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The preservation of meats using irradiation

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Introduction

In 1980, following more than 30 years of research, the World Health Organization Joint Committee on Food Irradiation concluded that foods irradiated with an average dose of up to 10 kGy posed no nutritional, microbiological or toxicological threat to public health. In 1983 the Codex Alimentarius Commission adopted a revised "Recommended International Standard and Code of Practice for Irradiated Foods" which listed low-dose treatments for a variety of foods. The flesh foods included were chicken and dried fish. These developments have led to a renewed interest in food irradiation and it seems likely that this technique will be applied to selected food items in Australia in the near future.

In the Netherlands, the irradiation of poultry portions at a maximum dose of 3 kGy has been permitted on an unconditional basis since 1976 and irradiated poultry has been released for test marketing in several countries (Kampelmacher 1983). The commercial application of this technique to red meats has not progressed as far as it has with poultry, but numerous studies have clearly demonstrated that irradiation can increase the storage life and reduce the public health hazards sometimes associated with red meats. In this paper the possibilities of using irradiation to improve the microbial quality of meats are discussed and potential future commercial applications are suggested.

Background

Food may be treated with electromagnetic radiation (x- or gamma-rays) or accelerated electrons. The energy level of the radiation used is such that there is no possibility of inducing radioactivity in the food being processed. The upper limits are 5 MeV for x- and gamma-rays and 10 MeV for accelerated electrons. The main gamma-ray producing source is the radionuclide cobalt-60 (^{60}Co) which emits gamma-rays up to an energy of 1.33 MeV. Radiation from ^{60}Co has good penetrating power and is used for treating bulky products. In contrast electrons penetrate poorly and thus their use is restricted to the treatment of surfaces or thin layers. However, treatment using accelerated electrons does have the advantage of being more rapid than that using radiation from ^{60}Co and in addition the electron accelerator may be switched off when not required.

The effect of radiation depends upon the energy absorbed by the material being treated. The SI unit of radiation dose is the gray (Gy) which is one joule absorbed per kilogram of material (1 Gy = 100 rads; 1 kGy = 0.1 M rad). Further background information can be found in an article by Wills (1982). See also following article by Fisher (p. 55).

Low-dose treatments of food which leave surviving organisms ("radiation pasteurization") may be aimed at extending storage life (radurization) or removing a particular pathogen (radicidation). Obviously, treatments aimed at radurization will also kill pathogens. Higher-dose treatments aimed at producing sterile or "commercially sterile" products are referred to as radappertization.

General aspects of the irradiation of meats

Several problems appear to limit the use of irradiation for the treatment of meats. It causes changes in flavour, aroma and colour and these may alter the product sufficiently to cause problems with consumer acceptance. When evaluated by trained analytical taste panels, the changes in aroma and flavour become statistically significant at quite low doses of about 2-2.5 kGy. The significance of taste panel results in terms of consumer perceptions is difficult to assess. Almost certainly the panel is more discriminating than an individual consumer if only because the panel operates in an experimental situation and compares the test samples to others which have not been irradiated.

Organoleptic changes can be limited by irradiating the meat chilled or (even better)

CSIRO Food Res. Q. 1985, **45**, 49-54

frozen (Urbain 1978; Kampelmacher 1983; Dempster 1985). Irradiation in air may accelerate oxidative changes which are a particular problem with fatty tissue. Lea *et al.* (1960) reported the development of a tallowy odour and flavour in fat irradiated in air. The fat was also noticeably bleached and peroxide accumulated more rapidly in the irradiated than in untreated fat. Irradiation under anaerobic conditions greatly reduces this problem (Urbain 1978) thus packaging prior to irradiation is desirable.

Chemical and biochemical reactions continue to occur during the storage of muscle at temperatures of 0°-5°C and these may cause the flavour defects which develop in fresh meats stored in the absence of a significant population of bacteria (Egan 1984). Since enzymes are usually not inactivated by irradiation at bactericidal dose levels (Ingram and Roberts 1980), changes caused by their activities have the potential to contribute to spoilage in meats stored following irradiation. This problem will not occur in meats in which the enzymes have been inactivated by cooking or some other processing procedures.

In a healthy animal, the muscular tissue is sterile. During slaughter and processing the carcass is contaminated with organisms from the hide, intestinal contents and abattoir environment. Thus contamination is largely confined to the surface, but during boning the bacteria are transferred onto cut meat surfaces. The surface nature of the bacterial contamination of meats means that treatment using accelerated electrons may be suitable, and the use of this technique would minimize organoleptic changes. However, the shape of carcasses may mean that some surfaces do not receive an adequate dose (e.g. inside the chest cavity).

One general problem that occurs with the low-dose irradiation of packaged meats is the growth of a secondary flora of organisms that survived the treatment. These include Gram-negative bacteria such as *Moraxella*, together with lactic acid bacteria and yeasts. Thus, when microbial spoilage of treated meats does occur it may be due to quite different organisms to those normally present and thus may be different in nature.

Following irradiation, meats may be readily recontaminated with bacteria from the environment. This problem can be avoided by packaging prior to treatment. Vacuum-packaging, which is now widely used for a variety of both fresh and processed meats, is recommended (Dempster 1985).

Destruction of pathogens

The Gram-negative pathogens commonly found on meats include *Salmonella*, enteropathogenic *Escherichia coli*, *Yersinia enterocolitica* and *Campylobacter jejuni*. These organisms are radiation sensitive, but there may be considerable variations between strains (e.g. between *Salmonella* serotypes; Ingram and Roberts 1980). Recently, Tarkowski *et al.* (1984) determined the dose necessary to reduce the population 10-fold (D_{10}-value) for strains of *Salmonella*, *Y. enterocolitica* and *C. jejuni* isolated from beef. They showed that a 1 kGy treatment of ground beef caused a reduction of more than 95% in the number of viable *Salmonella* cells present. Corresponding reductions in the number of the other two organisms exceeded 99.99%. Since these types of bacteria are usually only present in small numbers a dose of about 2.5 kGy will virtually eliminate them.

Clostridia may grow within meat tissue especially at temperatures above 20°C and cause obnoxious anaerobic putrefaction. This is an indication that pathogenic species, especially *Clostridium perfringens* and *Cl. botulinum*, may have grown. *Cl. botulinum* produces spores that are resistant to irradiation. To eradicate this very dangerous organism a sterilizing dose is required. Alternatively, a lesser dose may be used if assisted by other factors such as low pH or the presence of curing salts (sodium nitrite). In the thermal processing of foods (meat canning) an inactivation of 10^{12} (the so called 12D concept) is aimed for with this organism. To achieve this using ionizing energy a dose of about 45 kGy is needed (Ingram and Roberts 1980). This organism must be eliminated if fresh or carcass meats are to be stored at ambient temperature but the organoleptic changes caused by a dose of this magnitude are a problem.

On cured and processed meats the presence of the Gram-positive pathogen *Staphylococcus aureus* is common because it can tolerate high salt concentrations. Whilst there is a considerable range of sensitivities to irradiation reported for isolates of this organism, overall it is only slightly less sensitive than *Salmonella*.

With the exception of *Y. enterocolitica*, the organisms mentioned above are all mesophiles and thus do not grow below about 8°C. This needs to be considered when deciding upon possible irradiation treatments for meats. In many cases the optimal procedure will be one combining the use of a particular dose of radiation with packaging and storage at an appropriate temperature.

Treatment of carcasses or cuts of fresh meats in air

The flora on refrigerated fresh meats is composed predominantly of Gram-negative bacteria, *Enterobacteriaceae* and *Pseudomonas* spp. The latter become dominant as storage progresses and cause putrefactive spoilage which usually becomes significant when numbers reach about $10^7/cm^2$. Even with a low initial count, the storage life at 0-2°C is only about one week.

These organisms are sensitive to irradiation and a dose at 0.5-1 kGy can extend the storage life about four-fold, i.e. up to about 4 weeks at 0°-2°C (Wolin *et al.* 1957). This level of dose causes no significant organoleptic changes in the lean meat and it was clear by the mid-1960s that radurization was a suitable process for the preservation of fresh meat. However, as mentioned previously, accelerated oxidation may be a problem.

On-line irradiation of carcasses in the abattoir is possible particularly if only a low dose (0.2-0.5 kGy) is required. In a recent study the feasibility of the on-line irradiation of pig carcasses in the USA was examined in an attempt to eliminate the parasite *Trichinella spiralis* in pork (U.S. Dept. of Energy 1983). The high incidence of both *Salmonella* and *Campylobacter* on pork carcasses is also a world-wide problem and on-line carcass irradiation would help provide a solution.

The major problem with the in-works treatment of cuts or carcasses is recontamination during handling and processing. In the laboratory recontamination can be controlled or prevented but this is more difficult in industry.

Treatment of packaged fresh meats

By means of vacuum-packaging, the storage life of cuts of beef can be extended to 10-12 weeks at 0°C. To achieve this the muscle pH must be less than 6.0 and the packaging film must have a low permeability to gases ($<$ 100 ml of $0_2/m_2/24$ h/atm measured at 25°C and 98% R.H.) Vacuum-packaging extends storage life because the putrefactive spoilage bacteria do not grow and psychrotrophic lactic acid bacteria dominate. These are non-pathogenic and non-putrefactive and when they eventually cause spoilage it is by souring (Egan 1984).

Recent studies have shown that sterile beef muscle stored vacuum-packaged at 0°C still spoils slowly (storage life 14-18 weeks) because of the development of a changed flavour described as sour, acid, bitter and liver-like. Since commercially-produced vacuum-packaged beef has a storage life of 10-12 weeks, there appears to be little scope for further extension using irradiation since the meat will gradually deteriorate, for reasons unrelated to the presence of the microbial flora (Egan 1984; Egan and Shay 1982).

Vacuum-packaging works well with beef because there is normally only a low incidence of high pH, or dark-cutting, meat in the premium muscles of the hind quarter, which are the ones usually vacuum-packaged. If muscle pH is greater than about 6.0 *Alteromonas* spp. and *Enterobacteriaceae* can grow and contribute to spoilage which is then much more rapid (Egan 1984).

High pH meat is much more common in pig and sheep carcasses. These meats, which are also associated with increased fat content or fat cover, are commonly packaged as bone-in cuts or even whole carcasses, and this results in larger head space volumes and hence higher residual oxygen concentrations in the packs. These factors combine to give a shorter storage life than is obtained with beef cuts (Table 1). If the storage life of vacuum-packaged chilled pork and lamb can be extended by a low dose treatment (2-5 kGy) it may be possible to greatly increase international trade in these products. Workers at this Laboratory are now examining the effects of irradiation on the microbiology and storage lives of vacuum-packaged pork and sheep meats.

TABLE 1
Estimates of the maximum storage life of vacuum-packaged fresh meats at 0°C

		Muscle pH	Storage life (weeks)
Beef	Boneless cuts	5.4-5.8	10-12
Pork	Boneless cuts	5.4-5.8	6
	Boneless cuts	6.0-6.4	4-6
Lamb	Cuts (bone-in)	Variable	6-10[A]
	Carcasses	N/A[B]	6-8

[A]Little studied, varying estimates in literature
[B]Not applicable

Irradiation of vacuum-packaged mutton backstraps showed that a dose of 4 kGy prevented the growth of bacteria for at least eight weeks at 0°-1°C. At this dose level, the taste panel detected organoleptic changes in the meat but their significance requires further study (Macfarlane *et al.* 1983). These experiments are now being extended to vacuum-packaged, telescoped lamb carcasses.

Treatment of vacuum-packaged high pH pork striploins (pH 6.2-6.6) at a dose level of 2.5 kGy caused a reduction of 3 $\log_{10}$ units in the number of viable bacteria present. At 4 kGy the reduction was greater than 5 $\log_{10}$ units. However, both of these dose levels caused colour changes. The lean surface was brighter (pink-red), the skin was pink and there was noticeable bleaching of the fat. On opening the packs, atypical odours (described as "wet-dog" or "fishy") were noted but their significance in terms of consumer acceptability remains to be determined.

Minced and ground meats spoil rapidly. This is because the bacteria are no longer confined to the surface of the muscle but are distributed throughout the tissue. The advantages of irradiation to improve the microbiological quality of packaged ground meats have recently been discussed (Maxcy 1982; Niemand *et al.* 1983).

Treatment of processed meats

The principles to be observed in treating processed meats and the problems likely to be encountered are generally similar to those of raw meats. Some processed meats, such as luncheon meats, certainly pose a particular problem in having an inadequate storage life. These products, which are commonly sold sliced and vacuum-packaged, are cooked, but recontamination during slicing and packing may result in a starting count of 10^4-10^5 bacteria per g. Since the surface-to-volume ratio is comparatively high, bacterial spoilage may occur after only 2-3 weeks at about 5°C.

Recently, we have been examining the use of irradiation to extend the storage life of vacuum-packaged sliced corned beef. Table 2 shows the reduction in starting count, the taste panel evaluation of the changes in flavour and aroma and estimates of the storage life of this product following irradiation at different dose levels. These experiments indicated that a dose of 2.5-3.0 kGy was most likely to be suitable for the treatment of this product. Fig. 1 shows a taste panel evaluation of the acceptability of vacuum-packaged sliced corned beef during storage at 5°C following irradiation at this dose level. The meat was assessed by comparison with other irradiated samples which were stored at – 20°C and with non-irradiated control samples (also at – 20°C). Organoleptic changes were noted following irradiation and initially the acceptability of the irradiated meat was significantly lower than that of the non-irradiated control samples. The acceptability of the *frozen* irradiated meat remained lower than that of the non-irradiated frozen control samples throughout the experiment, but the difference was statistically significant only at the 4 week time point. The acceptability of the *irradiated* meat stored at 5°C showed little change for four weeks, but then declined rapidly. After six weeks storage its acceptability was significantly lower than that of both non-irradiated and irradiated samples that had been stored frozen ($P < 0.001$ in each case). This experiment demonstrates that the storage life of this product at 5°C can be doubled by a low-dose treatment (see also Table 2).

TABLE 2
Effect of treatment dose on microbial population, organoleptic properties and storage life of vacuum-packaged sliced corned beef

Irradiation dose (kGy)	Reduction in starting count ($\log_{10}$ units)	Panel evaluation of flavour/aroma changes	Estimated storage life at 5°C (weeks)
0	—	—	2-3
1	1	Not significant	2-3
2.5-3.0	3	Significant-slight	5
4	5	Significant-slight/ moderate	>6

The rapid reduction in acceptability that occurred in the irradiated meat after four weeks storage at 5°C corresponded with the bacterial flora reaching a population of about 10^8/g at that time. The composition of the flora on the irradiated meat after storage at 5°C varied from pack to pack. For example, of three packs individually examined after six weeks, one had a flora consisting almost entirely of Gram-negative bacteria (2.2×10^7/g), the second had a population composed of *Brochothrix thermosphacta* (1.4×10^8/g) and Gram-negatives (1.6×10^7/g) and the third had lactic acid bacteria together with Gram-negatives (7.3×10^7 and 2.4×10^7/g respectively). This result illustrates the problem mentioned earlier, viz. that the secondary flora, which grows following a low-dose irradiation, can vary considerably in composition.

Treatment of poultry

There is commonly a much higher incidence of pathogenic microorganisms such as *Salmonella* and *Campylobacter* on poultry carcasses than on red meats. Packaging of poultry carcasses followed by irradiation with doses of 2.5 kGy has been shown to be effective in greatly reducing the numbers of pathogens present and a dose of 2.5 kGy is generally

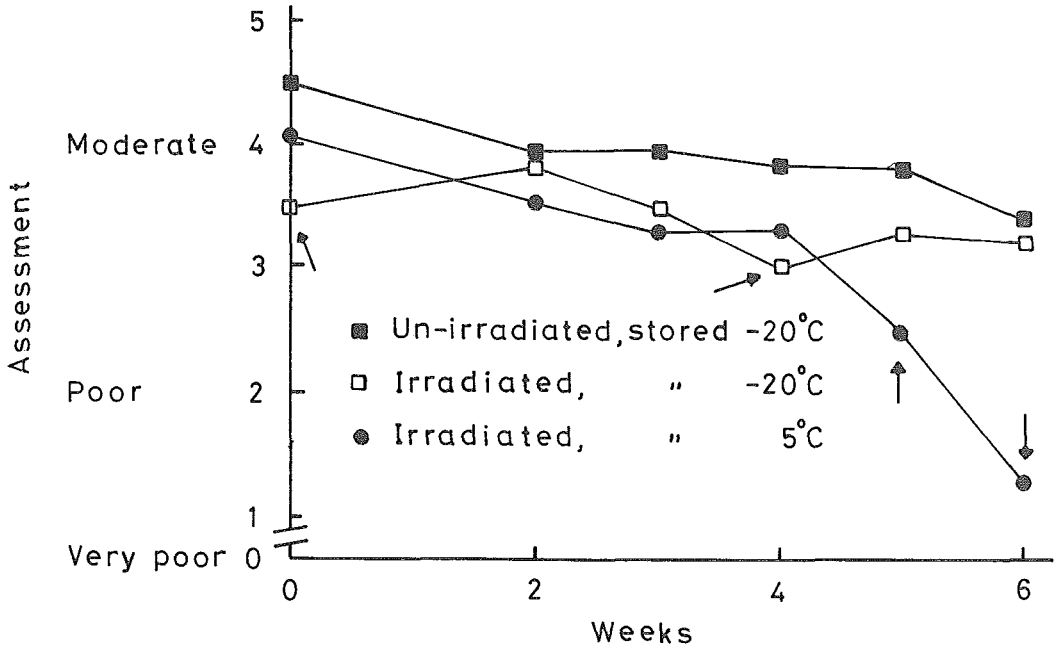

Fig. 1. Taste panel assessment of the acceptability of vacuum-packaged corned beef that had been irradiated at a dose of 2.5 kGy. Irradiated samples of meat were stored at 5°C and assessed by comparison with irradiated samples stored frozen (– 20°C) and with non-irradiated control samples also stored at – 20°C. Arrows indicate the times at which the acceptability of the irradiated sample indicated was statistically significantly different from that of the corresponding non-irradiated control sample.

considered suitable (Kampelmacher 1983). Recent studies by Mulder (1984) have shown that several parameters influence the radiation sensitivity of organisms such as *Salmonella* on chicken. For example his experiments indicated that the skin of the carcass seemed to afford the bacteria some protection from irradiation. He observed that the D_{10}-value for *Salmonella panama* in carcass skin was 1.29 kGy at – 18°C and 0.67 kGy at 5°C. In contrast, the D_{10}-value under optimal conditions in liquid culture media was 0.52 kGy. He showed that to reduce the population of *Salmonella panama* from about 1000 colony forming units per carcass to less than one, the approximate doses required were 4 kGy at – 18°C and 2 kGy at 5°C. However, to ensure eradication of the organism, defined as a reduction of the initial count by 7 $\log_{10}$ units, the required dose would be 7 x D_{10} or about 9 kGy.

A dose of 2.5 kGy will extend the storage life of poultry carcasses by at least seven days at 1°-3°C. Whilst irradiation induces organoleptic changes these are reduced by cooking and, in general, if a dose of less than 2.5 kGy is applied, no changes are detected in the cooked meat (Mulder 1984).

Special applications

Special applications of irradiation in the processing of meats have been discussed recently (Dempster 1985). For example it can be used to prepare "commercially sterile" meat products which are storable without refrigeration. This has been achieved with beef by cooking, vacuum-packaging, freezing to about – 40°C and irradiating at 50 kGy. In this process, cooking inactivates the enzymes and irradiating at low temperature greatly reduces the organoleptic changes.

Conclusion

The use of irradiation has the potential to increase the storage life and to reduce the public health hazards associated with meats. The products most likely to benefit from a low-dose treatment are packaged meats which are to be stored at 0°-5°C. In Australia, the first application of this technique to flesh foods is likely to be to improve the microbiological

quality of poultry meat. In contrast to vacuum-packaged cuts of beef, packaged pork and sheep meats do not have a storage life adequate to permit export to any part of the world from Australia by surface transport. Irradiation may assist in solving this problem.

Irradiation of meats causes undesirable changes in colour, aroma and flavour. These changes can be minimized by packaging followed by irradiation at low temperatures. The treatment to be applied to any particular type of product will need to balance the improvements in microbiological quality against the magnitude of organoleptic changes induced by the irradiation. This may require appropriate consumer acceptance studies. It will be the consumer and the food processor who will ultimately determine whether irradiated meats become part of our diet.

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Status of food irradiation in Australia

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In 1984, the Australian Agricultural Council, through its Standing Committee on Agriculture (SCA), formed an Advisory Group on the Application of Irradiation Technology to Foodstuffs. The Advisory Group is made up of representatives of most of the Australian States, the Australian Departments of Health and of Primary Industry, and CSIRO. The author is secretary of the Advisory Group.

One of the Advisory Group's first tasks was to prepare a position paper on developments in food irradiation, especially as they affect the situation in Australia.

The position paper was submitted to the SCA-Plant Health Committee in December 1984 and considered by the SCA early in February 1985. Because it deals with the kinds of questions raised by the Australian Food Industry and the community, an edited version of the position paper is reproduced here.

Position paper on developments in food irradiation

Following the 1980 meeting of the WHO/FAO/IAEA Joint Expert Committee on Food Irradiation and the subsequent recommendation of the Codex Alimentarius Commission of WHO to accept irradiation of food to an overall average dose of 10 kGy considerable interest in this process has developed world wide. This paper sets out in general terms the following aspects of food irradiation in Australia and elsewhere:

- Legislation overseas
- Legislation in Australia, including the steps still to be taken
- Existing commercial application overseas
- Research in Australia
- Perceived need in individual States in Australia (statement only).

Codex International Standard for Irradiated Foods and overseas legislation

The 15th Session (July 1983) of the Codex Alimentarius Commission adopted a revised Codex International Standard for Irradiated Foods and a Recommended International Code of Practice for the Operation of Radiation Facilities for the Treatment of Foods. The Standard allows the irradiation of all foods up to an overall average dosage of 10 kGy.

The labelling of irradiated foods for sale to the consumer is not yet covered in the standard but will be addressed in the revised Codex General Standard for the Labelling of Prepackaged Foods.

Legislation has been introduced in a number of countries to allow the irradiation of specific foods. The extent of such legislation is difficult to ascertain but the main approvals appear to be the following:

Belgium	: dried vegetables, garlic, onions, shallots, spices, strawberries
France (for 5 years only)	: spices, potatoes, onions, garlic, shallots, dried vegetables, deboned processed chicken meat
Israel	: potatoes, onions, poultry
Italy	: onions, garlic and shallots
Japan	: potatoes
Netherlands	: spices, dried vegetables and other foods
New Zealand	: spices
Norway	: spices
South Africa	: fruit, vegetables, frozen fruit juices, almonds, spices
USSR	: wheat and other products

The US Food and Drug Administration (FDA) is proposing regulations for the use of ionizing radiation for the treatment of food. The proposed regulations permit food to be irradiated for:

- Inhibiting the growth and maturation of fresh fruit and vegetables and disinfesting food of insects at doses not to exceed 1 kGy
- Disinfesting spices of insects and microorganisms at doses not to exceed 30 kGy.

FDA has not proposed any special labelling requirements but is inviting comments on this

issue. The deadline for public comment on the FDA proposals was 16 May 1984 but in anticipation of regulations, the US Government has for some time given 'special approval' for the irradiation of specific foods, notably spices.

Legislation to allow the irradiation of food is under consideration in Canada, Federal Republic of Germany, Sweden and the United Kingdom.

Regulations covering the sale of irradiated foods in the Australian States/Territories

Currently, New South Wales, Queensland and South Australia are the only States that have a regulation covering the sale of irradiated food. Their regulations are in line with the National Health and Medical Research Council (NHMRC) recommendation of June 1979 which precludes the preparation and packaging for sale or the sale of food which has been either deliberately or accidentally irradiated without the specific permission of the Director-General of Health.

The Food Standards Committee of the NHMRC has agreed to the endorsement of the Codex General Standard for Irradiated Foods and the associated Code of Practice for the Operation of Radiation Facilities Used for the Treatment of Food.

These documents have been redrafted into the format of Model Food Standards Regulations by the Queensland Department of Health. They are being considered by the Food Standards Committee and a code of practice is now being drafted. They will then be recommended to the States and Territories for incorporation in their food legislations.

It is not possible to give a precise time scale for this operation, but it is hoped that the steps preparatory to the adoption of the regulations by the States and Territories will be completed early in 1986.

Commercial application overseas

The increasing interest in food irradiation world wide can be seen from the Table. It is particularly relevant to Australia in those countries which are our trading partners.

Research in Australia

Research in Australia over recent years has concentrated on low dose treatment of fresh fruit, with limited work on the treatment of seafoods, meat or poultry.

A major research program has been developed on the disinfestation treatment of fresh fruit against pests such as Queensland fruit fly and mango seed weevil. This follows the limitations applied to ethylene dibromide (EDB) fumigation and other similar treatments within Australia and by Australia's trading partners. The research has confirmed that a dose of 75 Gy (0.075 kGy) is suitable for disinfestation of fruit fly with a ten-fold higher dose for mango seed weevil.

Perceived need in individual States in Australia

Apart from the requirements for present and future exports of Australian agricultural produce, the treatment has application in interstate trade and in the importing of material subject to quarantine into Australia, especially because there is a general concern, not only within Australia, but world wide, with the post-harvest chemical treatment of food for human consumption. The ban on EDB fumigation in the USA and the reduction of chemical residues on food imported into Japan are current examples.

These concerns have been recognized by the States and Territories. For some foods, irradiation is a proven and safe method of achieving these goals, with a notable absence of residue.

There is increasing commercial interest in the development of food irradiation in Australia. The Advisory Group believes that this development will require coordination in legislative aspects, research and the safeguarding of Australian agricultural exports.

What does food irradiation entail?

Food irradiation is the treatment of foods with ionizing energy. The source of radiation may be an electron beam machine or a gamma-ray emitting isotope. Cobalt is the most commonly used isotope because of its ready availability, high penetration and long 'half-life' (more than 5 years). The advantage of an electron beam machine over isotopes is that it can be switched 'off', whilst gamma sources require expensive installations and storage facilities to provide effective biological shielding. However, the radiation produced by an electron beam machine is only able to penetrate food to a depth of 5-20 mm, so that it cannot be used to treat, say, fruit packed in cartons.

As already mentioned, one potential application of irradiation in Australia is the treatment of citrus against infestation by the Queensland fruit fly *(Dacus tryoni)*, because of the dissatisfaction, on health grounds, with chemical fumigation. Irradiation, using a cobalt

TABLE 1

Some commercial applications of ionizing energy treatments of foods[A]

Country	No. of plants[B]	Type[C]	Volume (tonnes per annum)	Examples of foods treated
In operation				
Belgium	1 : G	I	3000	Spices, egg powder, frozen sea food
France	1 : P	EB		Processed chicken meat
Israel	1 : G	EB		Poultry feed
Italy	1 : P	I	30 000	Potatoes, onions
Japan	1 : P/G	I	30 000	Potatoes
Netherlands	1 : P	I	3500	Spices, dried soup mix, frozen seafood
New Zealand	1 : P	I	Small volume	Spices
S. Africa	2 : P	I		Strawberries, lychees,
	1 : G	I	28 000	bananas, mangoes, papaya, chutney, spices, herbs
USSR	2 : G	EB	$10^{6[D]}$	Wheat
Under consideration				
Canada	1 : G	I	Not available	Poultry, fish
USA				
- Mainland	3 : P	I, EB		Spices
- Hawaii	1	I (under construction)	Not available	Papaya

[A] Excludes Countries of Eastern Bloc, Latin America, China

[B] P = Private G = Government

[C] I = Isotope EB = Electron beam

[D] In period 1980-84

source, is clearly an alternative of great promise.

Commercial facilities in Australia

There is at present only one commercial cobalt irradiation plant in Australia undertaking contract work. It is operated by Ansell International at Dandenong in Victoria and is used mainly to sterilize medical and pharmaceutical products. The company is building a second plant in Sydney which should be operational towards the end of 1985.

Consumer education

Although some fears have been expressed that the introduction of food irradiation may be met with consumer resistance, such fears have not been borne out overseas. For example, in Canada the Consumers' Association declared its support for the technology, *provided* that treated food is appropriately labelled. Again, in South Africa, where food irradiation was introduced some years ago, consumers often seek out labelled irradiated fruit in shops, knowing it to be of good quality and to have a better shelf-life. The Australian Federation of Consumer Organizations at a recent general meeting adopted a resolution "accepting that food treated with ionizing radiation would be an acceptable product on the Australian market, provided the food was labelled to show that it had been irradiated". In addition the food must be irradiated under conditions specified by the Australian Government.

Training of personnel

The Australian School of Nuclear Technology (ASNT), located next to the Lucas Heights Research Laboratories of the Australian Atomic Energy Commission, has for many years run courses designed for persons working in a range of occupations associated with radiation. In May 1985 ASNT organized a Workshop on Commercialization of Ionizing

Energy Treatment of Food, under the Regional Project on Food Irradiation. Australia is a signatory of the Regional Asian Cooperative Agreement of the International Atomic Energy Agency. Participants at the Workshop came from seven Asian countries, New Zealand and Australia. At the conclusion of the workshop the following recommendations were made:

"This Workshop recommends that those in attendance should seek to initiate and stimulate interest in food irradiation among food manufacturers and the community generally, and to this end should work towards forming a steering group/committee involving representatives of food industry, consumers' organizations, etc. to prepare and disseminate educational material and if necessary to urge the adoption of the Codex Alimentarius Commission's General Standard of Irradiated Foods and its Recommended Code of Practice for the Operation of Radiation Facilities used for the Treatment of Foods.

It is further recommended that the steering group should operate through the central organization representing food manufacturers, and/or food producers."

The current interest in this technology may be illustrated further by its inclusion in the program of the convention of the Australian United Fruit and Vegetable Association held in Perth, WA in August 1985, when the subject of the disinfestation of fresh produce by irradiation was discussed.

Even when all the problems summarized above have been overcome, commercial irradiation of foods will not become a reality until the process has been found to produce benefits that outweigh its costs. The cost of irradiated foods to the consumer must also be competitive with the cost of foods produced by other processing technologies or they must satisfy some other important consumer need.

Further reading

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Sensory measurement: an introductory overview

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Systems of *physical* measurement are often taken for granted. For many people, it is as if such units as metres, kilograms, and litres have always been available. This is not the case, of course.

Take for example the development of a temperature scale. According to Shepard (1981), the first crude thermometer appeared in the early 17th century. However, this device was still quite arbitrary: although it allowed for some kind of 'temperature' estimate, it did not "really provide an adequate basis for assigning numerical values to temperatures in any unique way" (Shepard p. 23). It was some 200 years later, following important theoretical advances in thermodynamics, that a valid, equal-interval temperature scale was finally specified.

The current status of *sensory* scales of measurement is somewhat analogous to that of the crude thermometer mentioned above. As yet, there is no uniquely specified scale of sensory intensity – no universally accepted way of measuring sensory dimensions such as loudness, brightness, heaviness, or sweetness. In fact, three sensory scales have been promulgated: the *rating scale* (or category scale), the *JND scale*, and the *magnitude scale*. It is generally held, furthermore, that these three scales are nonlinearly related to one another (see Fig. 1). Which, if any, is correct?

This overview will first outline the development of these three types of scale. It will then be shown how, in the light of recent empirical evidence, the three scales might be rationalized to a single system of sensory measurement.

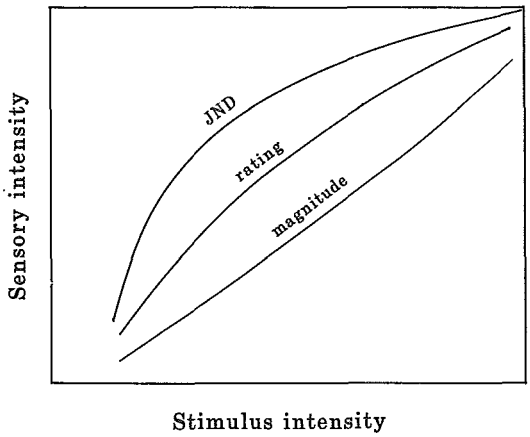

Fig. 1. The generally accepted (but recently challenged, see text) relationship between the three types of sensory scale – JND scale, rating scale, and magnitude scale (after Stevens 1975 p. 229).

The rating scale

The rating scale is a time-honoured yardstick. According to Stevens (1975 p. 23), it was used by astronomers to estimate the brightness of stars as early as 150 BC.

Rating scales come in many forms, and have been used for innumerable purposes. Two examples are given in Fig. 2. Typically, verbal descriptors are attached to the scale, occasionally with numbers as well; sometimes the scale is split into categories (Fig. 2a), sometimes it is not (Fig. 2b). The only common characteristic of rating scales is that they all depict some sort of quantitative, subjective continuum, and are *bounded at each end.*

In a typical rating task, assessors are presented with several levels of the stimulus, e.g. several different concentrations of sucrose. They are required to taste each in turn, in a controlled design, and to rate each sweetness sensation on a scale such as in Fig. 2. The responses to each concentration are then averaged over assessors, thereby providing an estimate of how sweetness varies with sucrose concentration. The resulting relationship will look something like the rating scale curve in Fig. 1 (McBride 1983a).

The rating scale is simple to use, and consequently has enjoyed widespread application. Although the experimental procedure may seem somewhat arbitrary

(especially in comparison with physical measurement), rating can provide very reliable information. For example, recently obtained sweetness scales for the sugars sucrose, fructose, and glucose (McBride 1983b) correspond very closely with earlier rating determinations of the same sugars (Schutz and Pilgrim 1957).

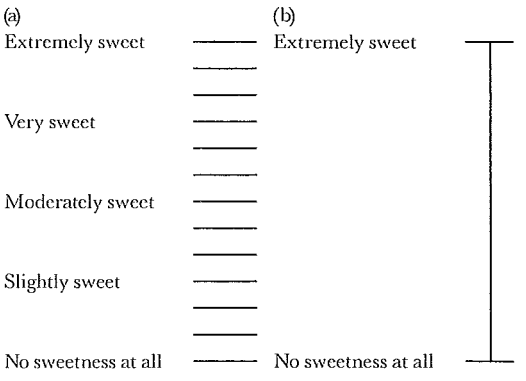

Fig. 2. Two examples of rating scales, in this case for the measurement of sweetness.

The JND scale

Despite its early beginnings, two millenia passed before sensory measurement became recognized as a scientific study in its own right. It was the German scholar Fechner who, in the mid-19th century, first sought to formalize a means of relating the internal, psychological world to the external, physical world; it was Fechner who coined the term *psychophysics*. However, Fechner claimed that this relationship could not be obtained directly, as with the rating scale; in his view, a sensory scale could be derived only in an *in*direct manner.

Fechner achieved his goal by drawing on the earlier (*c.* 1830) work of Weber, a German sensory physiologist. Weber had been interested in human sensitivity to sensory stimulation, and the following example shows how this sensitivity can be measured.

Suppose tasters are presented with two (unlabelled) sucrose solutions, of concentration 0.5% w/v and 1.0% w/v, and asked, "which is sweeter?". The 0.5% concentration is approximately the human threshold, and will be barely perceptible as sweet; the 1.0% solution, in contrast, will be slightly sweet, and relatively easy to identify as the sweeter member of the pair. If this pair is presented a large number of times (e.g. 100), with the order of presentation balanced to preclude bias, then the frequency with which the assessor answers correctly may be taken as an index of the sensory difference between the two solutions. In this case the frequency might well be 100%. But if the upper concentration is reduced by the experimenter, say to 0.7%, the sweetness discrimination task will become more difficult; the tasters will choose incorrectly on some trials, and the frequency of correct response might drop to, say, 80%. As the upper concentration is progressively lowered, the frequency of correct response will correspondingly fall, until, when both concentrations are equal at 0.5%, random responding is expected, i.e. the responses will be split 50%/50%.

Thus, when the response split is 100%/0%, there is perfect discrimination; when the split is 50%/50%, there is no discrimination at all; and when the response split is 75%/25%, there is said to be a *just noticeable difference* (JND) between the two solutions.

In practice, the JND is determined by presenting assessors with a number of pairs of solutions, one member of which is a constant standard, the other of slightly higher (but systematically varied) concentration. The concentration difference that corresponds to a 75%/25% response split may then be obtained by interpolation. The JND can be determined empirically at any concentration of sucrose – it is not restricted to the threshold. When determined at a concentration above threshold, it is customary to present both stronger and weaker comparison stimuli: the JND is then taken as the average of the two estimates that correspond, respectively, to the upper (75%/25%) and lower (25%/75%) response splits.

As with many other sensory stimuli, the size of the JND for sucrose is found to be approximately proportional to the concentration at which it is measured. When the sucrose standard is 1.0%, the JND is approximately 0.2%; when the standard is 10.0%, the JND is approximately 2.0% (McBride 1983a). This proportionality relationship is known as *Weber's law* (see Guilford 1954 pp. 118-153 for more detail).

Application of the Weber technique allows measurement of human sensitivity to changes in sucrose concentration, but it says nothing of sweetness, the internal sensation. However, Fechner bridged this gap between the external and internal by making a simple assumption. He proposed that for every just noticeable difference, as measured by the Weber technique, there is a corresponding increment in sensory intensity; and that, furthermore, these increments in sensory intensity are always equal – just like the intervals between the centimetre calibrations on a ruler (see Stevens

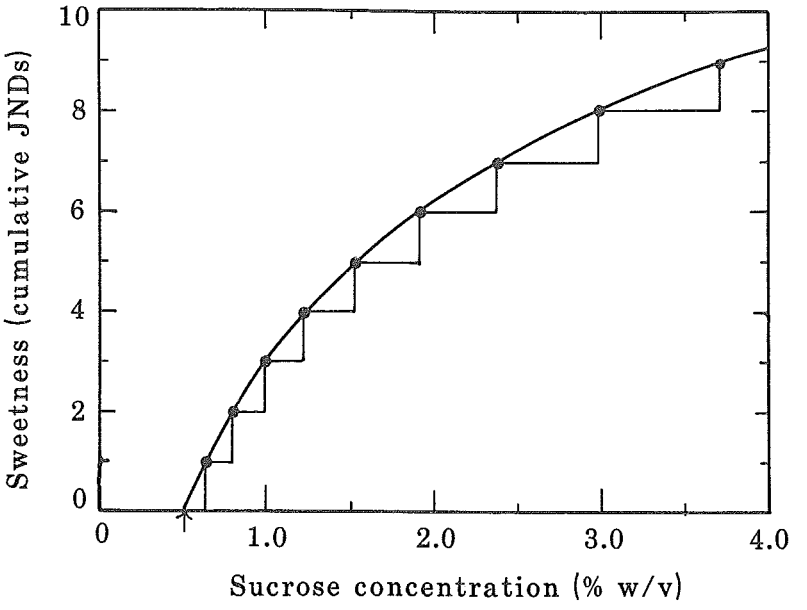

Fig. 3. Derivation of the JND scale. Beginning at the sensory threshold (arrow), the first just noticeable difference (JND) is determined and marked off horizontally on the x-axis (base of first step); a corresponding increment in sensory intensity is then added to the vertical scale. This procedure is repeated at the new stimulus level (threshold + 1st JND), and so on, with the resulting steps providing the sensory scale (see text for more detail).

1975 p. 9). Implementation of this assumption produces the *JND scale*, which can be conceptualized as a staircase of equidistant JND units, ranging from sensory threshold to the point of sensory saturation.

The construction of a JND scale for sucrose is illustrated in Fig. 3. The sucrose threshold (0.5%) is given by the arrow on the x-axis; there is zero sweetness at this point. Using this threshold concentration as the standard, the first JND is determined by experiment and marked off at the appropriate point (threshold + 1st JND) further along the x-axis (base of the first step). In accordance with Fechner's assumption, a unit increment in sweetness is now added vertically, giving the first point above threshold on the sensory scale. Now, using this concentration (threshold + 1st JND) as the standard, the second JND is determined experimentally, and marked off horizontally [(threshold + 1st JND) + 2nd JND]; a second increment in sweetness is now added vertically, giving the second point above threshold on the sensory scale. This process is repeated, step after step, with equal increments in sweetness on the y-axis corresponding to successive JNDs on the x-axis.

If the size of each JND is found to be proportional to the concentration at which it is measured (i.e. the data conform to Weber's law), then it follows that a constant ratio increment on the x-axis will produce a constant arithmetic increment on the y-axis; that is, sensory intensity (y) will be proportional to the logarithm of stimulus intensity (x), where stimulus intensity is measured in multiples of threshold concentration. This logarithmic relationship is known as *Fechner's law* (see Guilford 1954 pp. 37-39).

Fechner's pioneering contribution to sensory measurement was enormous. His logarithmic law had given psychophysics a quantitative footing, and was accepted virtually unchallenged for 100 years. It inspired, among other things, the well known decibel scale – a logarithmic scale of sound intensity.

The magnitude scale

Psychophysics lost momentum after Fechner, and nearly a century passed before it was revived by S. S. Stevens in the United States. Stevens was critical of Fechner's indirect method of deriving a scale; he claimed the best way to obtain a sensory scale is to have assessors assign quantitative estimates to stimuli directly.

For example, assessors might be presented with a number of sucrose concentrations, as in the rating task described earlier. But, instead of assigning ratings on a sweetness scale, assessors respond by nominating numbers, the magnitudes of which are considered to represent the respective magnitudes of sweetness. No restrictions whatsoever are imposed on number usage: one taster might use numbers within the range 1-100; another 0.5-4; yet another 7-23; and so on. Thus, the main difference between rating and magnitude estimation is that the former involves a bounded response scale, the latter does not.

For each level of sucrose, the geometric mean (or median) of all numerical responses is obtained, and these provide an estimate of how sweetness varies with concentration. This procedure, called *magnitude estimation*, was first devised in 1953, and has proved to be the dominant technique in psychophysics over the past 30 years. Curiously, although it seems similar to the rating task, magnitude estimation in fact provides different results, as indicated in Fig. 1.

The question of scale validity

The question of scale validity has been the major block to progress in sensory measurement: how can we be sure that the *external* response, as measured by some kind of sensory scale, correctly reflects the *internal* (private) sensation? This issue has not been given the attention it deserves. Until it is sorted out, there is no way of knowing which (if any) of the above three scales is correct.

The rating scale

For the rating scale, the question of scale validity amounts to whether or not ratings can be taken directly as measures of sensory intensity, i.e. are the ratings *linearly* related to sensory intensity?

A number of recent studies directed at this question do support rating as a valid (linear) means of reflecting sensory intensity. Description of this work is beyond the scope of this article; however, foremost is the contribution of information integration theory (e.g. Anderson 1979, 1981; see also Birnbaum 1982).

The JND scale

For the JND scale, the validity question reduces to a discussion of Fechner's assumption of JNDs as subjectively equal units of sensory intensity. If Fechner's assumption is valid, the derived JND scale will be valid; if the assumption is wrong, the scale must also be wrong.

Fechner's assumption is plausible, but, since it deals in units of covert sensory intensity, it is not amenable to direct empirical check. All that can be said is that there is no compelling reason why it should be rejected. As demonstrated elsewhere (McBride 1983c), cases of apparent failure of Fechner's assumption can more likely be ascribed to failure of Weber's law.

But there is one snag. If Fechner's assumption is correct, thereby vindicating the JND scale, and if the rating scale is also valid, as contended above, then why do the scales differ as shown in Fig. 1? The simple answer may be that they do not. Although the three-curve display of Fig. 1 is still generally accepted in psychophysics, a survey (McBride 1983a) revealed it to rest upon flimsy evidence. In fact, when both the rating scale and JND scale for a given stimulus are derived very carefully, it appears that they may lie one upon the other – they converge to the same yardstick (McBride 1982, 1983a).

The magnitude scale

Can the overt, numerical responses of magnitude estimation be taken as a valid measure of covert sensory intensity? The evidence would suggest not. When magnitude estimation is subjected to the same validity criterion as has been used on the rating scale (Anderson 1981), it generally fails: there seems to be a bias in the way in which people use numbers in a magnitude scaling task.

More specifically, inspection of many data sets (cf. Stevens 1975 p. 134) suggests that the magnitude scale is related to the other two scales in an *approximately* logarithmic fashion. So, if the y-values of the magnitude scale in Fig. 1 are transformed logarithmically, the revised magnitude scale then approximates to the shape of the top two curves. Moreover, there is a plausible, theoretical rationale for such a transformation.

According to many authors (e.g. Attneave 1962; Banks and Hill 1974), people perceive numbers as if constant geometric (ratio) increments, rather than constant arithmetic increments, are subjectively equal – as if the jump between the numbers 10 and 11 is more akin to the jump between 100 and 110, than to that between 100 and 101. In other words, the perceived number continuum is not linearly related to the actual, objective number continuum. As a consequence, overt numerical responses cannot be taken at face value as legitimate estimates of covert sensory intensity.

A prognosis for sensory measurement

The issues discussed in this overview are not clear-cut; in particular, debate continues on the status of validity criteria (e.g. see Birnbaum 1982). Notwithstanding, the following practical recommendations can be made:

- *The magnitude scale* should be discarded in applied sensory measurement. Although it is of some theoretical interest for psychophysics, as a practical yardstick it is likely to be biased and misleading. To persist with the magnitude scale, in light of the contrary evidence, is to persist with a ruler that is known to be warped.
- *The JND scale* might well be valid, but it is of little practical use to sensory measurement; derivation of a JND scale is time-consuming and tedious in the extreme. However, the JND scale, based as it is on human sensitivity, still holds much theoretical interest – especially since indications are that it converges on the rating scale.
- *The rating scale* appears to be valid, and should be regarded as the standard yardstick in applied sensory measurement. This is not to say that it is foolproof; it should not be applied without proper methodological precautions (McBride and Anderson 1985; Poulton 1979). Strangely, there has been only scant (McBride 1982) theoretical investigation of how the rating scale works, an omission that should be redressed in future psychophysical research.

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Protein-lipid interactions in food: with special reference to egg yolk

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The Division of Food Research is interested in protein-lipid interactions in food for several reasons, but particularly because of their possible importance for the structure of certain foods. At first sight the way proteins and lipids interact in food is not of particular interest or importance. After all, we know that food is thoroughly broken down when it is digested, so what does it matter how its proteins and lipids interact before it is eaten? This argument neglects the need for a food to be palatable. If a food is not palatable it is not likely to be eaten even if theoretically it has a high nutritional value.

The yolk of hens' eggs provides an especially good example of what is meant by palatability of food. If a yolk could be split up into its non-covalently-bound constituents, we should get three things (Fig. 1): 10-20 ml of salt water, a few millilitres of yellow oil that smells like slightly bad fish especially if it has been exposed to air, and some white protein with the consistency of dried seaweed. By themselves these are quite repulsive. If they are heated, under the conditions used for boiling or frying an egg, their appearance becomes even worse. The oil becomes brown and has an extremely unpleasant smell, and the protein becomes hard like toenails. It may be assumed that these constituents are also indigestible, especially after heating, but their appearance discourages attempts at eating them. What makes them into a digestible food with the familiar structure of egg is the way in which the proteins and lipids interact in nature. In the native structure the lipids and proteins are carefully packaged so that oxygen, which permeates the yolk once the egg is laid, cannot get to the reactive lipids, and the proteins are arranged so that they do not form lumps. As mentioned, these interactions are all non-covalent. Water is an essential constituent because the so-called "hydrophobic

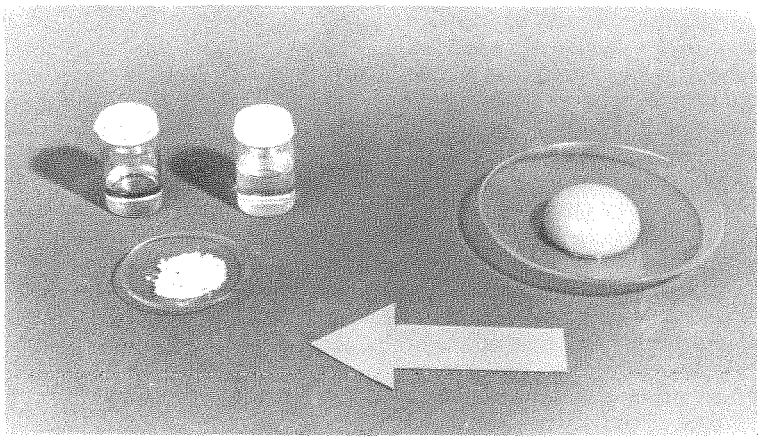

Fig. 1. The constituents of the yolk of a hen's egg after separation. If an egg-yolk, such as that at the right, is fractionated by solvent extraction and centrifuging the three products on the left are obtained. They are: a clear yellow oil (top left bottle), water (top right), and protein (white powder on glass at bottom).

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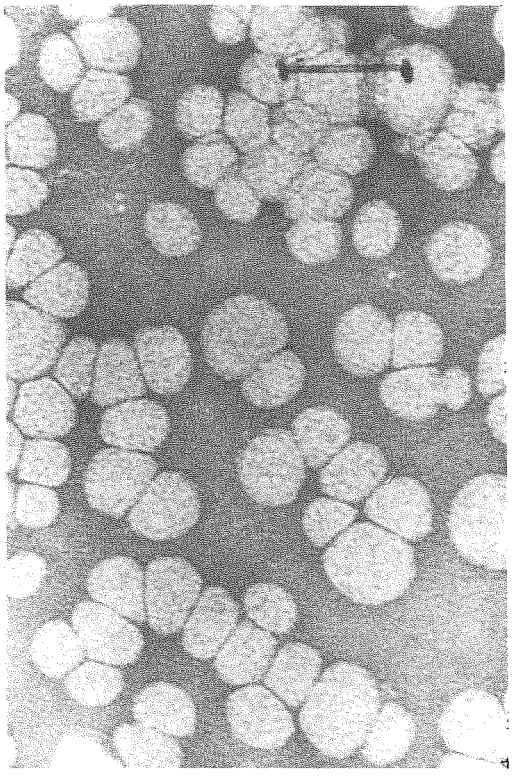

Fig. 2. Electron micrograph of particles of the main low-density lipoprotein of hen's egg yolk after negative staining. (X 133 000)

interactions" between proteins and other substances and between different proteins are an important part of the non-covalent interactions in any food that is not anhydrous.

The original protein-lipid structure of eggs does not survive cooking without change; nevertheless enough structure remains, unless there has been overcooking, to ensure that the lipids are not oxidized and that the proteins do not aggregate into indigestible lumps: consider, for example, egg custards. Similar arguments could be applied to other foods that contain a large proportion of protein and lipid.

If it is agreed that protein-lipid interactions are important in food, the next question is: what is the nature of these interactions? A simple answer would not be expected in view of the large diversity of both food proteins and lipids. In fact a wide range of interactions is possible, from proteins that do not have much affinity for lipids, such as collagen and gelatin, to certain special proteins that have a high affinity for a particular lipid. An example of the latter is the retinol-binding protein of vertebrate blood, which binds tightly to vitamin A but not to closely related lipids. Presumably this type of binding is analogous to interactions between enzymes and substrates and is unlikely to be of interest for foods such as egg yolk because yolk does not have enough protein for each molecule of lipid to have its own protein molecule. Furthermore it is known that in egg yolk all the lipid is packed in small particles referred to as "lipoproteins".

Fig. 2 shows particles of the main lipoprotein of yolk viewed in the electron microscope. These particles are 60% of the dry weight of yolk and contain 12% of protein. As far as we know the protein is at the surface of the particles, but there is not enough to cover the surface. There is, however, a large proportion of charged lipid, i.e. phospholipid, and this is also at the surface (Burley and Kushner 1963). It is reasonable to suppose that the phospholipids and proteins interact at the surface and it is possible that cholesterol is part of the surface

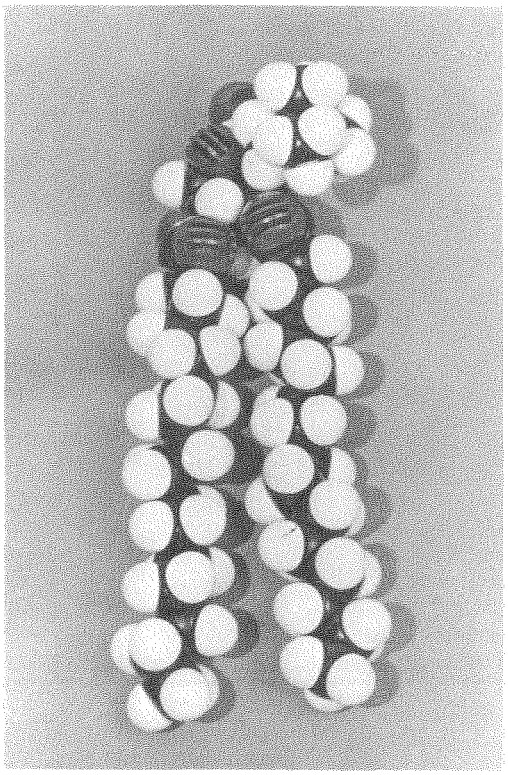

Fig. 3. Model showing arrangement of atoms in a molecule of the phospholipid, dipalmitoyl lecithin.

layer (Schneider and Tattrie 1968). This leaves those lipids that do not contain phosphorus, chiefly the neutral lipids, to occupy the centre of the lipoprotein particles, where they form essentially an oily droplet well protected from the outside by the protein-phospholipid-cholesterol layer.

Our work at the Food Research Laboratory has been based on the assumption that protein-phospholipid interactions are responsible for the integrity of the surface layer of the lipoproteins, although we recognize that such interactions could serve to anchor the protein in the surface layer without necessarily contributing to the stability of the particles. In either case, the binding of phospholipids would be expected to be an important property of some yolk proteins. The impetus for this work came from the isolation at FRL of purified samples of apoproteins, i.e. lipid-free proteins, from the main lipoprotein of yolk (Burley and Sleigh 1983). One protein has been used for most of this work, namely, apovitellenin I from hens' eggs. This protein has several advantages. It can be isolated in relatively large amounts. It has a very low molecular weight. It has been isolated from eggs of several species of bird, and the amino-acid sequences have been determined. These sequences show interesting differences as well as the expected homology (Inglis *et al.* 1982). A disadvantage is that apovitellenin I is insoluble in solutions at neutral pH although it is soluble at low pH and in protein solvents such as concentrated urea.

The interaction of hens' apovitellenin I with a single phospholipid, dipalmitoyl lecithin (Fig. 3) has been studied in detail. We have found that there is strong interaction to give stable complexes that can be isolated by gel-filtration chromatography. A sensitive test for the formation of complexes was provided by the differential scanning calorimeter designed and constructed by Smith and Rose (1975) at the Food Research Laboratory. According to measurements with this calorimeter, when equal weights of apovitellenin I and dipalmitoyl lecithin are mixed at 45°C, which is above the transition temperature (i.e. "softening

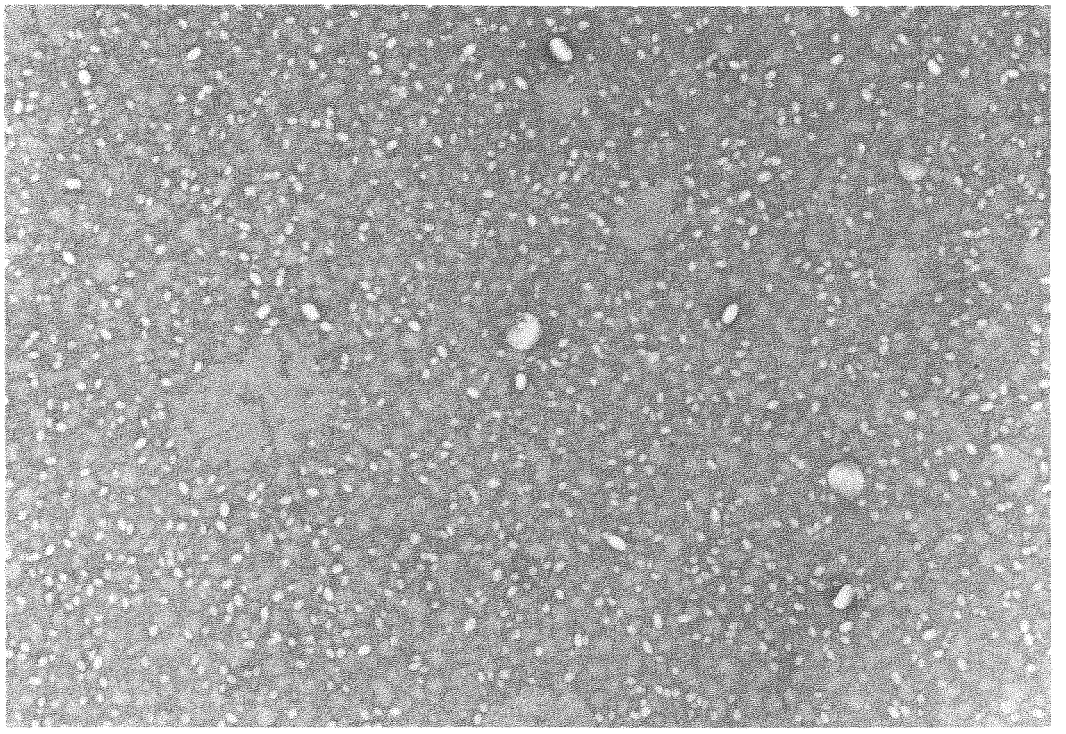

Fig. 4. Particles of the complex ("Complex A") formed rapidly by hen's apovitellenin I and dipalmitoyl lecithin mixed in equal proportions. Figs 4 and 5 are electron micrographs of negatively stained preparations. (X 137 000).

temperature") of the lipid (40°C), a complex is formed immediately. This complex consists of globular particles that can be seen in the electron microscope (Fig. 4). On prolonged heating in the presence of excess lecithin, another complex is formed. This has larger particles which are probably disc shaped (Fig. 5).

Other properties of these complexes have been examined. For example, each protein chain is usually associated with ten phospholipid molecules. This number varies slightly with different preparations for reasons that have not been determined. Another yolk apoprotein, apovitellenin II, gave no evidence for interaction with lecithin, so interaction with phospholipids is not a property of all yolk proteins. Details of the interactions between apovitellenin I and phospholipid at the molecular level are not yet clear, but are likely to be important for a detailed understanding of the industrial properties of yolk such as, for example, the well-known emulsifying power of yolk. Fortunately, protein-phospholipid interactions are now an important research topic in many laboratories interested, for medical reasons, in the blood lipoproteins (e.g. review of Sparrow and Gotto 1982). Considerable progress has been made in understanding their chemistry. It is now clear that phospholipid-binding proteins have one feature in common: they have a structure that is potentially highly helical. An example of the helical structure of proteins – the so-called α-helix, is shown in Fig. 6. When these proteins interact with phospholipids the proportion of helical structure increases, according to physical measurements such as those obtained with circular dichroism or optical rotatory dispersion.

In spite of many such studies, we still do not have a complete understanding of the way in which phospholipids interact with proteins, either in general or for particular proteins and lipids. We cannot at present tell whether a protein will bind to phospholipids or other lipids simply by examining its amino-acid sequence. The next stage of the work at the Food Research Laboratory will involve a more intensive study of interactions between egg-yolk

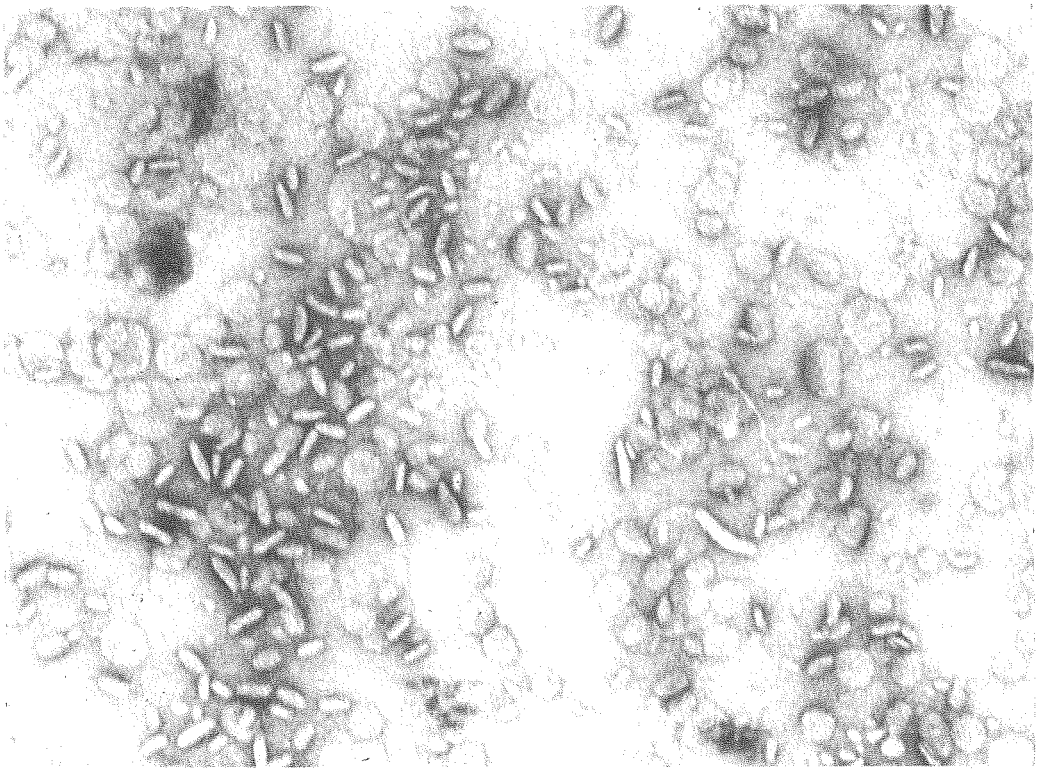

Fig. 5. Particles of a second complex ("Complex B") formed by excess lecithin and apovitellenin I after interaction for several hours.

and other food proteins and lipids at the molecular level, in an attempt at contributing towards solving such problems. In this work the Norwegian Food Research Laboratory will be cooperating.

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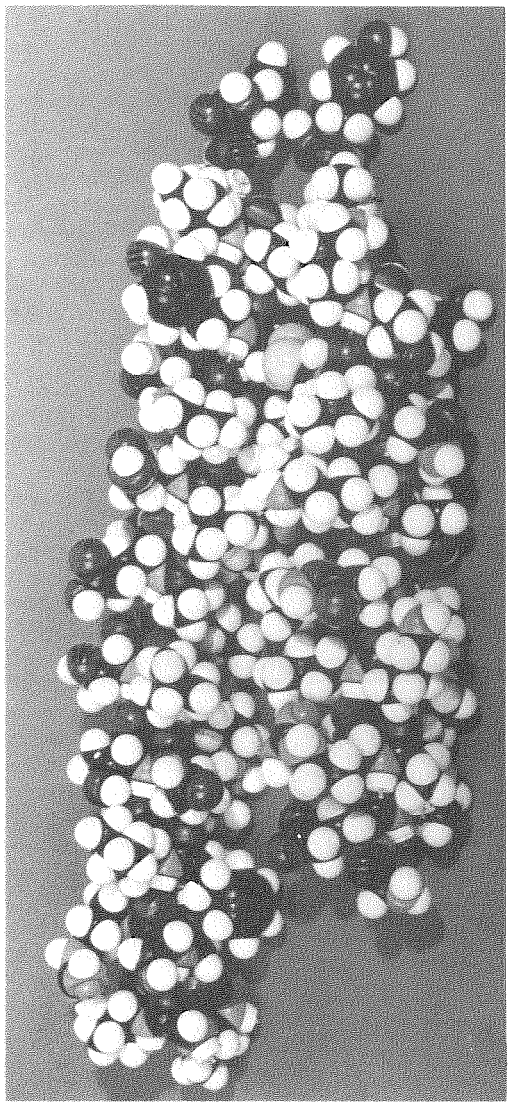

Fig. 6. Atomic model of part of the protein of hen's apovitellenin I. This part has a high probability of having an α-helical structure according to its amino-acid sequence.

News from the division

AIFST Open Day

On 19 June 1985 an Open Day was held at FRL for members of the Australian Institute of Food Science and Technology. Almost 80 people attended. During the morning, after introductory talks by Dr J. H. B. Christian and Dr A. R. Johnson, short lectures were presented by Drs D. G. Laing, F. B. Whitfield, J. I. Pitt, R. V. Holland and R. J. Steele. After lunch, the visitors inspected the laboratories and had informal discussions with members of staff.

Honours, Awards

Dr A. F. Egan of MRL has been made an Honorary Research Fellow, School of Science, Griffith University, Queensland.

The Malcolm Bird Commemorative Award for AIFST Young Members was presented to Mr F. J. van Doore of MRL in June 1985 for his paper 'The development of a dynamic equilibrium cell for the determination of food product adsorption/desorption isotherms'.

FRL's E. W. Hicks Memorial Prize for 1984 was awarded to Mr Glenn Hodson, Apprentice Carpenter, for the excellent results gained in his Trades Course.

Dr B. A. Cornell (FRL) has become an Associate of the University of Sydney.

Mr P. W. Board has succeeded Dr A. R. Johnson as Leader of the Applied Food Science Group at FRL.

ASTEC Review of Public Investment in R & D in Australia

At the behest of the Australian Government, the Australian Academy of Science and Technology is carrying out a comprehensive review of expenditure on R & D in this country.

CSIRO is being examined first in view of the imminent retirement of its Chairman, Dr J. P. Wild, FRS. As part of this review, members of the Review Committee visited the three major laboratories of the Division during June.

Visiting scientists

Professor Dan Farkas, Head of the Department of Food Science and Nutrition, University of Delaware, USA, spent two months as Visiting Scientist at FRL, collaborating with Dr Don Casimir on food engineering projects.

Dr T. Matsuo of the Department of Horticulture, Kagoshima University, Japan spent 12 months from June 1984 to May 1985 working in the Plant Physiology Group with Dr D. Graham and Dr B. D. Patterson on chilling injury in plants, in particular examining the involvement of proteins in the chilling response. He was supported by funds from Kagoshima Prefecture. His visit is one of several which indicate the increasing collaboration between PPG and Japanese scientists. Dr D. G. Bishop and Mrs J. Kenrick will visit Professor N. Murata's laboratory at the National Institute for Basic Biology at Okasaki, Japan, in August and September, 1985, for collaborative work on lipids in chilling injury which is being partly supported under the Australian Academy of Science-Japan Society for the Promotion of Science Exchange Agreement.

Exhibition

The Division mounted an exhibit at FOODTECH '85 in Sydney in June. The exhibit included a working prototype of the Counter Current Extractor developed at FRL by Dr Don Casimir.

Specialist course

A course entitled Diagnosis of Spoilage of Canned Foods and Related Products was conducted at the University of NSW from 1-5 July, 1985. It was organized jointly by the Division, the University's Department of Food Science and Technology, and the Australian Institute of Food Science and Technology (NSW Branch) Food Microbiology Group. The course was designed to train participants in laboratory techniques for diagnosing the cause of defects in canned foods and related products, with special emphasis on the correct interpretation of the results of laboratory investigations. Lectures covered canning technology, various aspects of the microbiology of canned foods and raw materials, sampling, non-microbial spoilage, water chlorination, sanitation, the properties and examination of tinplate, glass and flexible packages, procedures for investigating spoilage, and the recovery of foods suspected to be defective. Laws and regulations governing the manufacture, distribution and sale of canned foods and the legal responsibilities of people giving technical advice to the industry were also discussed. Microbiological examinations of spoiled canned foods and assessments of container integrity were performed by the participants during laboratory sessions. Twenty-two of the 30 registrants were from industry, with the remainder representing educational institutions or government authorities. Two participants were from overseas.

A manual containing the lectures presented during the course has been prepared and is available from Mr G. Fisher at FRL. The price is $12 post paid in Australia, $8 plus postage to full-time registered students.

CSIRO Energy Management Unit

An Energy Management Unit has been established by CSIRO Headquarters. The Unit became operational on 1 December 1984 as an independent group within the Buildings and Property Section. The manager of the Unit will report to the Manager, Buildings and Property, Mr J. V. Dunn.

For the three year period 1984/87 the Unit will be based at the Cannon Hill site and will be managed by Mr J. W. Buhot, with technical assistance from Mr J. Anderson and Mr W. K. Larnach. The three staff have been seconded from their present positions at the Division of Food Research, Meat Research Laboratory, Cannon Hill.

The functions and responsibilities of the Unit may be summarized as follows:

- Promote awareness in the various CSIRO Divisions and Units of the opportunities for the benefits of energy conservation and management and provide advice as requested.
- Carry out energy audits on each significant CSIRO site as resources permit.
- Based on information collected during energy audits, develop an energy management program for each site and present the program to the senior CSIRO officer at each site.
- Assist with the implementation of the various energy management programs.
- Review the design of new CSIRO building proposals to ensure that the building services are energy efficient.
- Prepare an annual report for the CSIRO Executive providing details of CSIRO's energy consumption and estimated savings for the previous year. The report will also review progress of the Energy Management Unit's aims and indicate proposals and targets for the following year.
- Prepare an annual report for the Department of Resources and Energy as required by the Government directive.

Death

The death has been reported of Mr C. C. Kuchel. Mr Kuchel joined the Food Preservation Section of the Council for Scientific and Industrial Research as an assistant research officer (biochemist) in 1938. In conjunction with Mr W. A. Empey he studied problems of the processing and preservation of fish at the Section's Homebush (NSW) headquarters.

During World War II, a serious shortage developed in the supplies of cod liver oil. Mr Kuchel was seconded to a team from CSIR Division of Fisheries and Messrs Nicholas Aspro Ltd studying the quality and methods of extraction of Australian fish liver oils.

At the end of the war, he resigned from CSIR and joined the research laboratories of Nicholas Aspro Ltd and he remained with this company until his retirement about six years ago.

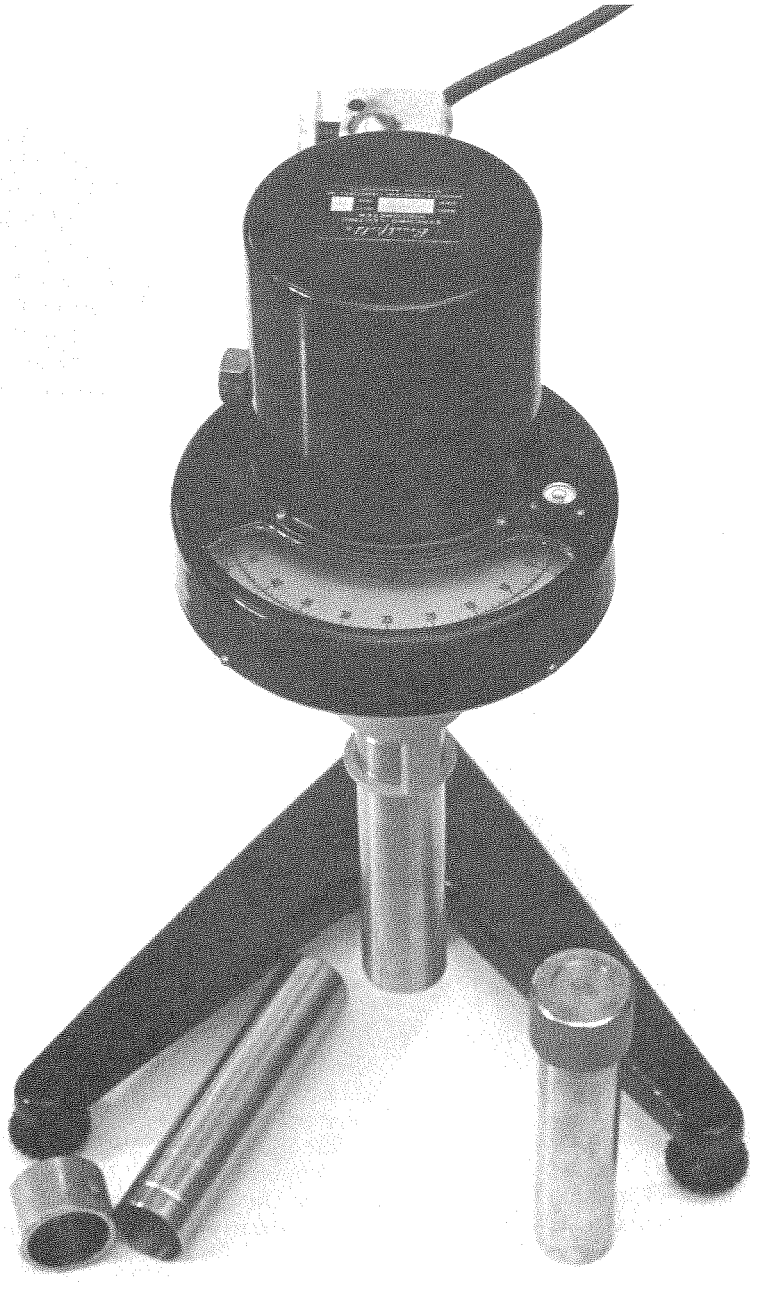

Fig. An instrument for measuring the viscosity of milk and milk products – Brookfield Viscometer.