System. The OPT uses a load cell to measure the compressive load as the peas are forced by a piston through a stationary wire grid. These features enable the user to check both the standardization of the machine by absolute mechanical methods and the condition of the wire grid by inspection. An evaluation of the OPT has been made by Atherton and Gaze (1980) at the Campden Food Preservation

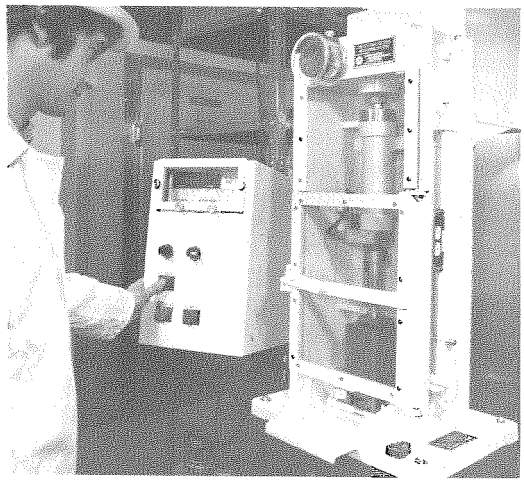

Fig. 3. Ottawa tenderometer (Photo: courtesy Campden Food Preservation Research Association)

Research Association, Chipping Campden, England. This work was designed to assess the OPT as an instrument to standardize the tenderometer which is generally used by pea processors throughout the United Kingdom.

During the 1980 pea season the OPT measuring cell was used on an Instron Model 1140 Universal Testing Instrument to examine three varieties of peas differing widely in size and appearance.* The varieties were Platinum, a medium to small, light-coloured pea, Scout, a dark-seeded, large-sized early pea and Waverex, a very small dark-seeded variety. Samples of the peas were harvested at daily intervals from the immature to overmature stage of development. Ten readings on the OPT and duplicate AIS% determinations were made on each sample of peas harvested. The means of these determinations, shown in Fig. 4, were linearly correlated to give the regression line,

$$\text{AIS\%} = 2.628 + 0.385 \text{ Ottawa reading}$$

with the number of pairs $n = 34$ and correlation coefficient $r = 0.983$.

An experiment was carried out to determine the effect of viner damage on the results from the OPT, maturometer and tenderometer. A large sample of peas (Sprite, a medium-sized variety) was vined, cleaned, and well mixed. The peas were divided into two lots, one lot being subjected to ten readings with each instrument. The other lot

*The author was working with scientists at the Campden Food Preservation Research Association under a CSIRO Study Award.

was passed twice through a stationary viner which caused a considerable amount of visible damage. Ten readings with each instrument were then taken on this lot. The mean readings for the peas are shown in Table 2.

These results show that the readings from both the tenderometer and OPT were not greatly affected by viner damage when compared with those from the maturometer.

The extent of viner damage on peas could be estimated from the maturometer readings if both tenderometer or OPT and maturometer readings are taken on the equivalent sample of peas. The tenderometer or OPT reading would give the maturity of the peas and the divergence in the maturometer reading from the established relationship between maturometer and tenderometer or OPT readings would give a measure of the viner damage. This measure could then be used as one measurement of quality for assessing the raw peas.

Conclusions

It was concluded that the OPT is the preferred instrument for measuring the maturity and quality of peas for processing. This instrument has the advantages of enabling rapid measurements which correlate satisfactorily with AIS% — the widely accepted basic measurement of pea maturity. The OPT readings are affected to a negligible extent by mechanical damage to the peas, in particular, damage caused by the vining operation. The OPT can be readily standardized by a simple mechanical procedure.

Since maturometer readings are appreciably affected by the extent to which peas are damaged during the vining process, and since the amount of damage under commercial conditions is influenced by many mechanical, field, or operator factors, the maturometer has limitations in the accurate measurement of vined peas for determining factory grade or final eating quality.

Although the readings of the tenderometer are not greatly affected by damage to the peas, this instrument is less suitable for measuring the quality of peas than the OPT because it is difficult to standardize.

Table 2. Mean readings for peas vined and excessively vined

	Maturometer	Tenderometer	OPT
Vined	204	108	102.5
Excess vined	144	106	100.0

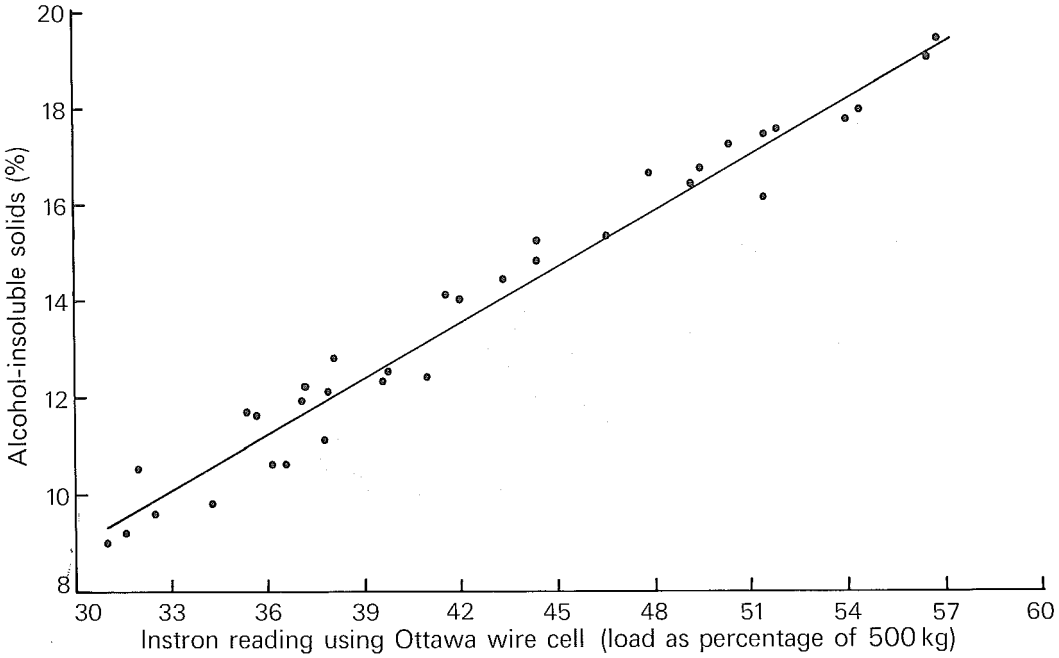

Fig. 4. Regression line for Ottawa tenderometer reading and AIS% showing mean values.

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Analysis of drying oils used to reduce the drying time of vine fruits

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Introduction

Dipping or spraying of sultana grapes with an aqueous emulsion containing 2% drying oil and 2.5% potassium carbonate is used throughout the Australian dried vine fruit industry to increase the drying rate of the grapes significantly. The drying oil is made by the transesterification of tallow with ethyl alcohol, followed by removal of free glycerol and excess ethyl alcohol. D. Barnett (unpublished data) has shown that the fatty acid ethyl esters in the drying oil act as plasticizers, altering the crystallinity, and thus the permeability to water, of the natural grape wax. Little is known of the role of potassium carbonate in the process. The costs of oil and carbonate are rising rapidly, particularly as more oil is required to spray grapes on the vine or on the rack in contrast to the older method of dipping the fruit.

In July 1980, the CSIRO Division of Food Research was awarded a one-year grant from the Dried Fruits Research Trust Account to initiate a project entitled 'Improved drying and dressing oils for dried vine fruits'. One of the authors (Deborah E. Burton) was appointed to undertake the experimental work. During the course of this study an analysis was undertaken of commercial drying oils presently used in Australia. This project was designed to look for ways of reducing the cost of the drying oil and to investigate possible alternatives to potassium carbonate.

Materials and methods

Coding and abbreviations. For convenience in presenting tabulated results, the commercial drying oils were coded as follows. A, Ampol Grape Dipping Oil Multipurpose, manufactured 1979; B, Voullaires Eemuls-Oyle Multipurpose, manufactured 1979; C, As B but manufactured 1980; D, Shelltana Dipping Oil Plus; E, Shelltana Rack Spray, manufactured 1980; F, Mobil Dipping Oil; and G, Voullaires Dipping Oil, manufactured 1976.

Direct g.l.c. analysis. The drying oils, known to consist largely of ethyl esters, were analyzed directly by gas-liquid chromatography (g.l.c.) with methyl behenate (C22 : 0) as an internal standard to calculate the true ethyl ester content (i.e. to correct for non-volatiles lost during g.l.c.). G.l.c. was performed by means of a glass column 4 m long, internal diam. 4 mm) containing 10% Silar 10 C on Gas-chrom Q at 200 °C.

Column chromotography on Florisil. Drying oils were separated into lipid classes by column chromatography on Florisil, by the method used by Carroll (1961).

Esterification and g.l.c. Oils were transesterified by the method of Glass and Christopherson (1969), and the resulting methyl esters were examined by g.l.c. An internal standard (C22 : 0) was used.

Differential esterification. In order to determine ethyl esters and free fatty acids separately in drying oils, a modification of the Glass and Christopherson procedure for differential esterification was devised in which two internal standards were used: methyl behenate for the ethyl esters and stearolic acid for the free fatty acids.

Saponification. Samples (5 g) of oil were refluxed with aqueous 5% w/v potassium hydroxide solution (50 ml) for 1 h. Non-saponifiable compounds and fatty acids were recovered, and the fatty acids were re-esterified with BF_3-methanol for g.l.c., to see whether a component other than ethyl esters (e.g. emulsifier) had contributed fatty acids additional to those obtained from the ethyl esters by saponification.

Thin-layer chromatography (t.l.c.) Fractions obtained during various analyses were monitored by t.l.c. by means of 0.25 mm

Table 1. Analysis of grape-drying oils

Determination	Drying oil A	B	C	D	E	F	G
Ethyl esters (%)							
by g.l.c.							
1st determination	63	53	56	65	74	63	70
2nd determination	60	52	55	64	83	62	73
by Florisil chromatography	67	64	56	65	85	61	67
by saponification							
1st determination	72	62	62	72	64	65	64
2nd determination[A]	68	63	71	73	86	63	71
by differential transesterification:							
using IS 1[B]	42	55	46	59	65	59	66
using IS 1 and 2	66	56	57	63	76	65	69
by t.l.c.							
Ethyl esters	✓[B]	✓	✓	✓	✓	✓	✓
Triglycerides	—	—	—	—	—	—	—
Free fatty acids	—	—	—	—	—	—	—
Other (emulsifiers)	✓	✓	✓	✓	✓	✓	✓

[A] Ether used as well as hexane to extract fatty acids more completely after saponification in the 2nd determination.
[B] Abbreviations: IS, internal standard; tick, present; dash, absent.

Table 2. Analysis of grape-drying oils

Determination	Drying oil A	B	C	D	E	F	G
Residue on ignition (%)	0.7	3.2	3.5	2.1	0.5	3.2	3.1
Volatile matter (%)	4.5	10.5	11.8	5.9	1.3	7.9	7.6
Free fatty acids (%)							
by A.O.C.S. Method							
1st determination	15.8	9.5	9.0	16.4	1.0	10.8	10.4
2nd determination	15.2	—[A]	—	15.5	1.1	—	—
by differential transesterification:							
using IS 1	34	8	14	9	17	13	11
using IS 1 and 2	24	1	11	4	11	6	3

[A] No 2nd determination on oils B, C, F and G.

silica gel G plates. The conventional lipid-separating solvent system was employed, e.g. 90 : 10 : 1, hexane : diethyl ether : glacial acetic acid. Spots were viewed under u.v. light after spraying with 0.2% dichlorofluorescein in ethanol.

A.O.C.S. Official Methods. The following methods of the American Oil Chemists' Society were used.

Free Fatty acids: Method Ca 5a-40
Saponification value: Method Cd 3-25
Unsaponifiable matter: Method Ca 6b-53
Moisture/volatiles: Method Ca 2c-25
Residue on ignition: Method Ca 11-55

Results and discussion

Composition of commercial drying oils

A summary of the analyses performed on the drying oils is given in Tables 1, 2, 3 and 4.

It can be seen from Table 1 that the dipping oils contain *c.* 60–70% of ethyl esters. The rack spray E contains about 80% of ethyl esters.

The t.l.c. results show clearly that there are no free fatty acids in any of these commercial oils, contrary to the widespread belief that free fatty acids are present in drying oils (Dried Fruits Processing Committee Booklet, 1973). This was puzzling, because all the dipping oils, with the exception of the rack

spray, appear to have a titratable acidity in the A.O.C.S. test Ca 5a-40 for 'free fatty acids' (Table 2). We subsequently realized that these oils contained an acidic emulsifier which interfered with the determinations for free fatty acids and saponification data (Tables 2 and 3).

The apparent anomaly between the t.l.c. evidence and the free fatty acid value by titration also led us to use two internal standards in the method of differential esterification to see whether free fatty acids were present as well as ethyl esters. However, even with two standards, the differential esterification requires a high degree of precision, because small errors are magnified during calculation (see Table 2).

T.l.c. showed unidentified components of the drying oils with R_f values lower than free fatty acids. These are believed to be due to the emulsifier present. They were quite prominent in all oils except oil E, suggesting that this oil contained less emulsifier. T.l.c. of the non-saponifiable matter obtained after quantitative saponification of the dipping oils also showed a pair of spots just tailing the fatty acid reference spot. Non-saponifiable compounds from oil E gave the same pair of t.l.c. spots, although they were less obvious than those of the other six oils. We presume that the non-saponifiable matter is derived chiefly from the emulsifiers present in the drying oils.

The evidence strongly suggests that

- Oils A, B, C, D, F and G consist of about 70% ethyl esters and contain no free fatty

Table 3. Quantitative saponification of grape-drying oils

Determination	Drying oil A	B	C	D	E	F	G
Saponification value[A]	172	159	153	165	174	159	157
Non-saps expected (% based on saponification value[B])	8	15	19	12	7	15	16
Fatty acids found (% of oil)[C]	71	62	62	72	64	65	64
Non-saps expected (% based on fatty acids found)	29	38	38	28	36	35	36
Non-saps found (% of oil)	24	22	7	11	19	12	17
Recovery from saponification[D] (%) (Fatty acids + non-saps)	95	84	69	83	83	77	81

[A] Values high owing to KOH-reactive non-ethyl ester component.
Theoretical values for tallow triglycerides, methyl esters and ethyl esters are 198, 197 and 188 respectively.
[B] Abbreviation 'non-saps' indicates non-saponifiable matter. Values low owing to non-ethyl ester component reacting with KOH.
[C] Values parallel the ethyl ester content.
[D] Incomplete recovery suggests presence of water-soluble, non-saponifiable component (e.g. emulsifier) not completely recovered during extraction of non-saponifiable matter.

Table 4. Major fatty acids of grape-drying oils

Sample	Total fatty acids (%) by g.l.c. [A]14 : 00	16 : 0	16 : 1	18 : 0	18 : 1	18 : 2
Drying oil:						
A	5.4	23.9	5.3	18.8	39.5	2.4
B	3.4	22.3	5.1	18.3	41.0	2.9
C	4.3	21.7	4.9	19.7	39.7	3.0
D	4.0	21.6	5.0	18.6	39.1	3.4
E	4.3	23.0	4.9	19.3	39.9	2.9
F	4.8	22.4	5.3	20.2	35.9	2.7
G	6.2	23.0	5.6	16.6	40.0	2.4
Beef oleo	2.7	24.0	5.6	13.5	46.0	2.1
Beef stearine	4.5	32.0	5.5	25.0	27.0	2.2

[A] Shorthand notation: 18 : 1 signifies an 18-carbon fatty acid with 1 double bond, and so on.

Table 5. Stability of drying oil emulsions

Alkali	Drying oil A	B	C	D	E	F	G
2.5% K_2CO_3	+++[A]	+++	+++	+++	++	+++	++
2.5% Na_2CO_3	+++	+++	+++	+++	–	+++	–
1.92% Na_2CO_3	–	++	+++	+++	–	+++	–
Apparent ethyl ester (%), after recovery of oil from emulsion	88[B]	64	96	90	89	76	82

[A] + + + no separation after 16 h; + + slight separation after 16 h; – complete separation after 16 h.
[B] The percentage of ethyl ester appears to increase owing to loss of emulsifier in the aqueous phase.

acids. Oil E contains about 80% of ethyl esters.

- The remaining 30% in oils, A, B, C, D, F and G is an emulsifier, with acidic properties. Compound E contains about 20% of a possibly different type of emulsifier.

Furthermore, the g.l.c. analysis of the drying oils suggests that they are all based on ethyl esters derived from tallow (Table 4). The typical analyses of tallow fractions known as 'beef oleo' and 'beef stearine' included in the table for comparison suggest that an unfractioned tallow was used to make the ethyl esters.

Emulsion stability of commercial drying oils

Samples (1 g) of each drying oil were suspended in aqueous solutions (50 ml) of potassium carbonate (2.5% w/v), to prepare the emulsions used for dipping grapes. Sodium carbonate solutions were likewise employed, either at 2.5% w/v or at 1.92% w/v (same equivalent weight basis as potassium carbonate). The stabilities of the emulsions were observed. Results are shown in Table 5. Sodium carbonate is as effective as potassium carbonate at the 2.5% w/v concentration for oils A, B, C, D and F. Oils E and G tend to separate even in 2.5% potassium carbonate. On an equivalent weight basis, sodium carbonate is not as effective as potassium carbonate in providing a stable emulsion. For drying oils A and B, the titratable alkalinity of an emulsion containing 2% w/v of oil in 2.5% w/v aqueous potassium carbonate solution did not change over 75 h. This showed that the ethyl esters were stable in the emulsified form, otherwise any fatty acids liberated by hydrolysis of the esters would have reduced the alkalinity of the mixture.

Analysis of emulsifiers.

Several commercial emulsifying agents were obtained in order to assess their ability to emulsify laboratory-prepared batches of ethyl esters (see below). These were examined by t.l.c., and their acidity was also checked, to see whether any of them resembled the emulsifier present in the commercial drying oils. The results of the acidity test are shown in Table 6. Only 2 of the 21 emulsifiers tested were 'acidic', namely Brinol AN which is believed to be a 'sulphated butyl oleate' or similar type of compound, and Polymuls SSL, a sodium stearoyl-2-lactylate. Only the latter is an approved food additive.

During t.l.c., the emulsifiers numbered 1 and 3 to 13 (see Table 6) remained at the origin. Brinol AN (2) produced a spot matching that of the emulsifier in the commercial dipping oils. This fact, coupled with its acidity, suggests strongly that an emulsifier of this type is used in commercial oils. T.l.c. of the remaining emulsifiers showed the expected spots, e.g. Polymuls GLS (glyceryl lactostearate), GMS (glyceryl monostearate), GMP (glycerylmono-palmitate) all showed mono-acylglycerol spots, plus di- and tri-acylglycerol spots; Polymuls PGMS (propyleneglycol monostearate) showed monoester and diester spots; and Polymuls SSL showed a spot in the mono-acylglycerol region and one in the fatty acid region, unlike the emulsifier in the commercial dipping oils.

Laboratory preparation of ethyl esters

Several ethyl esters were prepared on the laboratory scale to investigate various aspects of the esterification process. The methods were based on the typical procedure described by Wright *et al.* (1944) (see also Markley 1961), in which a neutral

Table 6. Acidity of commercial emulsifiers

	Emulsifier	Supplier	Apparent % FFA[A]
1	Teepol	Shell	4.0
2	Brinol AN	Steetley Chemicals	33.8
3	Teric N12	I.C.I. (Aust.)	Nil
4	Teric N13	I.C.I. (Aust.)	Nil
5	Teric N40	I.C.I. (Aust.)	0.1
6	Teric X10	I.C.I. (Aust.)	0.1
7	Teric X11	I.C.I. (Aust.)	0.1
8	Teric X13	I.C.I. (Aust.)	0.1
9	Alkanate 3SN5	I.C.I. (Aust.)	0.2
10	Triton X100	Rohm and Haas	0.3
11	Brydet X10	Robert Bryce	0.2
12	Tween 80	I.C.I. (Aust.)	0.4
13	Tween 60	I.C.I. (Aust.)	1.1
14	Span 20	I.C.I. (U.S.A.)	3.8
15	Arlacel 165	I.C.I. (U.S.A.)	0.7
16	Myrj 45	I.C.I. (U.S.A.)	1.0
17	Polymuls GLS	A. C. Hatrick	0.4
18	Polymuls GMP	A. C. Hatrick	0.3
19	Polymuls GMS	A. C. Hatrick	0.3
20	Polymuls SSL	A. C. Hatrick	38.3
21	Polymuls PGMS	A. C. Hatrick	0.1

[A] By A.O.C.S. Method Ca 5a-40.

triglyceride (vegetable oil, tallow, etc.) is mixed with 1.5 equivalents of anhydrous ethanol per acyl equivalent of the triglyceride, in the presence of 0.5% (w/w) sodium hydroxide catalyst. The reaction may be carried out at room temperature or above; we preferred to use 60 °C for *c.* 2 h. After withdrawal of the separated layer of glycerol the mixture is washed to remove soaps, alcohol, salts, etc.

Ethyl esters were prepared from anhydrous tallow, safflower oil, and palm olein ('palmolene'). Time-temperature runs were carried out to see how quickly the triglycerides converted to ethyl esters. At 60 °C, the reaction was essentially complete within 2 h. Differential analysis showed that mono- and di-acylglycerols, and residual glycerol were present in the non-washed batches. The laboratory batches of ethyl esters had very low levels of non-saponifiable matter (mostly sterols), and very low residue on ignition, provided the catalyst was removed by washing. Florisil chromatography of selected batches validated the ethyl ester content as determined by g.l.c. with internal standards.

It was found that the choice of acidification and washing procedures applied to the ethyl ester mixture after preparation had a considerable effect on the ultimate composition of the ethyl esters. The use of dilute hydrochloric acid to neutralize the catalyst, followed by washing with water, led to appreciable amounts of mono-acylglycerols appearing as a white precipitate in the ethyl ester. The effect was similar when dilute acetic acid was used. Since the ethyl ester is intended to be mixed with an emulsifier for later addition to solutions of potassium or sodium carbonate in the dipping tanks, it would seem that there is little reason for washing out the catalyst, traces of ethanol, etc. from the ethyl esters after they have been made. Only small amounts of sodium hydroxide would be added to the dipping emulsion, and after final washing the sultanas would be essentially free of sodium hydroxide. However, if the washing of the ethyl esters after preparation is required, it should be minimal (one wash only) using sufficient acetic acid to neutralize the sodium hydroxide catalyst. Further washing may lead to the formation of insoluble mono-acylglycerols.

Laboratory preparation of drying (dipping) oils

We tried a number of mixtures of commercial emulsifiers with either tallow or palm olein ethyl esters, and checked the stability of the emulsions when prepared with sodium or potassium carbonate solutions. A 20% w/w concentration of emulsifier in ethyl ester was used for these tests. Both tallow and palm olein ethyl esters gave reasonably stable emulsions when 20% Polymuls SSL (sodium stearoyl-2-lactylate) was used as the emulsifier. The emulsion in potassium carbonate was much more stable than the emulsion in sodium carbonate. Brinol AN did not form a stable emulsion at a concentration of 20%.

Conclusions

In assessing the possibility of producing less expensive drying oils, we have concluded:

- There is little likelihood of improving the procedure for preparing ethyl esters. Both the alcohol and oil used need to be anhydrous, and the chemical reaction involved is essentially complete in 2 h. Stirring need only be minimal.
- The glycerol layer formed during the production of the esters must be removed,

but for reasons outlined above, there seems little need to wash the crude esters before adding the emulsifier.

- There is a need to investigate alternatives to tallow. Palm olein (palmolene) may offer a good alternative. It is inexpensive, plentiful and of high quality.
- Considerable effort will have to be made to find a suitable emulsifier for the ethyl esters. Obviously, the identity of the emulsifier in present commercial dipping oils is a trade secret, but we suspect that an excessively high level is present in the drying oils, presumably to satisfy a need for emulsion stability, extending over several hours, even days. We wonder whether such stability of the emulsion is really required. There is no doubt that the use of emulsifiers at levels greater then 5% must elevate the cost of the drying oils considerably.
- It seems logical for rack sprays to be used instead of dipping oils since they can be produced more cheaply on account of their lower content of emulsifier.

The above findings are regarded as preliminary, and the brief foregoing remarks clearly indicate those areas which require further research. Even if further laboratory work is undertaken at some future date, it will be necessary to run pilot-scale and field-scale tests of any new products in order to evaluate them completely.

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News from the Division

Research supported jointly by industry and government

The Division of Food Research continues to experience reductions, in real terms, in its activities funded by the Commonwealth Treasury, and contributed funds from industry and other external organizations have become essential for the maintenance of research activities.

The Division continues to receive major grants from traditional supporters such as the Australian Meat Research Committee and the Dairying Research Committee and these form a very important part of the budgets of Meat and Dairy Research Laboratories (MRL and DRL).

During the financial period 1980–81 and in the current year, several grants of 1–3 years duration have been received by the Division. These are summarized below.

Fishing Industry Research

Three new grants involving six additional staff have been approved by the Fishing Industry Research Committee for the following projects:

- A major program on the development of fish handling, processing and packaging systems (Tasmanian Food Research Unit)
- Viral and bacterial contamination and recontamination of oysters (Food Research Laboratory)
- The biological origin of compounds responsible for distinctive off-flavours in prawns and other edible crustaceans (FRL).

Biotin studies

The National Health and Medical Research Council has funded a program at FRL which enables a continuation of studies of the Sudden Infant Death Syndrome (cot death) and biotin metabolism. An additional Experimental Officer has been appointed from the grant.

Egg Research

The Poultry Research Advisory Committee has awarded a grant to facilitate

a fundamental study of the constituents of hen's eggs and on properties likely to be of commercial importance. This grant has enabled the appointment of another Experimental Officer at FRL.

Chicken Meat Research

The Australian Chicken Meat Research Committee is funding two programs, requiring two additional appointments, at FRL:

- Removal of Salmonella from the gut of the live bird, and
- Poultry pasteurization combined with aseptic packaging.

Meat Research

The Australian Meat Research Committee has provided a grant for the expansion of meat processing technology investigations at MRL by the appointment of four staff.

The Australian Pig Industry Research Committee has funded two projects at MRL involving two new members of staff, a study of pre-slaughter treatments and a study of the storage life of vacuum-packaged chilled pork.

Dairy Research

Grants received through contractual arrangements entered into with the Australian Dairy Corporation and external contributors are supporting projects at DRL:

- Studies on improved cheese manufacture (3 staff) (Department of Productivity)
- Cheese base project (5 staff) (Schreiber Foods Inc.)

A further grant from a group of dairy companies to study age gelation in UHT milk provides for the employment of one additional member of staff.

Tomatoes

A grant from the Sydney Farm Produce Market Authority will enable an expansion of studies aimed at improving the quality of fresh market tomatoes, with the employment of a new Experimental Officer at FRL.

Potatoes

The Reserve Bank, through the Rural Credits Development Fund, continues to support work at FRL. The most recent grant is for metabolic studies of potato tubers with respect to the storage and marketing quality of new varieties developed in Australia. This grant also supports a new Experimental Officer at FRL.

Intermodal Containers

The Australian Chamber of Shipping provided funds for the establishment of a test facility at FRL in which commercial shipping containers may be tested under controlled temperature conditions. The facility was built by making major modifications to a controlled atmosphere storage complex previously used for large-scale fruit storage studies.

Apples

Further support has been received from the Australian Apple and Pear Corporation for a study of the calcium treatment of apples to prevent the physiological disorder 'bitter pit'. This project is being conducted at FRL in collaboration with the New South Wales Department of Agriculture.

FRL is collaborating with Howden Equipment Services Pty. Limited to develop commercially the technology of counter-current extraction. The technique provides an efficient method of extraction of soluble constituents from apples, grapes, and other fruits, tea, sorghum, and various food wastes. Prototype equipment has now been scaled up to a commercial unit with a capacity of 5 t of apples per hour.

Taste and odour research

The Director of the Institute of Animal and Food Sciences, Dr K. A. Ferguson, has allocated to the Food Research Laboratory a research 'position of excellence' which recognizes the significance and need for support of the studies on the mechanisms of smell and taste perception that have been initiated by Dr D. G. Laing.

Dr G. A. Bell, a PhD (1977) in psychology from La Trobe University has been appointed to this position. Dr Bell will collaborate with Dr Laing in an investigation of the perception of odour mixtures, which will involve the identification of odour responsive cells using neuroanatomical techiques and behavioural studies. The investigation will include psychophysical studies of human and animal responses to odours and tastes; neuroanatomical and neurochemical studies of olfactory cells selectively altered during prolonged odour exposure; and the sensory evaluation of foods.

Postharvest workshop

The Horticulture Postharvest Committee of the Commonwealth's Standing Committee on Agriculture in which the Division (through FRL) has played a significant part, organized a Postharvest Workshop in September, in Brisbane. More than 50 participants came from State Departments of Agriculture, the Commonwealth Department of Primary Industry, CSIRO, educational establishments and industry (representing transport, packaging, wholesale and retail interests).

A total of 38 papers was presented in workshop sessions which covered environmental effects on fresh produce, storage disorders, physiology of ripening and maturity, postharvest diseases, packaging and packages, temperature and humidity management, and postharvest education for industry and extension.

The proceedings of the Postharvest Workshop are to be published. Further information from Mr G. Fisher at FRL.

Following a major restructuring of the committees responsible to Standing Committee on Agriculture, the Horticulture Postharvest Committee will now report to the newly formed SCA-Plant Production Committee. The Secretariat of SCA-HPC, provided by the Division for many years, will be taken on by the Department of Agriculture in Victoria along with that of four other committees of SCA. The Division will, of course, continue to be represented on the Horticulture Postharvest Committee.

Work overseas

At the invitation of the International Potato Centre, Drs R. M. Smillie and S. E. Hetherington of FRL's Plant Physiology Group spent four weeks at the International Potato Research Centre in Lima, Peru. There, using a method recently developed by Dr Smillie, they quantitatively evaluated the degree of cold and heat tolerance of a number of commercial potato clones, and determined the range of cold tolerance in various potato species collected from different altitudes in South America.

Dr B. D. Patterson (PPG, FRL) also visited the International Potato Centre, to assess ways of using their collection of potato species by our group working on cold adaptation in enzymes. Dr Patterson's main purpose was to present a paper on recent innovations in postharvest treatments of fruit in Australia and New Zealand, at a seminar organized by Fundacion Chile in Santiago.

Dr D. J. Casimir, FRL, is Visiting Professor at the University of Dijon in France, for a year, where he has been invited to set up a Food Engineering Laboratory.

Bhutan aid project

During the last two years FRL has been responsible for an Australian Development Assistance Bureau funded project to provide assistance in the development of postharvest facilities in Bhutan. The aid involved the training in Australia of five Bhutanese and the provision of equipment (*CSIRO Food Res. Q.* **40**, p. 43). This stage is almost complete.

Recently, funds (*c.* $500 000) have been provided by the Australian Government for the second stage of the project, namely the purchase and installation of equipment for the operation of a cool store complex for the Food Corporation of Bhutan (FCB) at Phuntsholing, the border town with India. FCB has financed the construction of the building which cost *c.* $300 000 and was designed and built by the Public Works Department of Bhutan with advice from FRL. The building is almost complete.

The cool store complex will hold 1000 t potatoes, 250 t seed potatoes and includes smaller cool rooms for apples, oranges, fish and dairy products. The complex will provide a storage for produce for sale in India.

Mr G. B. Morgan, FRL, and Mr J. Smith, a Consultant Works Supervisor, recently returned from Bhutan where they had discussions on the progress of the aid project and with Indian firms who are tendering for the installation of the equipment. It is hoped that the cool store complex will be commissioned by June 1982 to be ready for the next potato harvest.

Mr Morgan and Mr Smith, at the invitation of the Tasmanian Department of Agriculture, also inspected an apple cool store complex at Sopore, Kashmir. This complex is part of another Australian aid project managed by the Tasmanian Department of Agriculture.

General

The XIIIth International Botanical Congress was held in Sydney from 22nd to 29th August 1981, the first time the Congress has been held south of the equator. Over

3000 participants were registered, about half coming from 64 overseas countries. It was attended by over 20 members of the Division who presented symposium lectures and contributed papers and posters relating to the research of the Division's Plant Physiology Group. The opening ceremony was held at the Sydney Opera House where the Governor-General, Sir Zelman Cowan, performed the official opening. The President of the Congress was Sir Rutherford Robertson, a former leader of the Plant Physiology Unit of the Division. Several members of the PPG were involved in the organization of the Congress. Most of the sessions were held at Sydney University which formed an ideal venue for the many concurrent sessions. A notable feature was the attendance of a delegation of 33 from China, some of whom visited the Division prior to the Congress. The associated exhibitions included a live display of Australian native flowers, Chinese floral paintings, a philatelic display in which the postharvest fruit and vegetable section was contributed by a member of the PPG, a scientific instrument display, and botanical book exhibitions. Numerous field excursions, both local and Australia-wide, were also a feature of the Congress. The Congress afforded a unique opportunity for presentation and discussion of some of the research of the PPG to a world-wide audience.

Liaison with the food industry

In addition to regular liaison and extension functions fostered by the Division's three main laboratories and Tasmanian Food Research Unit, visits by members of food industry organizations to the laboratories are arranged from time to time.

The Food Industry Council of Australia (F.I.C.A.), which held its December 1980 meeting at FRL, was entertained to lunch by the Chief of the Division and Research Leaders and then inspected the laboratories during the afternoon. More recently, in July 1981, the Technical Officers Committee of the Confectionery Manufacturers of Australia Ltd. arranged a visit to FRL which followed a similar pattern.

In June 1981 the Victorian Division of the Australian Society of Dairy Technology held a meeting at DRL, focusing mainly on the use of computers in laboratories. Then in July 1981, DRL hosted a meeting of the Victorian Branch of the Australian Institute of Food Science and Technology. AIFST members were given a brief account of the work carried out at DRL and then shown over the Laboratory. They also took the opportunity to see the low energy house and some of the solar energy experiments being conducted at the CSIRO Highett site.

Awards

Dr J. R. Vickery, Foundation Chief of the Division and now Senior Research Fellow, has been elected a Fellow of the Australian and New Zealand Association for the Advancement of Science (ANZAAS).

At the 1981 Convention of the Australian Institute of Food Science & Technology, Mr Peter Board was presented with the AIFST Award of Merit. At the time Mr Board was leader of FRL's Applied Food Science Group; the text of his address to the Convention, reviewing the Group's work for the food industry, is published in Food Technology in Australia, Vol 33, No 6 (June 1981), pp 266–70.

Mr Dan Smith, MRL's Extension Officer based in Melbourne, has won a CSIRO Study Award for 1981 to investigate intermediate moisture foods on overseas markets.

Miss P. L. Conway, a Microbiologist in FRL's Food Safety and Nutritional Quality Group, has been awarded the Sherris-ASM Scholarship, to enable her to study the interaction of ingested potential pathogens and the gut ecosystem, with Professor Gorbach at the Tufts University, School of Medicine, Boston, Mass, for 3 months in 1982. The scholarship was sponsored by Dr & Mrs Sherris to allow a young Australian microbiologist to participate in research in the U.S.A. in the field of epidemiology or applied pathogenicity.

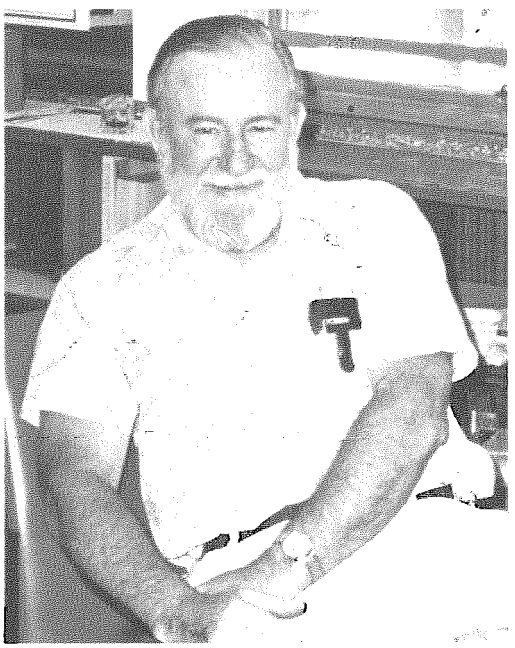
The E. W. Hicks Memorial Prize has been awarded for the first time to an apprentice. Mr B. J. Mann, apprentice fitter and turner, received the prize for 1981 for "the most meritorious academic record leading to a first post-secondary qualification". The Hicks Prize was established at FRL in 1960, following the untimely death, at the age of 52, of E. W. Hicks, an outstanding physicist and mathematician in the Division.

Obituary

Jack Shipton 1921–81

Jack Shipton died unexpectedly on 16 May 1981 at the Royal North Shore Hospital, Sydney, following a short illness. He was one of the group of young scientists who joined the Division of Food Preservation during its rapid expansion in World War 2.

Jack was born at St. Mary's, near Sydney, on 18 June 1921 but lived most of his younger years in the Murrumbidgee Irrigation Area. He graduated in 1942 from the University of Sydney with the degree of Bachelor of Agricultural Science and was appointed to the Division on 3 February 1943. Shipton worked initially in the rapidly expanding Dehydration Section on chemical aspects of dehydrated vegetables and on the storage of special army rations. With the end of the war, investigations on dried vegetables declined but by 1948, studies on dried fruits had increased and Shipton was co-leader of a small group working in this area until 1951.



Mr Jack Shipton

On 2 July 1951, Jack was seconded as Chief Food Technologist in the Department of Commerce and Agriculture. The term of secondment was initially two years and Jack's role spanned general administration, and planning and technical supervision of a wide program which included:
1) Development of equipment and processes for the commercial production of dried vegetables. An important defence laboratory, the Armed Forces Food Research Establishment at Scottsdale, Tasmania, grew out of this project.
2) Production of glucose-free powdered egg.
3) Toxicity of antioxidants used in foods. This project was sited at the University of Adelaide and brought together Jack and Dr A. R. Johnson in an association which was to continue for many years.
4) Development of special ration packs for the armed services.

During his secondment, Jack served on the Advisory Committee on Defence Food Research and the Commonwealth Food Specifications Committee. He was also the Australian delegate to the Food Working Group of the Commonwealth Advisory Committee on Defence Science and was responsible in Australia for liaison on Defence Food Research with other Commonwealth countries and the U.S.A. His initiative and administrative flair as well as his knowledge of food science and technology were well tested during this period of secondment but his determination overcame many difficult and frustrating situations. The period of secondment stretched to almost seven years and he returned to CSIRO on 12 May 1958.

Prior to his return, discussions took place on whether Shipton would take on the job of Officer-in-Charge of the Division's regional laboratory at Hobart which was in the course of expanding, but for personal reasons, he decided against acceptance. Instead he took charge of the Frozen Foods Section at the Homebush headquarters. He showed a keen appreciation of the needs of the expanding frozen foods industry but soon realized that the main problems lay in trying to elucidate the deteriorative changes in frozen foods.

With a small team he attacked this problem from a number of angles with most significant progress being made in the study of off-flavours, particularly in frozen peas.

In 1970, in one of the changes in research program that were made soon after the appointment of the new Chief, M. V. Tracey, Jack and his associated workers were incorporated in a Flavour Chemistry Group under the leadership of Dr K. E. Murray. Much of the success of this group was due to Jack's appreciation of food problems, his critical judgement and not least, to his manipulative skills at the bench. His part in the development of a series of distillation techniques which permitted the recovery of volatile flavours from foods, was notable.

In 1973, Jack Shipton started an investigation on new protein foods – a project which involved a study of extrusion and spinning processes for transforming vegetable proteins into meat-like products. In this, he was aided by John Last who worked with Jack for about 20 years.

In early 1977, Jack underwent very successful surgery for replacement of a heart valve. After recuperation, he gradually assumed the role of assisting Dr A. R. Johnson who was now Officer-in-Charge of the Food Research Laboratory of the Division at North Ryde. This supporting role was formalized by Jack's appointment as Scientific Assistant to the Officer-in-Charge in May 1979, a position he held until his death. His wide experience, constructive criticism and decisiveness made him a valuable ally to Alan Johnson and during the latter's absences overseas, Jack served in his stead on three occasions.

Jack undertook many duties peripheral to his scientific career. He was a foundation member of the Australian branch of the U.S. based Institute of Food Technologists formed in 1950, was a signatory to an application for the formation of a Southern Regional section in 1952, served on the committee of the Northern Regional section from 1960 to 1965 and was its branch chairman in 1962. He was made a Fellow of the Australian Institute of Food Science and Technology in 1972. He also held office in the formative days of the CSIRO Officers Association.

A love of the Australian bush which Jack acquired as a child at a one-teacher school in the MIA, grew with the years. Avidly encouraged by his wife Wilga, they made many trips into the Outback. Jack's eye for detail brought him great enjoyment particularly in areas of central and western Australia which are considered by many to be desolate. His heart surgery did not stop his travels into these less known parts of Australia.

Jack Shipton will be remembered for his critical perception, his decisiveness, his willingness to help people and his generosity. His knowledge of Australian wines was wide and his palate was discerning. He had planned to retire on 3 July 1981. Jack is survived by his wife, Wilga, and their daughter, Jennifer Leslie.

D. McG. McB.