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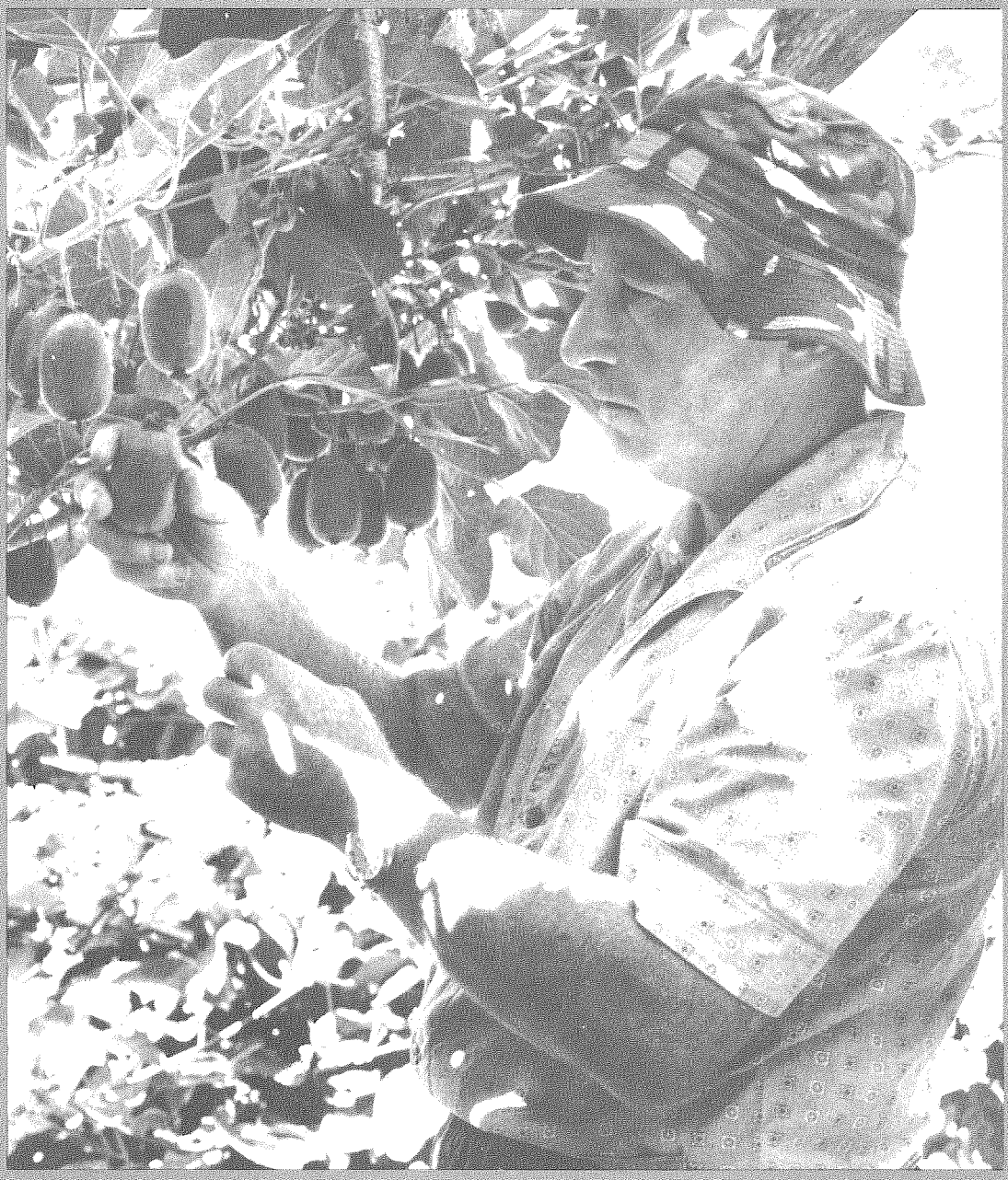

Two new maturity tests for Kiwifruit

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Kiwifruit (*Actinidia chinensis* Planch) is native to the mountains of southern China, where the wild plants exhibit considerable range in genetic material (Ferguson 1984). Commercial development of the fruit took place in New Zealand, with a number of cultivars being selected from seed. Long storage life was regarded as essential for the development of an export industry in New Zealand, so the cultivar Hayward, which has a storage life of at least six months at 0 °C, was adopted for cultivation. The Hayward cultivar is virtually synonymous for kiwifruit in the literature; other cultivars were rejected because of inferior storage characteristics (Baxter 1981).

It is not easy to determine when kiwifruit should be harvested, as colour and shape change little during the later stages of development. Fletcher (1971) recommended that, in New Zealand, the harvesting of export fruit should not begin before 1 May. Also in New Zealand, Pratt and Reid (1974) found the soluble solids content of freshly harvested fruit to increase in a linear fashion, from about 5.5% on 1 April to about 8.5% on 1 May. These authors suggested that harvesting could commence when the soluble solids level reached 8.0%; they proposed, furthermore, that the systematic increase in soluble solids might allow prediction of harvest date. Later work, which monitored changes in chemical composition during development (Reid *et al.* 1982), again supported soluble solids content as a useful indicator of maturity. However, no check was made on the relationship between chemical composition and eating quality.

The kiwifruit industry in New Zealand has adopted 6.25% soluble solids at harvest as the minimum level for export fruit (Harman 1981), and maturation of the crop is monitored by an industry based inspection service. Measurements must be taken immediately after harvest, because soluble solids increase as soon as the fruit is removed from the vine. In the United States the minimum maturity standard has been set at 6.5% soluble solids (United States Code of Federal Regulations 1985), although a recent study in California (Crisosto *et al.* 1984) has suggested that a composite measure of flesh firmness and soluble solids might provide an improved index of maturity.

The Australian industry has largely followed New Zealand practice in the production and marketing of kiwifruit, even though there are marked differences in growing conditions, and cultivars other than Hayward are important. Some planting material of the Hayward cultivar, imported from New Zealand, was found to grow more vigorously in New South Wales, and to produce fruit of a more elongated shape than the New Zealand Hayward. This "new" cultivar, subsequently named Dexter, is favoured in some areas because it requires less field chilling, and is early-bearing. Storage tests have shown Dexter to be only slightly inferior to Hayward (Scott *et al.* 1984).

Despite the disparity in conditions, some industry groups in Australia have sought to implement the New Zealand maturity standard, for both domestic and export fruit. This would require regulation by both Commonwealth and State authorities. In New South Wales alone, however, fruit is grown over a wide area and the cost of an inspection service would be prohibitive in relation to the value of the crop. Moreover, there is no evidence to indicate that the New Zealand standard is valid for fruit grown in the warmer Australian climate; nor is it known if the standard developed for Hayward is appropriate for other cultivars,

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such as Dexter and Bruno. The studies reported in this paper were carried out in response to industry requests that a maturity test be devised for Australian kiwifruit.

These studies were supported in part by a grant from the Rural Credits Development Fund of the Reserve Bank of Australia. The Australian Kiwifruit Association helped with supply of fruit. The late Arthur Kuskis assisted with the sensory testing, and we thank Michael Buckley, CSIRO Division of Mathematics and Statistics, for the statistical analyses.

Materials and methods

In 1982, fruit were obtained from several districts before and during the commercial harvest season, ripened by exposure to ethylene (10 µl/l) for 5 days at 20 °C, then assessed by sensory panels. Fruit ripened normally, and this ripening regime was used in all subsequent work.

Fruit collection

In 1984, fruit of the Dexter cultivar were collected from three orchards in the 'Hills District', near Sydney. At two of the orchards, five harvests were made over about two months; six harvests were made at the third orchard. At each harvest and at each orchard, 20 fruit were taken from each of 10 vines. Soluble solids at harvest ranged from 4.8 to 11.9% (orchard 1), 5.2 to 14.0% (orchard 2), and 5.5 to 10.1% (orchard 3).

In 1985, fruit of the three cultivars Hayward, Dexter, and Bruno were obtained from each of three areas in New South Wales: the Hills District, Coffs Harbour, and the far north coast. For each cultivar, fruit were obtained from two orchards within each area. Three harvests were made at each orchard. Thus, the design provided for a total of 54 samples (3 cultivars x 3 areas x 3 harvests x 2 orchards), each consisting of 80 fruit (in actuality 53 samples were evaluated).

Sample preparation

After harvest, samples were transported to the CSIRO Food Research Laboratory. Ten fruit from each harvest-sample were peeled, diced, frozen in liquid nitrogen, then held under dry ice until subsequent analysis. Further samples were treated similarly after immediate ripening, and also after storage at 0 °C and subsequent ripening.

The samples for sensory evaluation were either ripened immediately after harvest, or held in commercial packs for two months at 0 °C then ripened. After ripening, fruit was held for a few days at 0 °C before sensory testing.

Small samples of imported fruit were also purchased at the wholesale markets; these were ripened in a similar manner to the local fruit.

Sensory evaluation

The sensory panels comprised men and women employees of the CSIRO Food Research Laboratory, all of whom liked kiwifruit; 30 served on the 1984 panel, 20 in 1985. Most had had some experience in the sensory evaluation of food, though not necessarily with kiwifruit. At every session, each panellist evaluated a small number of half-fruits from different experimental samples. Only one cultivar was evaluated at each session.

Panellists assessed their liking for flavour on a 150 mm graphic rating scale. Three descriptors were attached to the scale: Extremely poor (0 mm), Satisfactory (75 mm), and Extremely good (150 mm).

Physico-chemical analyses

Chemical composition of samples was determined by standard techniques: soluble solids by refractometer (Harman and Watkins 1981), acid by titration with 0.1 N sodium hydroxide (AOAC 1980 method 22.061), sugars by high-performance liquid chromatography (Wade and Morris 1982), starch by colour development with iodine (Nielson and Gleason 1945), and total solids (dry matter as % of fresh weight) by oven drying (AOAC 1980 method 22.018). The last method was modified slightly, the samples being dried in an air oven at 70 °C before vacuum oven drying. Fruit firmness was measured with an 8 mm penetrometer.

Results

Soluble solids

Soluble solids of the 1984 samples increased as the fruit were left on the vine (Fig. 1, lower curves). The increase was slight from late February to early April, but became more pronounced during April and May. At harvest there were only small differences between samples from the three orchards.

In contrast, for samples that were harvested then ripened with ethylene (Fig. 1, upper three curves), there were marked differences between orchards: in February the soluble solids content of fruit from orchard 3 was approximately 17%, whereas

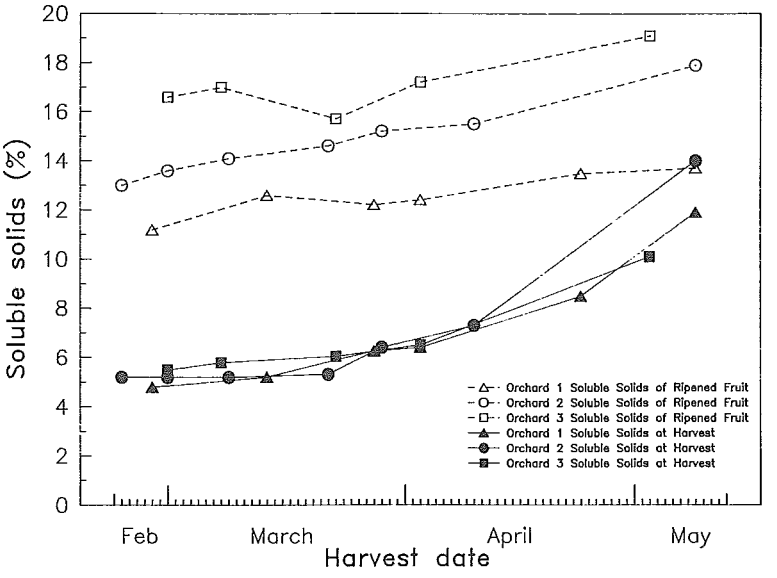

Fig. 1. Percentage soluble solids of kiwifruit (Dexter cultivar, 1984 samples) plotted against harvest date. Data shown are for both unripened (filled points) and ripened (unfilled points) fruit.

that for fruit from orchard 1 was only 11%. This difference was maintained as the season progressed, and overshadowed the slight upward trend in the top three curves. Thus, some ripened fruit (orchard 3) were of higher soluble solids content in February than other fruit in May (orchard 1).

The relationship between soluble solids after ripening and soluble solids at harvest is shown in Fig. 2. Data for the Hayward cultivar in New Zealand (Harman 1981) are included for comparison. For each orchard, there is clearly a positive correlation between soluble solids after ripening and soluble solids at harvest; however, the differences between orchards are such that soluble solids at harvest is a poor predictor of soluble solids after ripening.

Flavour ratings versus soluble solids at harvest

Although there was a tendency for panellists to rate the 1984 samples from the same orchard higher when soluble solids at harvest were higher (Fig. 3), the overall linear regression was not significant (r = 0.24, n = 30). For the more comprehensive 1985 study, Fig. 4 likewise demonstrates that there was no significant correlation between flavour rating and soluble solids at harvest (r = 0.16, n = 53). Clearly, soluble solids at harvest is a poor predictor of ultimate flavour quality — at least for samples gathered from a number of orchards in New South Wales.

Flavour ratings versus soluble solids after ripening

Figs 5 and 6 show the relationship between flavour and soluble solids content of ripe fruit for the 1984 and 1985 seasons, respectively. The regression was significant in all cases. In 1984, for Dexter fruit, the overall regression was highly significant (r = 0.77, n = 35, $p < 0.001$). In 1985, the individual regressions for Bruno (r = 0.81, n = 18), Dexter (r = 0.65, n = 18) and

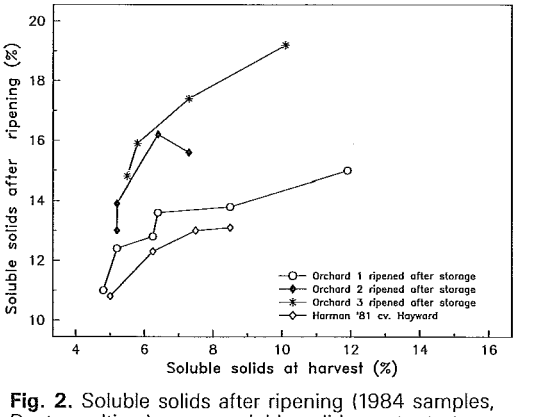

Fig. 2. Soluble solids after ripening (1984 samples, Dexter cultivar) versus soluble solids content at harvest (i.e. before ripening).

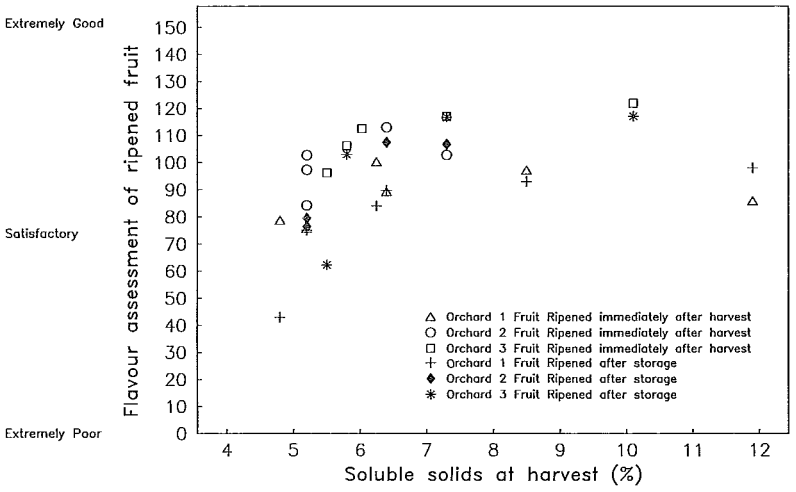

Fig. 3. Flavour rating (Dexter cultivar, 1984 samples) versus soluble solids content at harvest.

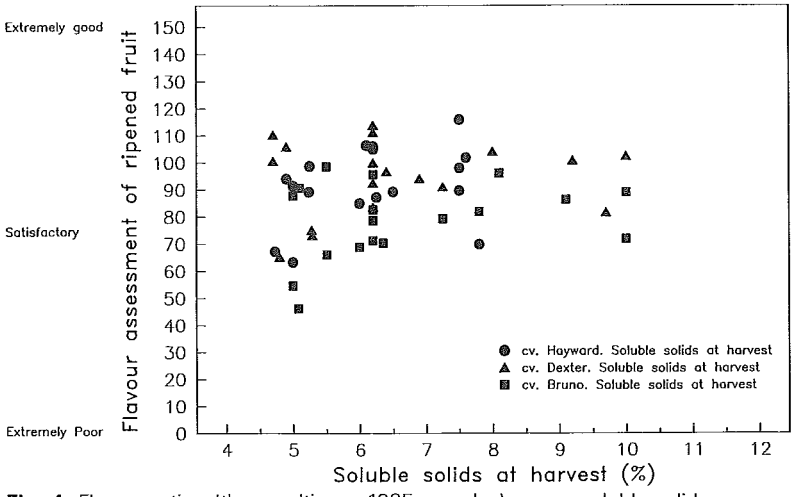

Fig. 4. Flavour rating (three cultivars, 1985 samples) versus soluble solids content at harvest.

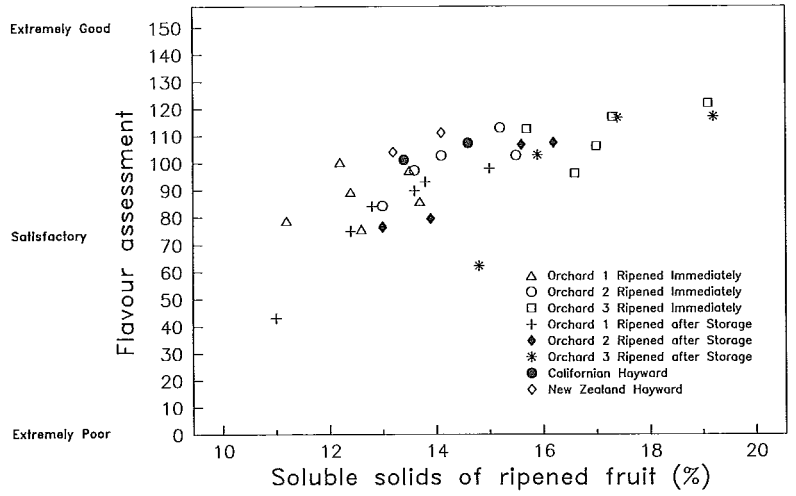

Fig. 5. Flavour rating (Dexter cultivar, 1984 samples) versus soluble solids content of ripened fruit.

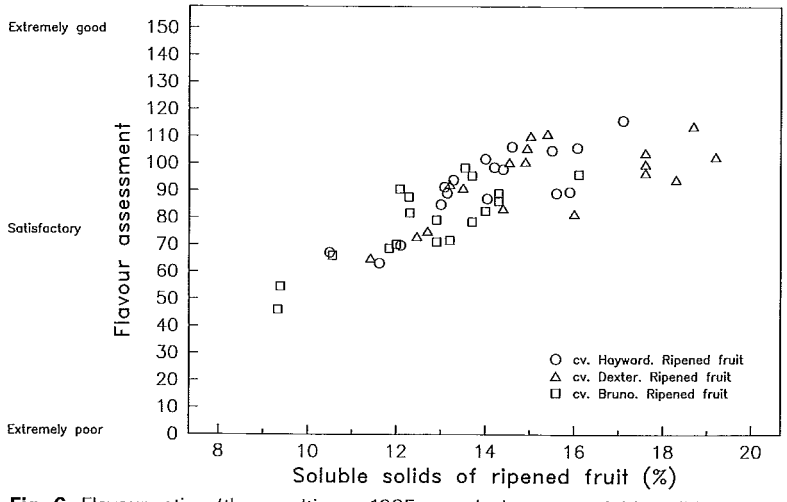

Fig. 6. Flavour rating (three cultivars, 1985 samples) versus soluble solids content of ripened fruit.

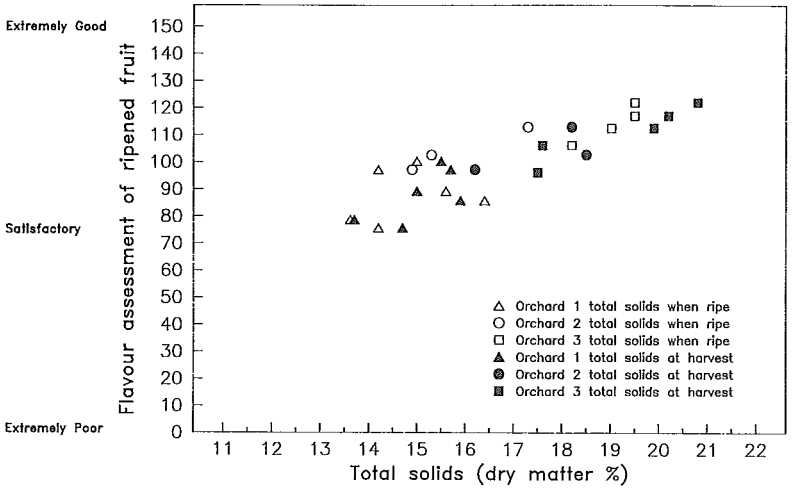

Fig. 7. Flavour rating (Dexter cultivar, 1984 samples) versus total solids (dry matter) content.

Hayward ($r = 0.83$, $n = 17$) were all highly significant ($p < 0.001$), as was the overall regression ($r = 0.79$, $n = 53$).

Flavour ratings versus total solids (dry matter)

Ripened fruit of high total solids content were consistently given high flavour scores; samples of low total solids were given poor flavour scores (see Figs 7 and 8). The regressions of flavour rating on total solids were significant in all cases. In 1984, the correlation for Dexter fruit was highly significant ($r = 0.91$, $n = 13$, $p < 0.001$) at harvest, and highly significant ($r = 0.81$, $n = 14$, $p < 0.001$) after ripening.

In 1985, for samples at harvest the regressions for Bruno ($r = 0.73$, $n = 18$), Dexter ($r = 0.61$, $n = 18$), and Hayward ($r = 0.69$, $n = 17$) were all significant ($p < 0.01$). The overall regression was also highly significant ($r = 0.73$, $n = 53$, $p < 0.001$). For ripened fruit, the regressions for Bruno ($r = 0.78$, $n = 18$, $p < 0.001$), Dexter ($r = 0.51$, $n = 18$, $p < 0.05$), and Hayward ($r = 0.90$, $n = 17$, $p < 0.001$) were significant, as was the overall regression for ripened fruit ($r = 0.77$, $n = 53$, $p < 0.001$). For predicting flavour quality, therefore, it mattered little whether total solids were measured at harvest or after ripening (see Figs 7 and 8).

Other attributes

The firmness of Dexter fruit was measured at harvest, from early March to mid-May, 1984 (Fig. 9). There appears to be a difference between orchards (cf. Fig. 1), but there was no systematic change in firmness as the season progressed. The

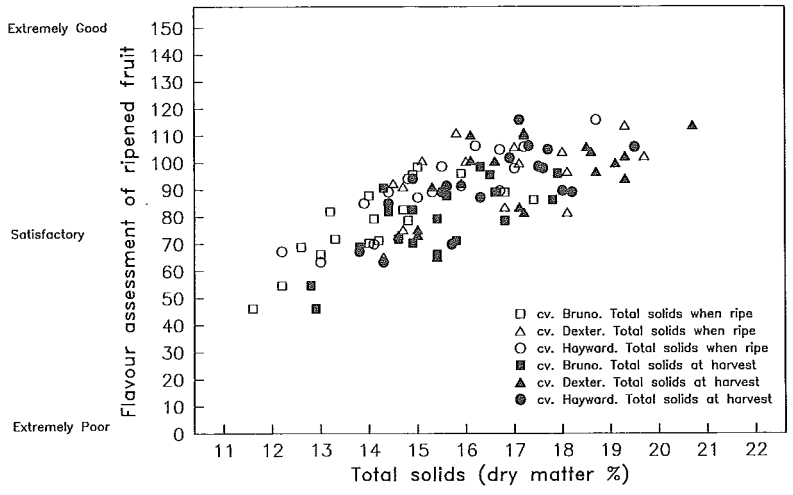

Fig. 8. Flavour rating (three cultivars, 1985 samples) versus total solids (dry matter) content of fruit at harvest, and when ripe.

decrease in firmness in mid-March occurred after a period of rain.

Neither the correlation between flavour rating and titratable acidity ($r = 0.25$, $n = 53$; see Fig. 10), nor flavour rating and starch content at harvest ($r = 0.16$, $n = 9$) was significant. There was no systematic relationship between flavour rating and concentrations of the individual sugars sucrose, fructose, or glucose at harvest.

Discussion

The data presented in this paper indicate that soluble solids content at harvest is of little use in predicting the quality and maturity of Bruno, Dexter, and Hayward cultivars grown in New South Wales.

However, the soluble solids content of *ripened* fruit, and the *total solids* content of the fruit, were indeed found to be useful predictors of flavour quality and harvest maturity. If a flavour score of 75 (satisfactory) is taken as the minimum level of acceptable flavour, then Figs 5-8 suggest that the ripened fruit become acceptable when their soluble solids content reaches 12%, or when the total solids content reaches 15%. The cultivars were similar with respect to the level(s) at which they became acceptable, although Dexter and Hayward developed acceptable levels more often than Bruno.

The soluble solids content of ripened fruit appears to offer growers a satisfactory means of monitoring maturation, particularly during the early part of the season. Samples should be collected from a representative number of vines, either exposed to ethylene gas or dipped in Ethrel (Ciba-Geigy), then allowed to ripen for 4-5 days. Soluble solids content of the ripened fruit is readily determined by refractometer.

Although this method could also be used for regulatory testing, the 4-5 day delay would be a disadvantage. In this instance it would be more appropriate to use total solids content: provided a drying oven is available, a reading could be obtained 24 hours after harvest. Use of a microwave oven would reduce the delay still further. We have no data on the microwave-drying of kiwifruit, but the method is effective on avocados (Morris and O'Brien 1980), for which it is now used in regulatory testing.

The total solids method has the important practical advantage of working for both ripened and unripened fruit, fresh or stored. Furthermore, the total solids content appears to correlate with flavour score in much the same way for all three cultivars, implying that a common criterion may well be applicable. More work would be needed to establish the exact value of this criterion.

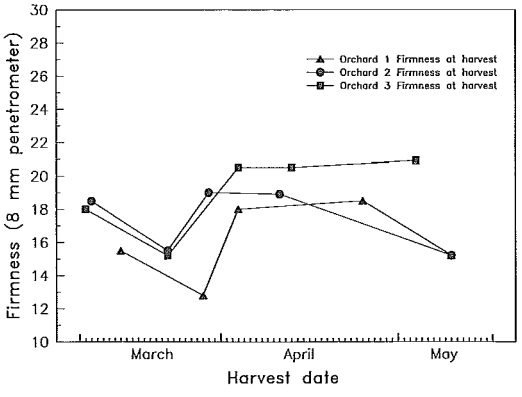

Fig. 9. Firmness of kiwifruit (Dexter cultivar, 1984 samples) versus harvest date.

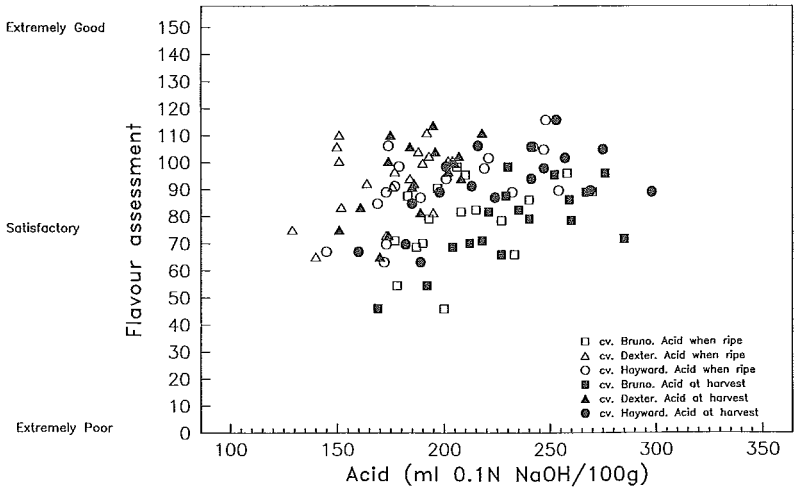

Fig. 10. Flavour rating (three cultivars, 1985 samples) versus titratable acidity at harvest.

In the meantime, it is recommended that growers in New South Wales consider using the new maturity tests voluntarily. The adoption of these tests is likely to improve the quality of fruit offered for sale, and may allow the marketing of some fruit earlier in the season, when there is less competition and market prices are higher. It is important, however, that all early-harvested kiwifruit be treated with ethylene to initiate ripening before sale. Ethylene treatment could be effected at major wholesale markets simply by placing the fruit in banana ripening rooms for 2 days. This would ensure that the consumer obtains high quality fruit, ready for almost immediate consumption.

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(Preamble)

The Seafood group of the CSIRO Division of Food Research, of which Mr Thrower is a member, was transferred to the CSIRO Division of Fisheries Research on 1 March 1986.

Research on seafoods in the Division of Food Research began at Homebush, NSW, in 1938 and was continued at North Ryde, NSW, when the Division was relocated in 1961. Some research on fish and lobsters was carried out in Hobart during the early 1950s. It restarted there in 1963 and expanded steadily. At the time of transfer to the Division of Fisheries Research, the Seafood group, led by Dr J.N. Olley, had a staff of ten, including six professional scientists.

(JHBC 4/4/86)

A strategy for an industry liaison service for the Australian seafood industry

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A strategy for the provision of extension services to the seafood industry has been devised to assist in translating the results of research into industrial practice. Mechanisms for the collecting and dissemination of information are described as well as the need to make provision for effective communication of results to industry when planning research programs.

Introduction

The seafood industry is at present caught in a spiral of increasing costs, particularly for labour and fuel, and relatively static prices for its products. More than ever before the keyword is 'control', control of quality, control of waste, control of staff, control of finances and control of plant and equipment at all stages of production. Effective control requires reliable information. The development of relatively cheap computers and database systems provides a mechanism for monitoring performance and collecting and accessing vast quantities of information.

The effective use of information depends on the skill and experience of the people using it. This paper describes an information service developed by the Tasmanian Food Research Unit (TFRU) to serve the needs of the Australian seafood industry. It is intended to assist in bridging the gap between the research scientist and the seafood consultant and so provide some insights into the problems encountered in technology transfer.

The CSIRO Tasmanian Regional Laboratory has a long history of involvement in seafood research. In 1951 two technical officers from the then Division of Food Preservation were sent to "Stowell", one of whom was assigned the task of investigating ammonia production in shark (McBean *et al.* 1977). From 1963 seafood research became an increasing part of the Division's work in Hobart and by 1985 the TFRU had a staff of ten who work exclusively on seafood. Funding for the Unit relies heavily on grants from the Fishing Industry Research Trust Account (FIRTA) which supplies the salaries of four staff members and provides most of the Unit's operating funds. The success of the TFRU in attracting FIRTA grants has been attributed to the readiness with which its officers respond to industry problems (Connell, personal communication). The designation of an industry liaison officer for seafoods in 1984 gave added impetus to this activity.

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The Australian seafood industry

The Australian fishing industry is small in comparison to other primary industries. It has been estimated that the total investment in vessels, processing works etc. is about A$500 million, yielding an input into the gross domestic product of about A$900 million. The industry is however highly decentralized and has a large multiplier effect, employing 200 000 people directly, of whom 25 000 are actually employed in fishing (Anon. 1985).

The industry is heavily reliant on invertebrate species notably prawns, rock lobsters, scallops and abalone. Landings of finfish are lower and a considerable quantity of such material is imported. Such local finfish as is caught is readily absorbed by the fresh fish markets in metropolitan centres. Australian fishing companies have traditionally been commodity suppliers who simply pack and freeze raw material. Those companies which do produce value added products use mostly imported raw material that is cheaper, better presented and more readily available than the local product.

High costs of labour and fuel, low prices, low per capita consumption, and lack of productive fishing grounds are usually cited as reasons for lack of interest in finfish production. There is, however, some evidence of growing interest in the domestic market, brought about by the popularity of well presented, reasonably priced products from New Zealand. If that interest continues, opportunities for import replacement will prompt more interest in catching finfish.

A seafood liaison service

The diverse nature and the geographical spread of the Australian seafood industry present special problems in operating a liaison service. Wherever the service is based it will be remote from most of the industry. Officers must be prepared to travel widely, a costly operation. A network of contacts throughout Australia must be set up to provide a link between 'clients' and the liaison service.

The TFRU receives enquiries from many sources, fishermen, processors, consultants, the State and Federal government agencies and the CSIRO itself. Recently an expansion of the Bureau of Scientific Services of CSIRO has led to the appointment of Industry Liaison Officers in each State whose task is to refer enquiries to the relevant Division. An information network called INFOLINK has been set up using the national CSIRONET computer service to provide technical information and a directory of experts who can advise on specific topics. Access to this service is available to the public through the CSIRO Central Information and Library Service.

Sources of information

Obviously the scientific library is the major source of information on technical subjects. On-line computer searches can be used to quickly scan the more recent literature to identify relevant articles in publications held in local and overseas centres. If necessary these articles can then be requested from their source. These databases do not, however, access older publications.

A large amount of information is held at the Tasmanian Regional Laboratory in the library and in the private collections of individual staff. Whilst the library collection is catalogued, private collections are not. A constant stream of new material comes into the TFRU as a result of reprint requests etc. that arise from research work and industry enquiries. In order to facilitate ready access to information, a local database system has been set up.

In addition to published sources of information such as books and journals, there is a great deal of information that comes from other less formal sources, and indeed such information may be the most useful in some industry applications. It is not, however, freely available. The tight strictures imposed by referees and editorial staff often cut down on details in published articles, details which are essential for effective implementation of new technology. Publication of industrial research is sometimes delayed to keep faith with collaborating companies which would otherwise be placed at a commercial disadvantage by early disclosure.

Information comes from visits to companies, consultations with industry personnel, and collaboration with consultants, academics and other professionals in the field. Much of this information is not verified but is based on observations made by non-scientific people in circumstances that are not easily duplicated or simulated. Such information, although sometimes superficial, can be scrutinized by experienced professionals and may be useful in assisting industry. It could be rather ephemeral, relying as it does on the memory

of a small number of people. In order to overcome this difficulty a number of internal documents have been devised.

Food Research Reports

For many years these reports have been used to transmit the results of applied research to industry. There is a varying level of confidentiality for each report which depends on the type of information contained and the wishes of the companies concerned.

Information Statements

If frequent enquiries are received on the one topic a brief statement is drawn up which seeks to present the best available knowledge on that subject at that time. These statements are revised as new information becomes available. They are sometimes regarded as confidential when such material has been requested in confidence by companies and its disclosure would be unethical.

Some information is also sensitive in that the veracity of the observations has often not been tested by scientific experimentation. Information of this kind does, however, form an important part of the knowledge that a liaison officer brings to bear in his consulting service and can be very valuable in the planning and execution of research programs.

Advisory services

There is an important distinction between information and advice. As described above, information is a body of facts to which a person has access, through his own experience, through experimentation, observation, reading the literature, consulting a database or another person. Advice, however, is the selection of the available information that a consultant decides to take cognizance of when confronted with a problem in an effort to assist in solving that problem and the conclusions he arrives at from that cognizance. The paths that lead to the formulation of advice are often tortuous and may involve both deduction and intuition. It is useful to set out clearly the logic that went into a decision so that this can be revised at a later date if necessary.

An essential factor in the formulation of advice is the experience and training of the officers concerned. The staff of the TFRU come from a range of disciplines, biochemistry, industrial chemistry, metallurgy, microbiology and engineering. This means that there is a wide pool of knowledge and experience available that can be brought to bear on most problems. At the same time the Unit must continue to pursue research goals if the knowledge base of its staff is to remain relevant.

Dissemination of information

For some years the staff of the TFRU has been experimenting with different methods of disseminating information to industry. Courses on handling and quality control funded by the Australian Department of Primary Industry have been run by TFRU staff in several ports. The response to such courses has been variable, in general most people who are successful in the seafood industry are too busy to spare the time to attend a specialist course, and it is difficult to tailor a course to meet the needs of the variety of those people who do attend. Officers of the Unit are often invited to present papers at seminars etc. organized by other organizations on related fishing topics such as net making, echosounder operation etc. These forums are usually well attended because they address the needs of participants more directly. Often, however, one segment on seafood handling in such a course is often seen as a diversion from the major topic of the course and it is difficult to get the message across.

Publication of articles in journals read by the industry would seem to be a good way of reaching an audience, but this is not always the case. In discussions with fishermen and processors, it often becomes obvious that the articles so carefully written and refereed, are ignored by the industry. One of the reasons for this is the complicated nature of the material. Long descriptions of factorially designed experiments are anathema to even those industry people capable of understanding them. Careful phrasing to ensure that the text fits the statistically derived results often tries the patience of more pragmatic minds, and is regarded as esoteric rambling. I have seen more direct results from a practical one column article I wrote on icing scallops than from any of my other papers. The reason for this is obvious, the icing system described was simple to follow and resulted in an immediate two-day increase in time available for fishing.

It might seem that the best time to get the attention of industry would be when things have gone wrong and a trouble shooting exercise is in progress. To some extent this is

the case but it should be remembered that at such times the efforts of all concerned are directed at solving the problem in hand. Sometimes this will entail a broad consideration of the whole operation, but eventually it will be restricted to a few key points. A processor who is worrying about loss of production is unlikely to lend a sympathetic ear to a long discourse on the deficiencies of his quality assurance procedures.

Officers of the TFRU are often invited to visit to "look over" a factory. Such visits provide a good opportunity to assess the operation and occasionally make a few suggestions. It is important to restrict the suggestions in both scope and number to avoid overwhelming the client.

Sometimes officers of the TFRU become involved in the establishment of a fishing venture at the planning stage. This provides an excellent opportunity to work in with the principals, architects, building contractors and refrigeration engineers to see that conditions are right for safe, efficient design to produce good quality product.

Fishermen often ask for advice on fish handling, usually when they have just bought a boat. It is more effective to discuss handling systems etc. on the boat rather than try to visualize the layout from enthusiastic descriptions. A visit to the boat will allow the officer to ascertain the layout exactly, taking into account such details as the size, headspace, nature of the vessel, deck surface etc. (Thrower, unpublished data).

Technology transfer

The implementation of the results of research findings in Australia has come under frequent criticism in recent times. A study of science policy commissioned from the Organization of Economic Cooperation and Development (OECD) showed that whilst the proportion of the gross domestic product spent on basic and applied research in Australia was roughly equivalent to that in other developed countries, that spent on experimental development is much less (Table 1). Australia produces 2% of the published scientific papers in the world but only 0.7% of the patents. It would appear that companies in Australia are reluctant to use the results of local research but would rather import technology from overseas at considerable cost (OECD 1984).

Processors cite ready availability of published material to competitors and the lack of costing information for their reluctance to capitalize on the results of innovative research. Mechanisms for ensuring the confidentiality of some research have already been discussed. A coordinated research and development program covering biological, processing and marketing aspects that was successful in establishing a fishery for underutilized ocean pout (Sheehy *et al.* 1977) provides an example of good development follow-through. Perhaps provision should be made to employ consultants in appropriate programs to extend research results. Such an initiative was taken in a project on abalone aquaculture in Tasmania. A booklet on costing abalone farming (McMullen and Sumner 1985) assisted investors in presenting a business plan to financial institutions and resulted in rapid adoption of the technical aspects of the research.

TABLE 1

Apportionment of gross domestic product spent on research and development

Type of research	Percentage of gross domestic product		
	OECD	USA	Australia
Basic research	0.24	0.30	0.33
Applied research	0.46	0.54	0.41
Experimental development	0.65	1.50	0.21
Total	1.35	2.34	0.95

Source: OECD (1984)

Conclusion

Many of the answers to the technological problems facing the seafood industry have already been found. They are not adopted because of ignorance and conservatism. Gains which will determine the viability of the industry will come from increased yields, reduced labour, development of value added products and premium prices for high quality products. Collaboration between scientists and industry must be developed if such benefits are to be realized.

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Relationship between industry and regulatory bodies in establishing standards

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Introduction

The involvement of industry in setting standards is not essential — many seem to have been set in the past without it. However, if the objective of standards is, as it should be, to help assure a safe, wholesome food supply at minimum cost, then industry involvement in setting those standards is highly desirable.

Philosophically, industry will naturally be more relaxed about standards that its members have had the opportunity to discuss before promulgation, whether or not their views have been accepted. However, it is the practical rather than the philosophical aspects of industry involvement that concern us here — what should be the nature of industry input?

This discussion will be centred on the food industry and it must be appreciated that where microbiological standards are concerned we should be considering both food manufacturing and food service activities. Any principles that are established should be largely applicable to other industries for which microbiological standards are appropriate.

The setting of microbiological criteria has been considered at length by WHO Consultations (WHO 1983) and the Codex Committee on Food Hygiene which makes recommendations to the Codex Alimentarius Commission on the microbiological component of food standards. The general principles for the establishment and application of such criteria were accepted by the Commission several years ago (Codex Alimentarius Commission 1981) and, although they relate basically to Codex needs, they may be applied at national level with advantage. I will now look at these principles and suggest where and how the industry may contribute to the process.

General principles

Microorganisms of concern

Where a food is a potential health hazard, given, say, temperature or other abuse, the pathogens of concern will generally be known as well to regulatory authorities as to the producers. Industry recognizes that it has to produce a product that is safe both chemically and microbiologically. It knows that the association of illnesses with a food product that it produces can be an economic disaster and can even erase that product from the marketplace. For this reason industry usually has no argument with microbiological standards for pathogens in foods which are proven to be, or are potentially, hazardous.

The sometimes vexed question of indicator organisms frequently needs extensive discussion between the two parties. For standards to achieve credibility with the food industry, there must be a clearcut relationship between the occurrence of the indicator organisms and the pathogens in the food, e.g. the significance of *Escherichia coli* in water cannot be extrapolated willy-nilly to any food.

The organisms that limit shelf-life will be the particular concern of the industry and are

best identified by them. However, the question of whether organisms other than pathogens should be in standards that are set as health standards is debatable. There is a tendency for standards that are set for different purposes to be lumped into health standards and this causes major problems. The General Principles state that standards should cover only pathogens, with indicators accepted if no appropriate tests for pathogens are available.

Let me give an example of problems caused by establishing microbiological standards related not to safety but to quality. An industry, in an effort to produce a very high standard for a national product which is being exported, may set down a number of criteria which are all related to an extremely high standard of manufacturing practice. It will earmark for export only that product which meets these criteria. Then the problem arises — what to do with the rest of the product, which in fact does not present a health hazard. Should it be considered as a second-rate product to be sold at a cheaper rate? Apart from their microbiology, the products accepted and not accepted may be indistinguishable. Involvement of regulatory bodies in such matters can greatly confuse the issue.

Analytical methods

Microbiological standards require standard methods, and these are frequently chosen by bodies distinct from those setting the standards. Wherever the choice is made, industry involvement is essential to ensure that the methods are practical, accurate and reproducible under the conditions that prevail in the laboratories of both industry and government. Both should be involved whenever inter-laboratory trials are undertaken.

Sampling

Agreement on the number and size of samples to be taken can usually be agreed fairly simply, taking as a basis the Cases defined by ICMSF (1974). However, there are major problems, from the points of view of both regulatory authorities and industry, in the sampling of foods traded in large bulk. The cost of sampling x 44-gallon drums of a product or y 40-lb cheeses, which can be subject to spoilage after sampling or can be made to appear defective by the sampling procedure, is not appreciated by the food industry. It is very necessary to have consensus here between the regulatory body and the industry on the procedures to be adopted.

Determining when sampling should be done can also be very difficult, especially with foods with microfloras that change significantly with time, either towards spoilage as with fresh foods or towards maturation as with fermented foods. The industry viewpoint on these matters is essential.

Microbiological limits

Before sensible limits can be set, a very large range of data on microbial populations needs to be considered. These data should come from as many plants as possible and be correlated as well as can be with adherence to Good Manufacturing Practice (GMP). Only industry can provide these, but it will expect, for some of its data at least, that confidentiality be maintained.

Industry input here should ensure that the variations that can exist in processing a particular product, all under GMP, and that result from the use of raw materials from different sources are all taken into account.

Concern is sometimes indicated about the reliability of data that members of a competitive industry will provide. Will they be selective data, chosen to give an impression of a very high microbiological quality on the one hand, or a low (and hence always achieved) level of quality? The temptation for such practices must be very slight. The required data are usually available only from the more technologically advanced and better controlled plants, where the quality should be uniformly high. Data that encourage loose standards would favour less competent competitors. Experience suggests that instances of unreliable data are very rare.

Number of samples to conform to limits

As with sampling, this can be determined from a study of the Cases (ICMSF 1974).

General considerations

The General Principles also list several general considerations that should be taken into account when deciding on the need for criteria. Industry input is important in the following:

Evidence of hazards to health

Clearly, if a food has caused health problems, the regulatory authorities should be well aware that it is a hazard, and for what reason. However, foods that have not so far been thus incriminated will often come under

notice as potential hazards because of their particular properties or likely responses to abuse. In such cases, involvement of the industry in abuse trials may provide data on which amicable decisions can be reached.

It should be noted that there may be two types of "abuse" after a product leaves the manufacturer:

- it may be abused in respect of transport, storage, and handling in the hands of the retailer, and
- it may be abused by the purchaser either in respect of the same factors, or during or after further manipulation, e.g. cooking. It is sometimes difficult to decide the limit of the manufacturer's responsibility here. In some cases, e.g. the infant food/*Salmonella* problem, the industry accepts that its product must be "completely" safe, and that any hazards are the result of rehydration and handling deficiencies.

Turning from abuse back to evidence of hazards, an example of setting a standard without this evidence is the standard for frozen precooked complete meals, suggested by the forerunner of ICMSF in 1962. It was, and is, a completely rational standard, based on the apparent ease with which temperature abuse could occur, but such foods have consistently failed over the years to live up to their (then) reputation as a major hazard if mishandled. That standard has rarely been applied because of absence of evidence of hazard, although a similar standard has been used for certain seafoods. Even here, many would argue that its use has not been properly justified.

Microbiology of raw material

An obvious area for industry input, as raw materials can be major sources of hazardous microbes.

Effect of processing on the microbiology of the food

This is of profound importance, whether the process be one that reduces, stabilizes or increases the microbial population. Processes differ in detail from one plant to another, although the same GMP and Critical Control Points may apply. The microbiology will thus also differ, and industry input is necessary to encompass the range of industry situations.

The likelihood and consequences of subsequent microbial contamination and/or growth

Industry experiences in this matter will greatly assist in decision-making on microbiological standards.

The category of consumers at risk

Foods for special groups of sensitive consumers are usually so labelled. However, the processor's market research may indicate wide use of other foods by such groups, perhaps justifying standards of increased stringency.

Interpretation of results

When a product fails to meet a standard, it is rejected as unfit for its intended use. The fate of such food is of great concern to both the agency and the producer and will depend upon the nature of the defect. The options available might include sorting, reprocessing, and destruction. Clearly, industry's perception of the appropriateness of such options would be of the greatest relevance. Normally, instructions on further action on reject product are not included in standards. However, future standards relating to salvage of certain products could cover this important aspect.

Sampling methods, reporting and reviewing

The General Principles also refer to the taking and handling of samples, details of reporting and the need to review standards at regular intervals. Industry clearly has a role to play in deliberations on each of these. Changes in technology, in particular, may justify the rethinking of relevant standards.

Making it work

Industry-government cooperation

From the above considerations, it seems clear that there are few aspects of standards-setting that will not benefit from industry involvement. National and like standards are set by governments, generally on the advice of expert committees. It is a minimal and simple requirement that industry be represented on such bodies. While such representatives can be an excellent source of information about the industry's general philosophy and attitude to particular standards proposals, their individual database may be small and very narrow.

The accumulation of data from across an industry, covering both major producers and smaller enterprises, requires a collection centre that has the confidence of contributors and that can guarantee confidentiality. Most commonly this is handled by an industry association, which, at the request of the advisory group, can seek specific data from its membership. These are coded to ensure anonymity and sent to the advisory

committee to be used in its deliberations. Draft standards should be circulated to industry, regulatory authorities and other interested bodies for comment at least once before the standard is recommended for adoption.

Within Australia there are excellent examples of this type of procedure. The Food Standards Committee (FSC) of the National Health and Medical Research Council, which recommends food standards to the States and Territories and, more recently, for inclusion in the Model Food Legislation, has on it a representative of the Council of Australian Food Technology Associations (CAFTA), a food industry body. It is predominantly through CAFTA that FSC communicates with the food industry to request information, to receive submissions and to obtain comment on draft standards which are normally circulated to industry at least twice during development. When appropriate, similar exchanges occur with more specialized industry bodies, such as the Australian Dairy Products Standards Organization (ADPSO). The FSC Subcommittees also have industry members, usually as individual experts.

At the international level, direct industry input into standards established by the Codex Alimentarius Commission may be a little more difficult to achieve. It is thus essential that government representatives are fully acquainted with, and hopefully in sympathy with, the attitudes of their industries to any proposals under discussion. In Australia, this input is provided through Codex Panels with strong industry representation which assist in the preparation of briefing for Australian delegations to Codex Committees. The recent development of informal consultations on WHO/Industry collaboration for the improvement of food safety has greatly increased the prospects for industry involvement at the international level and is to be commended.

There is no doubt that bad standards are not long enforced. They are a waste of time and money and may cause resources to be diverted from more useful tasks. Good standards require the collaboration of industry to make them work and even more to establish them in the first instance. The main operational difficulty may be to obtain from industry data that are truly representative of the full range of the food being produced.

Self-regulation

It could be said that the food industry is tending to become self-regulating. In this era of bulk buying, bulk transport and bulk storage, it is economically very important to achieve a maximum shelf-life. Both the chemical and microbiological state of the product as it leaves the factory need to be controlled to achieve this. To this end, industry must develop its own code of manufacturing practice, its own quality control program, and the policing of its own internal standards. This may also apply to storage and transport depending on the point of sale.

This of course raises the problem of the role the retailer plays in maintaining quality and how this is controlled. The problem of quality standards that can be applied to food products *at the point of sale* after the product has been through the distribution channel is one that has for some perishable foods yet to be successfully addressed.

The overall result

It needs to be remembered that in the processing of foods there are many factors other than microbiological status to be taken into account. For instance, it is possible to produce dehydrated carrot to very tight microbiological criteria which will be a very pale-coloured product. A major factor in the sale of this product is colour, and a purchaser will buy a highly-coloured product irrespective of its higher bacterial counts. Thus one of the contributions that the industry can make when establishing standards is to persuade the regulatory authorities that microbiology is not everything!

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The fatty acid composition of fish from the North West Shelf of Australia

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Introduction

The inclusion of fish or fish oils in the human diet has received increasing attention in recent times. Fish lipids, particularly those of marine origin, are a rich source of polyunsaturated acids of ω3 configuration and these fatty acids when incorporated in the diet may have important beneficial properties in reducing the incidence of cardiovascular disease in man. Recent research has demonstrated that ω3 fatty acids can influence the production of locally acting hormones such as thromboxanes and prostacyclins which regulate haemostasis and thrombus formation (Dyerberg and Jorgensen 1982). Furthermore, these fatty acids may also reduce the risk of atherosclerosis by their effect on lowering plasma triglyceride levels (Goodnight Jr *et al.* 1982; Phillipson *et al.* 1985). Although there are invariably two major ω3 fatty acids present in fish oils, namely docosahexaenoic (22:6ω3) and eicosapentaenoic (20:5ω3) acid, most research has been directed towards the latter. This is because 20:5ω3 is the predominant polyunsaturated fatty acid in the commercially important fish oils obtained from the northern hemisphere fisheries. However, studies on Australian fish have shown that docosahexaenoic acid is normally the most abundant ω3 fatty acid and that a polyunsaturated fatty acid of the ω6 configuration, arachidonic acid (20:4ω6), is also occasionally present in significant amounts (Pearson 1978; Gibson 1983; Sinclair *et al.* 1983).

With the extension of the Australian Fishing Zone in 1979 to 200 nautical miles, the area of the North West Shelf has become a fishing ground of major potential importance to Australia. During 1982 and 1983 the CSIRO Division of Fisheries carried out a series of survey trawls to evaluate the current state of the demersal (bottom) fish resources of this region. A general account of this work is provided elsewhere (Young and Sainsbury 1985). Collections made during this period provided the opportunity to obtain information on the fatty acid composition of a wide range of tropical fish species occurring in this new major fishing area and to compare their composition with that determined previously in Australian fish, predominantly obtained from southern fisheries. As all the fish species from the North West Shelf were collected from within the one region and from a broadly common habitat there was also an opportunity to investigate the influence of diet on the fatty acid composition of fish species. Fish were therefore selected to represent a wide range of feeding habits.

An account of the distribution of fatty acids between the major lipid classes from some of these fish has already been published (Fogerty *et al.* 1986).

Experimental methods

Fish, cephalopods and crustaceans were collected by demersal trawling between latitudes 20° to 20° 30'S and longitudes 117° 40' to 117° 55'E in waters ranging in depth from 30 to 70 m. Samples were collected in October and November 1983 from water with a temperature range of 23° to 26°C. A general description of the region and details of the catching methods are provided separately (Sainsbury and Whitelaw 1984; Young and Sainsbury 1985).

The major diet items of a fish species were determined as the two most frequently occurring feed materials identified from the gut contents of not less than 20 fish.

On collection, fish for lipid determinations were deep frozen and transported to the laboratories where they were kept at -25°C until analyzed.

Lipids were extracted according to the method of Bligh and Dyer (1959) from samples of muscle, separated from skin and subcutaneous fat. For small individuals, muscle samples were pooled, or otherwise extracts were made from whole individuals.

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Total lipid content was determined gravimetrically. For fatty acid determinations total lipids were transmethylated using the method of Glass and Christopherson (1969). The methyl esters of fatty acids were analyzed by gas liquid chromatography using a Pye model 104 chromatograph with a flame ionization detector and a 4 m by 2 mm coiled glass column containing 10% Silar 10C on 100/120 Gas-Chrom Q (Applied Science Laboratories, State College, Pa) operated isothermally at 200 °C. Peak areas were measured using a Hewlett Packard 3390A integrator.

Results and discussion

The collection of fish, cephalopods and crustaceans analyzed is listed in Table 1. The twenty-seven species of fish from seventeen families represented a wide range of feeding habits. Six of the fish species were of commercial significance. The cephalopods and crustaceans were collected as examples of the feed of certain fish species.

The total lipid content of the fish was low, mainly falling within the range of 0.6 to 1.9%. Only three species of fish had a lipid content greater than 2% and none of these species were common in the area.

The fatty acid composition of the fish is shown in Table 2. In general, the six most frequently occurring fatty acids, in order of their relative abundance were docosahexaenoic (22:6ω3), palmitic (16:0), oleic (18:1), stearic (18:0), arachidonic (20:4ω6) and palmitoleic (16:1). Of the polyunsaturated fatty acids the ω3 fatty acids were usually greatly in excess of the ω6 although the ω3 to ω6 ratio varied from 1.1 to 7.7. A similar range of values for the ω3 to ω6 fatty acid ratio has been obtained for fish from Australian temperate waters (Pearson 1978; Gibson 1983; Naughton *et al.* 1983). In Australian marine fish, when higher levels of ω6 fatty acids occur, this is invariably due to an increased amount of 20:4ω6. Consequently, lower values for ω3 to ω6 ratio frequently reflect an increased amount of this fatty acid. The two lowest values for this ratio for fish in this study were found in the herbivores. *Chaetodontoplus personifer* and *Scarus gobban* which both contained high proportions of 20:4ω6. The generally lower values for the ω3 to ω6 ratio obtained for fish caught in an intertidal zone along the North West Coast (Sinclair *et al.* 1983) adjacent to the region of our collections arose from higher proportions of 20:4ω6 and lower levels of total ω3 fatty acids. Overall, the proportions of 20:4ω6 in fish from the North West Shelf were higher than those normally found in fish from temperate waters, confirming the earlier observations of Sinclair *et al.* (1984) that a high level of this fatty acid is most often found in fish from warmer waters.

The principal ω3 fatty acids were usually 22:6ω3 and 20:5ω3 although where the latter was present as only a minor component the fatty acids 22:4ω3 and 22:5ω3 were relatively more plentiful. The fatty acid 22:6ω3 was always the most abundant ω3 fatty acid with the ratio of 22:6ω3 to 20:5ω3 ranging from 4.2 to 14.1 for fish from the North West Shelf. While 22:6ω3 is also the predominant ω3 fatty acid in most Australian fish the ratio of 22:6ω3 to 20:5ω3 is generally lower in Australian fish from temperate waters (Gibson 1983; Evans and Fogerty unpublished data) and was less than 1 for fish from the colder waters south of the Antarctic Convergence (Evans and Fogerty unpublished data). There are examples amongst tropical fish where 20:5ω3 occurs in greater amounts than 22:6ω3, namely, for some reef-dwelling herbivorous fish (Evans and Fogerty unpublished data) and members of the family Mugilidae (mullet) for which values of the ratio 22:6ω3 to 20:5ω3 appear to change little with their distribution between warmer and colder waters (Sinclair *et al.* 1983; Gibson 1983). In both cases the total ω3 fatty acid content was relatively low.

The polyunsaturated fatty acids of the ω3 and ω6 series of fish lipids are derived solely from the diet and ultimately are of plant origin. The amount of these polyunsaturated fatty acids, expressed as a proportion of the total lipid fatty acid, in fish from the North West Shelf, were inversely related to the lipid content of the fish (Fig. 1). This relationship was similar for fish of all dietary habits (Fig. 1) and presumably reflects the dilution of the dietary polyunsaturated fatty acid by endogenous fatty acid synthesis. Diet might be expected to have most effect on the comparative amount of individual polyunsaturated fatty acids. This possible effect was examined by plotting values for the ratio of 22:6ω3 to 20:5ω3 against the ratio of ω3 to ω6 fatty acids (Fig. 2). There was, however, no obvious grouping of values for fish species according to their diet categories. Moreover, the values for these important measures of polyunsaturated fatty acid composition were widely scattered for individual fish species within each broad diet category, a result which is well exemplified for piscivorous fish of the two categories shown (Fig. 2). However, the lower than

TABLE 1

List of fish, cephalopod and crustacean species from the North West Shelf[A]

	Scientific name	Common name	Family	Number analyzed	Mean weight (g)	Relative abundance and commercial status[B]	Total lipids (% net weight)	Major diet items
Fish	Sauridia sp. 1	White-spotted lizardfish	Synodontidae	3	232	C	0.8	Fish, cephalopods
	Lepidotrigla argus	Long-finned Gurnard	Triglidae	3	27	C	0.9	Crustaceans
	Sorsogona tuberculata	Heart-headed flathead	Platycephalidae	3	22	R	0.9	Crustaceans
	Epinephelus areolatus	Yellow-spotted rock-cod	Serranidae	2	731	C	1.9	Fish, cephalopods
	Glaucosoma burgeri	Northern Pearl perch	Glaucosomatidae	3	390	R	0.8	Fish, crustaceans
	Seriolina nigrofasciata	Black-banded kingfish	Carangidae	3	507	R	9.4	Fish
	Selaroides leptolepis	Yellow-striped trevally	Carangidae	3	88	C	1.2	Fish, crustaceans
	Carangoides caeruleopinnatus	Onion trevally	Carangidae	1		C	0.7	Fish, cephalopods
	Apolectus niger	Black pomfret	Formionidae	3	433	R	4.1	Zooplankton
	Lutjanus vittus	One-band sea-perch	Lutjanidae	4	236	A,CC	1.0	Fish, crustaceans
	Lutjanus sebae	Red emperor	Lutjanidae	5	540	R	0.7	Crustaceans, fish
	Lutjanus erythropterus	High brow sea perch	Lutjanidae	1		R	1.5	Fish, cephalopods
	Lutjanus russelli	Russell's snapper	Lutjanidae	1		A,CC	0.6	Fish, crustaceans
	Pristipomoides typus	Threadfin snapper	Lutjanidae	1		R	0.6	Fish, cephalopods
	Nemipterus furcosus	Rosey threadfin-bream	Nemipteridae	4	289	A,CC	0.7	Fish, crustaceans
	Pentapodus porosus	North-West whiptail	Nemipteridae	3	282	A,PC	1.0	Fish, crustaceans
	Diagramma pictum	Painted sweetlip	Haemulidae	6	412	C	1.0	Crustaceans
	Lethrinus choerorynchus	Lesser-spangled emperor	Lethrinidae	4	428	R	0.8	Crustaceans, fish
	Lethrinus nematocanthus	Threadfin emperor	Lethrinidae	3	153	A,CC	0.9	Crustaceans, fish
	Parupeneus pleurospilus	Spotted golden goatfish	Mullidae	3	148	A,CC	0.9	Crustaceans
	Upeneus tragula	Spotted goatfish	Mullidae	1		A,NC	0.8	Crustaceans
	Chaetodontoplus personifer	Yellow-tailed angelfish	Chaetodontidae	6	206	C	1.2	Algae, crustaceans
	Pristotis jerdoni	Green puller	Pomacentridae	3	34	C	1.0	Zooplankton
	Scarus gobban	Blue-barred orange parrot fish	Scaridae	7	1021	R	0.6	Coralline algae
	Siganus fuscescens	Pin-spotted spinefoot	Siganidae	1	213	R	2.4	Coralline algae
	Rastrelliger kanagurta	Indian mackerel	Scombridae	3	287	R	1.7	Phytoplankton, zooplankton
	Psettodes erumei	Tropical halibut	Psettodidae	3	635	C	0.7	Fish
Cephalopods	Loligo edulis	Loligo squid	Loliginidae	3			2.3	
	Sepia pharonis	Cuttle fish	Sepiidae	3			1.1	
	Cephalopod spp.			3			1.9	
Crustaceans	Metapenaeopsis spp.	Coral prawn	Penaeidae	3		C	1.5	
	Penaeus spp.	Prawn	Penaeidae	3		C	1.3	
	Scyllarus sp.	Slipper lobster	Scyllaridae	3		C	0.8	
	Portunus sp.	Swimming crab	Portunidae	4		C	0.9	

[A] Nomenclature following Sainsbury *et al.* (1985). [B] C, common; R, rare; A, abundant; CC, currently commercial; PC, potentially commercial; NC, not commercial. [C] Whole animals analyzed. Values indicate number of replicates.

TABLE 2

The mean fatty acid composition of fish, cephalopods and crustaceans from the North West Shelf

	Scientific name	Percent total fatty acids (minor fatty acids not shown)											total ω3	22:6ω3
		16:0	18:0	16:1	18:1	18:2ω6	20:4ω6	22:4ω6	20:5ω3	22:4ω3	22:5ω3	22:6ω3	total ω6	20:5ω3
Fish	Saurida sp. 1	21.2	7.7	3.6	9.9	1.4	5.5	0.5	5.3	3.0	1.3	37.4	6.3	7.1
	Lepidotrigla argus	18.1	9.3	4.6	11.4	1.7	5.5	0.2	5.9	2.5	1.6	36.9	6.4	6.3
	Sorsogona tuberculata	20.6	9.5	3.6	14.4	1.9	7.3	0.5	5.2	3.1	2.1	27.5	4.0	5.3
	Epinephelus areolatus	21.7	11.1	7.5	12.0	1.8	2.7	2.5	4.6	2.1	3.4	25.0	3.9	5.4
	Glaucosoma burgeri	20.6	9.9	4.2	12.8	1.2	4.9	0.9	4.7	3.0	2.7	30.8	4.9	6.6
	Seriolina nigrofasciata	36.3	12.8	7.7	33.8	0.2	1.2	0.4	0.9	0.1	0.4	4.8	4.1	5.3
	Seraloides leptolepis	22.7	10.6	6.4	9.0	2.3	3.1	0.3	5.6	2.2	2.2	32.4	7.7	5.8
	Carangoides caeruleopinnatus	16.9	11.9	2.6	11.0	1.4	3.4	0.7	3.0	3.0	1.6	38.3	7.2	12.8
	Apolectus niger	26.4	12.2	2.6	14.7	1.6	7.3	1.7	2.8	2.9	3.2	17.8	2.9	6.4
	Lutjanus vittus	21.2	10.2	5.9	13.4	1.4	4.4	1.0	3.8	1.9	2.4	31.4	5.5	8.3
	Lutjanus sebae	20.2	9.5	4.5	12.7	1.8	4.6	0.5	4.3	2.0	2.3	35.6	6.6	8.3
	Lutjanus erythropterus	22.5	9.1	6.9	13.9	2.5	3.7	0.7	5.5	3.1	2.2	20.0	2.8	3.6
	Lutjanus russelli	19.8	9.9	3.0	12.6	1.2	6.9	1.3	3.3	3.5	2.5	32.6	4.3	9.9
	Pristipomoides typus	18.7	9.0	4.4	12.2	1.6	4.0	0.7	4.3	3.4	2.9	31.4	3.8	7.3
	Nemipterus furcosus	19.8	8.7	4.3	7.9	2.1	5.1	1.0	3.7	3.7	2.6	38.7	6.1	10.5
	Pentapodus porosus	19.0	9.2	4.1	13.2	1.6	9.5	2.8	3.4	3.1	3.7	27.9	2.9	8.2
	Diagramma pictum	19.5	9.8	5.2	13.0	1.5	10.7	2.1	5.1	3.4	3.2	22.2	2.4	4.4
	Lethrinus choerorynchus	22.6	8.3	4.2	12.9	1.4	8.0	2.0	2.2	3.7	2.2	30.9	3.5	14.1
	Lethrinus nematocanthus	21.9	9.3	4.6	11.5	1.7	10.6	2.5	3.7	4.0	2.6	24.9	2.5	6.7
	Parupeneus pleurospilus	22.7	10.4	5.0	9.8	1.7	4.8	0.9	5.4	2.2	1.9	32.0	5.5	5.9
	Upeneus tragula	23.1	8.8	4.6	8.0	1.4	5.1	0.7	5.8	2.9	1.6	34.8	5.7	6.0
	Chaetodontoplus personifer	23.2	10.5	6.1	13.4	1.7	14.3	5.1	2.3	5.7	3.0	11.8	1.1	5.1
	Pristotis jerdoni	25.4	8.1	6.7	7.0	2.0	4.4	0.3	7.2	2.7	1.5	30.3	6.5	4.2
	Scarus gobban	17.1	11.0	4.5	12.1	1.8	14.4	0.9	3.5	5.7	1.3	25.4	2.2	7.3
	Siganus fuscescens	25.4	9.2	9.3	12.8	1.9	6.4	0.7	1.7	4.5	2.5	21.8	3.5	12.8
	Rastrelliger kanagurta	24.2	9.3	7.2	9.5	2.1	4.9	0.3	6.2	3.0	1.1	27.7	5.5	4.5
	Psettodes erumei	25.3	8.2	4.5	9.4	1.4	7.9	1.0	2.5	3.8	1.5	32.3	3.9	12.9
Cephalopods	Loligo edulis	26.5	6.9	3.1	6.5	0.7	5.4	0.2	10.9	1.1	0.4	34.6	8.0	3.2
	Sepia pharonis	20.7	10.0	2.6	5.6	0.6	9.0	0.4	8.5	1.1	1.2	37.2	5.1	4.4
	Cephalopod spp.	29.2	6.6	2.8	5.1	0.4	5.5	0.1	9.8	1.4	0.2	35.7	8.3	3.6
Crustaceans	Metapenaeopsis spp.	20.4	10.0	10.8	13.1	2.3	11.5	1.2	10.5	1.1	1.0	12.3	1.9	1.2
	Penaeus sp.	17.8	10.2	8.2	17.7	2.5	9.9	0.7	9.6	0.8	0.9	15.7	2.3	1.6
	Scyllarus sp.	18.8	9.7	7.8	15.8	2.3	7.6	0.2	11.5	1.5	0.7	18.3	3.5	1.6
	Portunus sp.	18.5	9.2	7.1	13.6	3.0	7.1	0.1	13.5	0.8	0.7	20.3	3.9	1.5

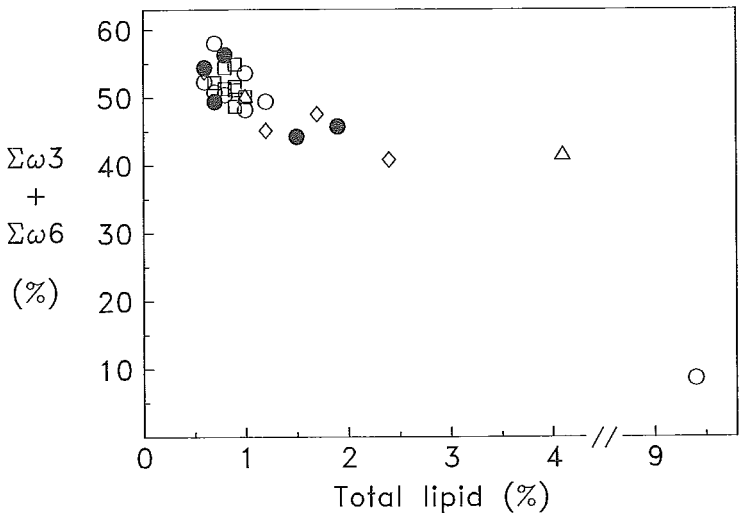

Fig. 1. The relationship between lipid content and total polyunsaturated fatty acid (ω3 + ω6) content in fish from the North West Shelf.
Legend for diet categories:
fish and cephalopods ●; fish and other feeds ○; crustaceans □; zooplankton △; plants ◇.

average values for the ratio of 22:6ω3 to 20:5 in most of the fish species feeding on crustacea may be attributable to the very low value for this ratio found in crustaceans (Table 2).

Since there is normally little 22:6ω3 present in marine algae, this fatty acid is normally produced in fish and other marine animals by chain elongation and desaturation of other ω3 fatty acids. In those fish species feeding at a low level in the feed chain, such as herbivores and zooplanktivores, it might be expected that the ratio of 22:6ω3 to 20:5ω3 would be lower than for other groups. Although for five out of the six species of fish in these diet categories, this ratio was less than the average value (Fig. 2), similar low values were also obtained for other fish species feeding at higher levels in the feed chain.

Under experimental conditions it has been shown that the fatty acid composition of the diet can play a major role in determining the nature and proportion of poly-unsaturated fatty acids in fish (Yu and Sinnhuber 1972). The absence of any marked influence of dietary habits on polyunsaturated fatty acid composition in North West Shelf fish might suggest otherwise. However, while other factors such as age, reproductive state and species may also influence fatty acid composition, it is also likely that the relationship between diet and fish lipid composition would only be established from much more detailed information on the composition of fish diets. While important information continues to be gained on the fatty acid composition of Australian fish there is still clearly much to be learnt about sources of variation in natural fish populations.

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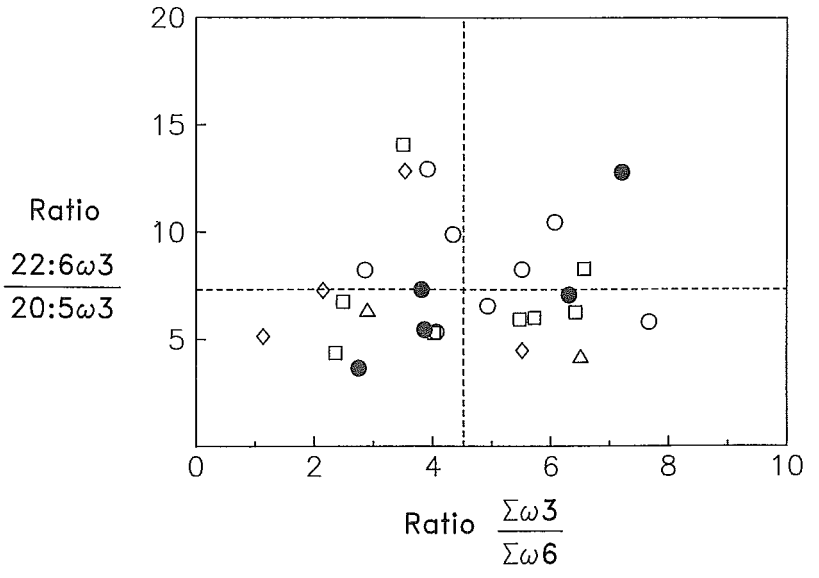

Fig. 2. The relationship between the ratio of 22:6ω3 to 20:5ω3 and the ratio of ω3 to ω6 fatty acids in fish species of various dietary habits from the North West Shelf. See Fig. 1 for legend of diet categories. Broken lines indicate average values of the ratios from all fish species.

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News from the Division

Work Overseas

Dr Robert Sleigh

During 1984/85 Dr Robert Sleigh of FRL was the recipient of a CSIRO Overseas Fellowship and worked with Prof. Jerker Porath at the Institute of Biochemistry at Uppsala in Sweden to gain experience in the synthesis and the applications of a range of affinity chromatography supports. A result of this work was the development of a modified agarose gel capable of selectively removing the lipoprotein fraction of human serum. Prof. Porath has invited Dr Sleigh to return to Uppsala to complete tests of the gel's characteristics and operational parameters.

So far applications for the gel have been limited to the separation of the serum lipoprotein fraction which is of commercial interest to clinical laboratories and blood processing operations. However, the modified-agarose also appears to be highly suitable for the isolation of the commercially interesting food proteins, lactoferrin and lysozyme.

After attending the 10th International Conference of Column Liquid Chromatography in San Francisco in May, Dr Sleigh will spend the latter half of 1986 at Uppsala further developing protein separation techniques of interest and prospective value to the Australian food industry.

Dr Brian Patterson

In March and April 1986, Dr Brian Patterson of FRL's Plant Physiology Group visited the Hawaiian Islands to conduct experiments on the transfer of genes for cold resistance from the wild tomato *Lycopersicon hirsutum* to the domestic tomato. The visit was funded by the US/Australia Joint Science Agreement, and involved cooperation with Dr Robert Paull of the University of Hawaii and Dr Lloyd Loope of the US National Parks Service.

Staff of the University of Hawaii grew hybrids of the two species from seed supplied from Australia at low altitude on the island of Maui. Experiments using the hybrid plants were then performed at a high altitude station in Haleakala National Park at 2200 m, where the climate is close to that of the native habitat of the wild tomato. Although cool, with night minimum temperatures of about 7 °C, frost is not a normal hazard as it has been under Australian conditions, and sudden deviations of temperature because of cold fronts are rare and relatively small. Pollen and seed developed under these conditions is now being analysed to discover the extent to which it is enriched in genes for cold resistance derived from the wild parent.

If the theories on which the experiment was based prove correct, the cold resistance present in the wild tomato will be able to be better exploited in the tomato breeding program being carried out by the NSW Department of Agriculture. More cold-resistant varieties of tomato could enable better maintenance of quality during storage and transport, and better control over ripening.

Honours and Awards

Mr J.D. Mellor's Honorary Research Fellowship has been extended until February, 1987.

Dr Len Fisher (FRL) has won an Australian-Royal Society Exchange Fellowship.

Mr Hing Moong Chua of MRL has been awarded the degree (with distinction) of Master of Information Systems, by the University of Queensland.

Miss Emma Mitchell (FRL) received the Le Fevre prize from Macquarie University for her results in the subject of Physical Chemistry.

Dr D.G. Oakenfull (FRL) has been elected Chairman of the NSW Branch of the Nutrition Society of Australia.

Mr P. Stephenson, Apprentice Sheetmetal Tradesman at DRL, has been named Victorian Apprentice of the Year (Metal Trades).

International Congress

The Second International Congress of Meat Science and Technology will be held on 29 August—2 September 1988, in Brisbane, Australia, and is timed to coincide with World Exposition 88 and the celebration of Australia's Bicentenary. For further information, contact the Secretariat, 14th Floor, MLC centre, 239 George Street, Brisbane, 4000, Queensland, Australia. Telephone (National) (07) 221-0833 (International) 61 (07) 221-0833. Telex AA43620.

Death

Dr Josef Czulak

The death of Dr Joe Czulak on the 6 August 1985 closed the career of one who contributed a great deal to dairy science, particularly to cheese manufacture.

Joe Czulak was born in Cracow, Poland in 1915 and completed his secondary education there before enrolling in the Polish Cavalry College. He graduated as an officer in 1938 and joined the Polish 12th Lancers Regiment. When Poland was invaded in 1939 he was wounded but later escaped from occupied Poland to France where he again joined the army. After the collapse of France in June 1940 he escaped with some of his soldiers to Britain. He graduated there from the Army Staff College and later took part in the invasion of Normandy and the liberation of Western Europe as an officer in an Armoured Division. He was awarded the Polish Cross of Valour during this campaign.

After World War II he studied at Reading University and obtained a B.Sc. (Agric) degree in 1948 and a postgraduate diploma in bacteriology in 1949. He joined the staff of Central Research Laboratory, United Dairies, London and worked on cheese starter culture problems until 1951 when he accepted a position with the Dairy Research Laboratory, CSIRO, Melbourne Australia.

During his period of 25 years with CSIRO until his retirement in 1976 he made many important contributions to the cheese industry. He had two main objectives. The first was to mechanize Cheddar cheese manufacture so as to reduce some of the very demanding manual effort involved in the process as it then existed. The second was to improve understanding and control of the behaviour of cheese starters.

His energy, dedication and brilliance in applying science to practical objectives, together with his leadership qualities, resulted in major contributions in both fields.

His work on cheese starters during the 1950s included pioneering discoveries on inhibition of activity by peroxidase, on loss of activity due to mutation and on the protection of lactic streptococci against bacteriophage attack once coagulation of milk has taken place. Among other important findings, his studies also led to understanding of the mechanisms responsible for bitter flavour in cheese.

The research and developmental activities that were probably responsible for much of Joe Czulak's international reputation were his team's efforts to mechanize cheese manufacture. In collaboration with the dairy machinery company, James Bell Machinery (now APV-Bell Bryant Limited), the first continuous milling, salting and hooping machine for Cheddar cheese manufacture (Bell-Siro Cheesemaker III) was developed commercially by the very early 1960s and some 40 machines were installed in Australia and several overseas countries during the decade.

This machine was followed in 1967 by the first continuous curd fusing (or cheddaring) machine — Bell-Siro II. Again, several dairy companies around the world purchased this machine. Today, even though later versions of such equipment have been produced by other companies and accepted by the industry, many of the original Bell-Siro Cheesemakers II and III continue to give satisfaction to their users — a monument to Joe Czulak!

While the visible evidence of his achievements gave him considerable pleasure, as did the Gold Medal of the Australian Society of Dairy Technology, awarded in 1960 for outstanding services to the cheese industry, perhaps his greatest pleasure was derived from the award of an honorary degree of Doctor of Science from the Sardar Patel University, India, late in 1973. This cherished degree recognized not only his contributions to dairy science, but also a research effort of particular interest to India. He recognized that high calcium and phosphate content of buffalo's milk was responsible for excessive syneresis of curd in

the manufacture of cheese from such milk. Practical steps to overcome this problem were devised and applied successfully.

Retirement from CSIRO did not mean that Joe ceased his interest in dairy science. He continued to be very actively involved, partly as a consultant, but frequently as an entrepreneur seeking collaborators or partners to join in development of his ideas. He worked closely with his many friends in France on aspects of the role of ultrafiltration in cheesemaking and was closely involved with Australian dairy companies in several new developments.

Joe Czulak's energy and inventiveness were still at a high level right up to his death. His friendship and his contribution to dairy science and technology will be sadly missed.

LLM

AIFST 1986 Award of Merit

At the 19th Convention of the Australian Institute of Food Science and Technology (Brisbane, 25-29 May), Dr June Olley, leader of the Tasmanian Food Research Unit, formerly of the Division of Food Research, received the Institute's Award of Merit for 1986.

Dr June Olley took an honours chemistry degree at University College, London, under Professor C.K. Ingold and a PhD in the chemistry of nutrition at the London School of Hygiene and Tropical Medicine under Professor B.S. Platt. In 1950 she joined the staff of Torry Research Station, Aberdeen, Scotland and collaborated for eighteen years with Dr J.A. Lovern on various aspects of fish processing technology, gaining a DSc in 1968. In that year she went to Tasmania and joined the CSIRO Division of Food Research, where she is now leader of the Tasmanian Food Research Unit. This Unit specializes in work on fish and shellfish and has very recently been transferred to the CSIRO Division of Fisheries. Under Dr Olley's leadership the Unit has come to enjoy a distinguished international reputation.

She has also worked in the USA, Israel and South Africa. In 1956 she spent a year with Professor D.J. Hanahan working on lipid chromatography at the University of Washington, Seattle, in 1961 with Professor Benyamin Shapiro on lipid synthesis at the Hebrew University, Jerusalem, and in 1974 with Dr J. Wessels at the Fishing Industry Research Institute, Cape Town, on lobster processing.

From 1966-68 she was scientific secretary to the International Association of Fishmeal Manufacturers. She is a fellow of the Australian and UK Institutes of Food Science and Technology and a Foundation Fellow of the Australian Academy of Technological Science. She is an Australian Representative on the Indo Pacific Fisheries Commission Workshop on fish technology and marketing and Australian Representative on Commission C2 of the International Institute of Refrigeration. She is a member of the Faculty of Agricultural Science, University of Tasmania and a Senior Fellow of Christ College at that University.

Dr Olley has published some ninety-five papers concerned with fish technology which may be listed under eighteen main headings. This 'jack of all trades' approach which fish technology demands of its devotees, has led her to think more closely about the functions of a small technologically based research group. For her very considerable contribution to the advancement of fish science and technology, Dr June Olley has been awarded the Award of Merit for 1986.