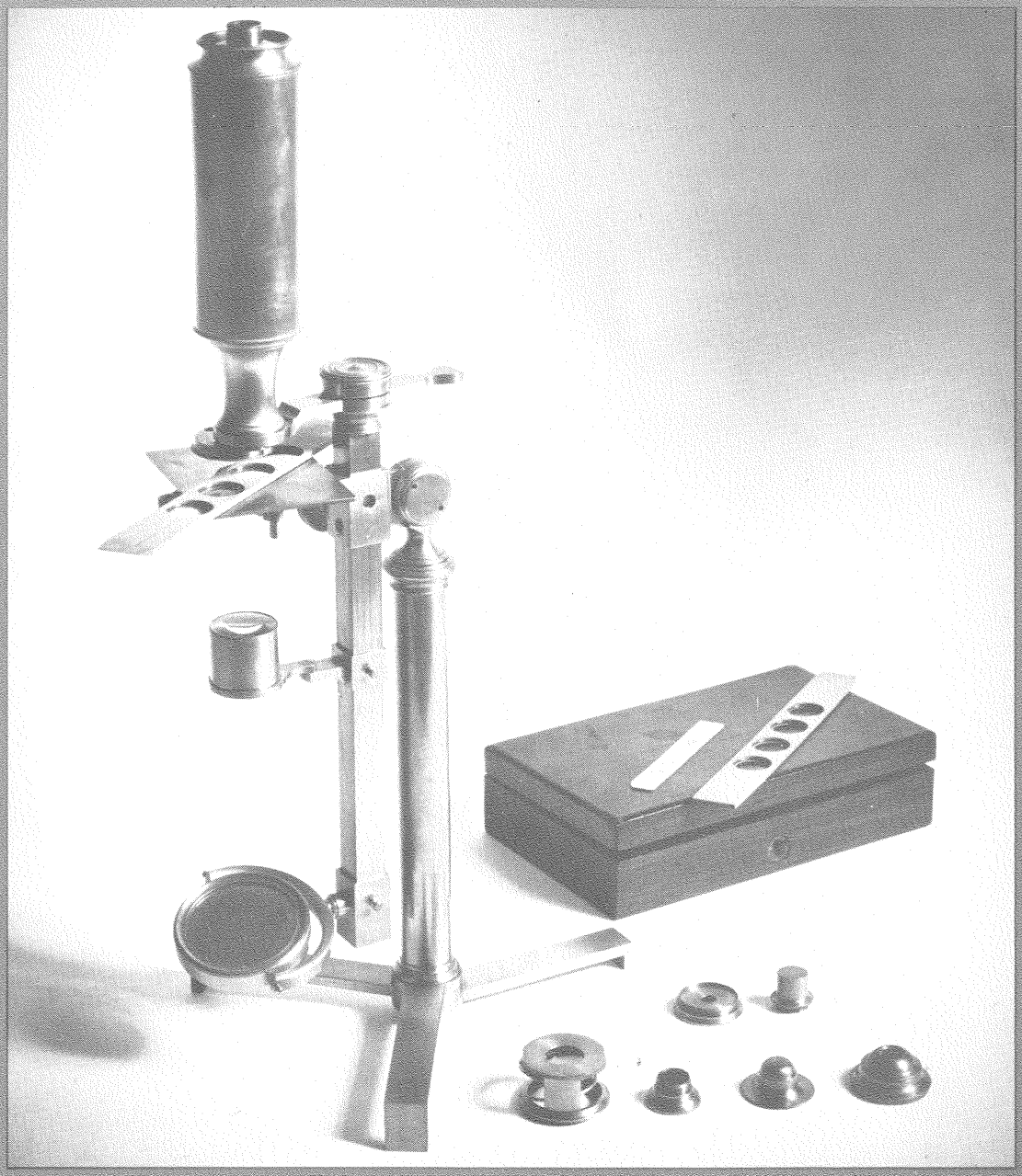
Vol. 36 No. 1 March 1976

CSIRO Food Research Quarterly



Shelf life of packaged foods

Compiled by K. C. Richardson

CSIRO Division of Food Research, Food Research Laboratory, North Ryde, N.S.W.

A subject that is exciting world-wide interest in the area of food standards and regulations at the present time is the date-marking of foods. It is not appropriate to discuss here the controversial aspects of this subject, but inquiries that the Division of Food Research has received from food manufacturers, consumers and government departments indicate a need for factual information about the storage properties of foods. Accordingly, we present here information on the keeping qualities of foods which brings together published data and the experience of the Division.

In considering this information the following basic concepts may be stated:

- The period from the time of its preparation or manufacture during which a food remains suitable for human consumption is limited and is commonly known as the shelf life of the food.
- A food may become unsuitable for human consumption, i.e. its shelf life may be terminated, because of microbial deterioration, and the food may then be positively harmful to consumers.
- The shelf life of a food may be terminated by non-microbial deterioration, e.g. deterioration in quality or nutritive value; the food is then generally not positively harmful to consumers.
- The shelf life of a food is not a fixed period but is dependent upon the conditions under which the food is stored. The most important of these conditions is temperature, but other conditions such as package attributes, atmospheric humidity and exposure to light, may all be important for specific foods.

When a food is stored under known and controlled conditions it is possible to estimate its shelf life with some confidence, but a prediction of commercial shelf life under the different and changing conditions experienced between preparation and retail sale is at best only a rough guide. The shelf lives given in Tables 2–9 must be regarded in this light; they do not represent the maximum lives which might be attained under optimum conditions.

The storage temperature affects the rate of both microbial growth and chemical reactions in foods. The rate of most chemical reactions is approximately doubled with each 10°C rise in temperature. The relative rates of chemical change in foods stored at the average temperatures in five Australian cities are shown in Table 1. Similar daily or seasonal changes in a store at a particular location would influence rates of deterioration in quality in the same way. Changes occurring in a food during storage at a temperature higher than a recommended range cannot be reversed by returning the product to the recommended temperature. This applies whether the higher temperature has accelerated chemical reactions or microbial growth.

Table 1. Effect of storage temperature on rates of chemical reactions in foods

Location	Average temperature (°C)	Relative rates
Melbourne	15	1·00
Sydney	17	1·20
Brisbane	20	1·49
Cairns	25	2·00
Darwin	28	2·53

Canned foods

Most canned foods are packed in hermetically sealed containers and sterilized by heat. If the seal is faulty or the heat process is inadequate, microbial spoilage generally occurs within a few weeks of manufacture and before the pack reaches the retail

market. Canned foods thus provide the most clear-cut example of foods which are stable indefinitely against microbial spoilage and whose shelf life is therefore governed by other considerations.

In fact, the shelf life of many canned foods is determined by the rate of corrosion of the container. Many factors influence this rate but, in general, acid foods such as fruit juices have shorter shelf lives than low-acid canned foods such as meats and vegetables.

The less corrosive canned foods reach the end of shelf life because of deterioration in quality, e.g. darkening in colour, breakdown in texture, or loss of desirable flavour. We are now in an area of subjective judgments where definitions are difficult. There is no sudden moment or day when such a food becomes unsuitable for consumption, but rather a slow decline in quality so that at some time it may be said that the *product probably will not have the quality attributes normally expected by the consumer*. This form of words is one used by the Codex Alimentarius Commission.

Dry foods

A large proportion of the foods on supermarket shelves fall within this category and depend for stability in storage on control of water activity. Only if they are very unfavourably stored are they subject to microbial spoilage, and then generally by moulds. These foods therefore also reach the end of shelf life mainly because of loss of quality. The same considerations as were discussed under canned foods apply here, and we are concerned with loss of quality or nutritive value because of chemical reactions such as oxidation of fats, browning reactions and chemical loss of nutrients.

The properties of the package may have a particular influence on the shelf life of dry foods, especially when the food is sensitive to the entry of water vapour or oxygen or both. Because packaging costs are often a dominant component in production costs, a food manufacturer may decide what is an adequate shelf life for marketing his product and then select packaging materials that are just good enough in permeability properties to give him this shelf life.

Most dry foods are susceptible to attack by insects such as moths, beetles and weevils, but in this article it is assumed that the food is stored in an insect-free area and so shelf life would not be limited by such contamination.

Table 2. Expected shelf life of packaged cereal products under defined storage conditions

Type of food	Usual packaging material	Storage conditions	Shelf life
Biscuits			
Savoury, sweet, chocolate-coated	Plastics	Cool and dry*	15 weeks
Bread			
White, sliced	Waxed paper		1–4 days
Rye, sliced	Plastic	20–25°C	3 weeks
Fruit loaf, sliced	Waxed paper		1–4 days
Breakfast cereals ready to use			
Wheat, corn and rice-based products	Waxed paper	Cool and dry	3–6 months
Breakfast cereals requiring cooking			
Oatmeal	Paper or plastic	Cool and dry	6 months
Cake mixes, dry	Waxed paper	Cool and dry	2 years
		If above 25°C	12 months
Flour, plain	Paper	Cool and dry	2–3 years
Pasta			
Spaghetti	Plastic	Cool and dry	6–8 months
Puddings, canned			
Fruit, sponge	Can	25°C or lower	2 years
Rice, polished	Plastic	Cool and dry	1 year

* Ambient conditions under 25°C and under 60% R.H.

Table 3. Expected shelf life of packaged cheeses under defined storage conditions

Type of cheese	Usual packaging material	Storage conditions	Shelf life*
Blue Vein	Foil or plastic	Under refrigeration†	2–3 months
Brine-packed Feta	Can	Under refrigeration	3 months
Hard grating			
Romano, Parmesan	Plastic or waxed paper	25°C or lower	6 months
Natural firm matured			
Edam, Gouda	Plastic or waxed paper	Under refrigeration	3 months
Natural firm surface ripened			
Havarti	Foil or plastic	Under refrigeration	2–3 months
Natural hard			
Cheddar	Plastic or can	Under refrigeration	3 months
Natural semi-soft surface ripened			
Meunster, Port Salut, Limburger	Foil or plastic	Under refrigeration	2–3 months
Natural soft surface ripened			
Camembert, Brie	Foil or plastic	Under refrigeration	2–3 weeks
Processed Cheddar	Foil or plastic	25°C or lower	12 months
Spreads, pasteurized	Foil or glass	Under refrigeration	6 months
Unripened firm			
Mozzarella	Plastic	Under refrigeration	2–3 months
Unripened soft			
Cottage, Bakers, Quarg, Ricotta, Cream	Plastic, foil, plastic-lined paper	Under refrigeration	10 days

* Time between movement from the manufacturer and opening of package.
† Between 0·5°C and 5°C.

Frozen foods

The temperature of storage has a special significance with frozen foods because they are defined as foods stored at temperatures below −18°C. At such temperatures microbial growth is completely inhibited and therefore only if they are grossly abused is the shelf life of frozen foods determined by microbial spoilage. For frozen foods also, therefore, shelf life is determined by the rate of decline of initial quality; this rate differs considerably from product to product but is slower the lower the storage temperature. Fluctuations in temperature should be avoided in the storage of frozen foods; as already mentioned, quality lost by storage at a higher temperature is irreversible and cannot be recovered by storage at a lower temperature.

Perishable foods

A group of foods that includes both fresh and processed foods is designated *perishable* because the shelf life is characteristically short and is terminated by microbial spoilage. In order to retard microbial growth and so extend the shelf life, perishable foods should be held under refrigeration, but they are distinguished from frozen foods because they are held at temperatures just above the freezing point. The shelf life of perishable foods is greatly influenced by the initial load of microbial contamination.

Fresh fruits and vegetables and fresh fish are not included in the tables because of the special nature of their storage properties; this may be the subject of further articles.

Table 4. Expected shelf life of packaged dairy products (other than cheeses) and margarine under defined storage conditions

Type of food	Usual packaging material	Storage conditions	Shelf life*
Butter, after packing in consumer packs	Foil, plastic, paper	Under refrigeration†	6–8 weeks
Cultured products			
Yoghurt, buttermilk, sour cream	Glass, plastic, plastic-lined paper	Under refrigeration	10–15 days
Ice Cream (up to 4 litres)			
Manufacturers' store	Plastic	−25°C or lower	1 year
Retail outlet	Plastic	−18°C or lower	2 months
Milk and milk products (liquid)			
Milk, pasteurized and/or homogenized	Glass, plastic, plastic-lined paper	Under refrigeration	5–8 days
Cream, pasteurized	Glass, plastic, plastic-lined paper	Under refrigeration	5–8 days
Evaporated milk	Can	25°C or lower	6 months
UHT pasteurized milk	Can or plastic-lined paper	25°C or lower	3 months
Infant's food, sterilized liquid	Can	25°C or lower	4 months
Sweetened condensed milk	Can	25°C or lower	12 months
Milk and milk products (powdered)			
Full cream, skim	Can or plastic	25°C or lower	12 months
Infant's food (powdered)	Can	25°C or lower	12 months
Table margarine, polyunsaturated	Foil, plastic, paper	Under refrigeration	6 weeks

* Time between movement from the manufacturer and opening of package.
† Between 0·5°C and 5°C.

Table 5. Expected shelf life of packaged seafoods under defined storage conditions

Type of seafood	Usual packaging material	Storage conditions	Shelf life
Canned			
Fish	Can	25°C or lower	3 years
Fish paste			3 years
Fish in tomato sauce			2 years
Frozen			
Fishfingers, prawns	Plastic-lined paper	−18°C or lower	6 months
In glass			
Bismarck herrings	Glass	Under refrigeration*	12 months
Rollmops		Under refrigeration	12 months
Oysters		Under refrigeration	3 days
Scallops in vinegar		25°C or lower	6 months

† Between 0·5°C and 5°C.

Table 6. Expected shelf life of packaged fruits and fruit products under defined storage conditions

Type of food	Usual packaging material	Storage conditions	Shelf life
Beverages, fruit-based			
Juice in flagons	Glass, plastic or plastic-lined paper	Under refrigeration*	2 weeks
Juices, drinks and concentrates, chilled	Glass, plastic or plastic-lined paper	Under refrigeration	2 weeks
The above foods may be pasteurized and/or contain chemical preservatives; they are not sterilized.			
Juices, canned	Can	25°C or lower	12 months
Juices, concentrated, frozen	Can	−18°C or lower	2 years
Fruit, canned			
Berry fruits	Can, lacquered	25°C or lower	12–18 months
Other fruits	Can	25°C or lower	2 years
Rhubarb	Can	25°C or lower	6 months
Jams and conserves			
Most fruits	Can or glass	25°C or lower	2 years
Fruits, dried			
Most fruits	Paper or plastic	Cool and dry†	12 months
Prunes (moist-pack)	Plastic or can	Cool and dry	12 months
Glacé fruits	Plastic	Cool and dry	12 months

* Between 0·5°C and 5°C.

† Ambient conditions under 25°C and under 60% R.H.

Table 7. Expected shelf life of packaged meat products under defined storage conditions

Type of food	Usual packaging material	Storage conditions	Shelf life
Fresh			
Chicken	Plastic	Under refrigeration*	3 days
Cuts of beef, lamb, pork or veal	Plastic	Under refrigeration	5 days
Cooked			
Bacon, frankfurters, ham, sliced corn beef	Plastic (vacuum pack)	Under refrigeration	3–4 weeks
	Unwrapped sliced meats should be stored under refrigeration for not longer than 4–5 days.		
Canned			
Cured meat	Can	25°C or lower	4 years
Meat and cereal	Can	25°C or lower	4 years
Meat and vegetables	Can	25°C or lower	3 years
Items, e.g. ham, labelled 'Keep under refrigeration'	Can	Under refrigeration	2 years
Frozen			
Beef, lamb	Plastic or	−18°C or lower	10–12 months
Chicken	plastic-lined		12 months
Pork	paper		6 months
Beef extract, concentrated	Glass	25°C or lower	2 years

* Between 0·5°C and 5°C.

Table 8. Expected shelf life of packaged vegetables and vegetable products under defined storage conditions

Type of food	Usual packaging material	Storage conditions	Shelf life
Vegetables			
Canned			
Asparagus, tomatoes, green beans, sauerkraut	Can	25°C or lower	12–18 months
Beetroot	Can, lacquered	25°C or lower	12 months
Tomato paste	Can	25°C or lower	12 months
Other vegetables	Can	25°C or lower	3 years
Frozen			
Green vegetables, carrots, cauliflower	Plastic	−18°C or lower	15 months
French fried potatoes	Plastic	−18°C or lower	2 years
Dried, various	Foil laminate or can	20°C or lower	12 months
Soups			
Canned, various	Can	25°C or lower	2 years
Dry mix, various	Foil laminate	20°C or lower	12 months
Pickles and sauces			
High-acid			
Mustard pickles, chutney	Glass	25°C or lower	2 years
Low-acid			
Olives, gherkins, bread and butter cucumbers	Glass or can	25°C or lower	3 years
Vinegar-based sauces			
Tomato, Worcestershire	Glass	25°C or lower	3 years

Comment and constructive criticism on the information in this article would be welcomed.

Source material

Anon. (1956). Keeping quality of canned fruit and vegetables. (Fruit and Vegetable Canning and Quick Freezing Research Association: Chipping Camden.)

Cecil, S. R., and Woodroof, J. S. (1962). 'Long term storage of military rations.' (Dept of the Army, Q'master Food and Container Institute for the Armed Forces: Chicago.)

Davis, E. G. (1970). Evaluation and selection of flexible films for food packaging. *Food Technol. Aust.* **22**, 62.

Gutschmidt, J. (1974). The storage life of frozen chicken with regard to the temperature in the cold chain. *Lebensm. Wiss. Technol.* **7**, 137.

Hearne, J. F. (1964). Long term storage of foods. *Food Technol.* **18**, 318.

Hicks, E. W. (1945). Temperatures in non-refrigerated stores for processed foods. *CSIRO Fd Preserv. Q.* **5**, 33.

International Institute of Refrigeration (1972). Recommendations for the processing and handling of frozen foods. 2nd edn, p. 54. (International Institute of Refrigeration: Paris.)

Richardson, K. C. (1973). Some aspects of the microbiology of packaged foods. *CSIRO Food Res. Q.* **33**, 59.

Shepherd, A. D. (1960). Relative stabilities of various frozen foods. Conference on Frozen Food Quality. (USDA Agricultural Research Service: Albany, Calif.)

Van Arsdel, W. B., Copley, M. J., and Olson, R. L. (eds) (1969). 'Quality and stability of frozen foods: time temperature tolerance and its significance.' (Wiley: New York.)

Table 9. Expected shelf life of miscellaneous packaged foods under defined storage conditions

Type of food	Usual packaging material	Storage conditions	Shelf life
Baby foods, various	Hermetically sealed glass or can	25°C or lower	2 years
Beverages			
Tea	Paper	Cool and dry*	6 months
Coffee, ground	Can, vacuum pack	25°C or lower	9 months
Coffee, instant	Glass, vacuum pack	25°C or lower	9 months
Cocoa	Paper	Cool and dry	9 months
Sugar-based or low calorie, carbonated	Glass	25°C or lower, out of direct sunlight	12 months
Sugar-based, carbonated	Can	25°C or lower	6–9 months
Low calorie, carbonated	Can	25°C or lower	4–6 months
Beer, apple cider	Glass	25°C or lower, out of direct sunlight	12 months
Beer	Can	25°C or lower	12 months
Chocolate			
Dark or milk, bars	Aluminium foil or opaque laminate	25°C or lower	12 months
Soft or hard centred, specialty	Plastic over-wrapped box	25°C or lower	12 months
	Storage over 30°C may cause melting and whitish surface bloom. Wholesomeness is not affected by this.		
Cooking oils			
Olive, peanut, safflower or sunflower	Can, glass or plastic	25°C or lower	12 months
Dressings, dry mix			
Salad	Foil laminate	25°C or lower	12 months
Dressings, oil-based			
Coleslaw, mayonnaise, salad	Glass	25°C or lower	12 months
Eggs, fresh in shell	Paper or plastic cartons	25°C or lower	1–2 weeks
		Under refrigeration†	3–6 weeks
	Shelf life depends greatly on previous history.		
Honey	Glass or plastic	8–10°C	12 months
	Darkens when stored above 25°C; may granulate if refrigerated		
Jelly crystals	Paper	Cool and dry	12 months
Nuts			
In shell	Unwrapped or paper	Under refrigeration	12 months
Shelled	Plastics or can	Under refrigeration	12 months
Peanut butter	Glass	25°C or lower	12 months
	Subject to oil separation on long standing but wholesomeness is unimpaired.		
Snackfoods			
Potato crisps	Plastic, laminates	Cool and dry	3–4 weeks
Pretzels			
Salted nuts	Plastics	25°C or lower	6–8 weeks
	Vacuum-sealed cans or glass	25°C or lower	12 months
Sugar	Paper	Cool and dry	2–3 years

* Ambient conditions under 25°C and under 60% R.H.

† Between 0·5°C and 5°C.

Polycyclic aromatic hydrocarbons and foods

By D. Barnett

CSIRO Division of Food Research, North Ryde, N.S.W.

This article is intended to give readers an overview of the topic. The nature of the compounds, their occurrence in foods and the sources of contamination are outlined. Recent theory of carcinogenesis in animal cells caused by polycyclic aromatic hydrocarbons is explained. The probable significance of human exposure to these substances in foods and the general environment is briefly discussed

Evidence for carcinogenesis by certain polycyclic aromatic hydrocarbons (PAH) in laboratory animals is well established. Extension by analogy to humans is reasonable and is supported by a great deal of circumstantial evidence. It is of interest to note that the first reported occupational disease was a cancer prevalent in chimney sweeps. This disease, noted by Sir Percival Pott in 1775, was probably caused by PAH in soot acting on delicate skin. Pott's observations and conclusions mark the beginning of the recognition that cancer might be the result of causative agents in the environment and did not proceed from supernatural causes, as was believed hitherto.

In the 1930s the nature of the causative agents present in soot and associated tars was investigated by a number of workers. Such work ultimately led to the identification of the first known carcinogen of coal tar, benzo(α)pyrene (Cook *et al.* 1933). The number of known carcinogenic PAH has grown considerably since and the search for such materials in all areas of human contact continues at a highly active level.

Nature and origin of the compounds

Structural formulae of some PAH which have been isolated from food and are known to be carcinogenic, appear in Fig. 1. The molecules are planar and exhibit a high degree of electron delocalization. Most of the compounds have intense, characteristic fluorescence emission spectra. Such spectra provide a most sensitive means of detection and estimation of PAH at levels of μg/kg of sample. Volatility is generally low and the compounds are insoluble in water. Being relatively chemically inert, PAH are persistent in the environment and even active systems such as soils accumulate considerable concentrations under favourable conditions.

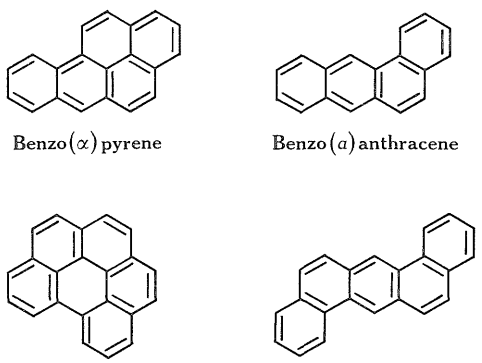


Fig. 1. Structures of some polycyclic aromatic hydrocarbons which have been isolated from certain foods.

The origin of these compounds in general, and more particularly in foods, is of great significance. Incomplete combustion of fuels results in formation of PAH. A mechanism for the formation of benzo(α)pyrene by such a process is given

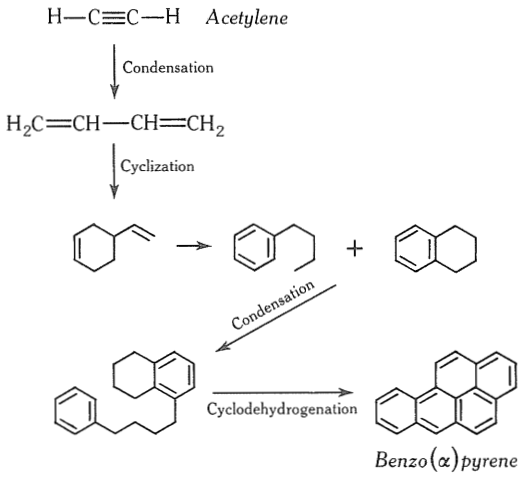


Fig. 2. Mechanism of formation of benzo(α)pyrene from products of incomplete combustion. Badger and Novotny (1963).

in Fig. 2 (Badger and Novotny 1963).

It has been shown that the concentration of benzo(α)pyrene in the soils of an area is related to the type and intensity of industry present (Shcherbak and Kogan 1970; Tilgner 1971). Environmental PAH may enter foods by various routes, e.g. contaminated air or water.

In foods, an area of particular concern is the role of processing operations which may contribute to the presence of these compounds. Evidence suggests that heating organic materials at high temperatures may generate PAH. Certainly, the smoking of foods has been shown to be responsible for some contamination (Haenni 1968) and PAH are produced when a wide variety of foods are heated strongly (Fritz 1972). Pyrolysis studies of a number of food components have shown that saturated and unsaturated fatty acids and glycerides, cholesterol and beta carotene may give rise to PAH when heated to 400°C (Halaby and Fagerson 1970). This temperature may be reached, at least locally, during roasting or grilling of foods.

Mechanism of carcinogenesis by PAH

PAH are chemically rather inert and most efforts directed toward discovering their mode of action in carcinogenesis have been concentrated on how they may be modified by the organism to produce more reactive substances. *In vivo* and *in vitro* studies suggest that microsomal oxidase is

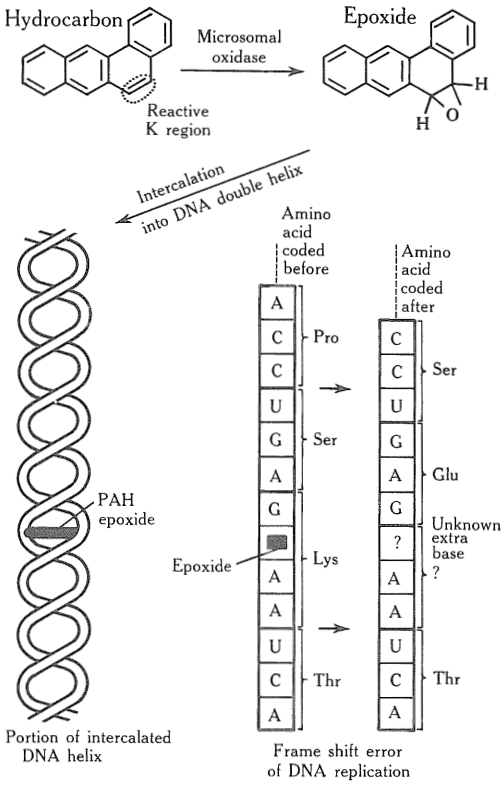


Fig. 3. A scheme which accounts for carcinogenesis or mutation by PAH. Grover (1973).

involved to produce epoxides. The PAH epoxide is then intercalated into the cell's DNA strand to produce possible frameshift errors in subsequent DNA replication (Fig. 3). The recent work in this area has been reviewed by Grover (1973). A mechanism of this type would seem feasible; indeed acridine, which is a planar heterocyclic molecule similar in many respects to the PAH epoxides, is known to cause mutation by intercalation of DNA. Further, such a mechanism would also explain the carcinogenic effects which have been produced by extremely small doses of PAH in laboratory animals.

Analysis of foods for PAH

It is not certain which of the many PAH that have been isolated from foods may be the most potent in human carcinogenesis. Benzo(α)pyrene has been the one most thoroughly investigated and occurs in mixtures with other PAH in a wide variety

of foodstuffs. The basis of almost all the sensitive methods used in detecting these substances is fluorescence spectroscopy. Benzo(α)pyrene has an extremely intense and characteristic fluorescence spectrum and is easily detected at the μg/kg level even in the presence of other fluorescent substances. For this reason it is used as an indicator of the presence of this group of carcinogenic materials, although it may not be the main causative agent in any group isolated from a sample (Schoental 1964).

Methods of analysis reported in the literature differ in detail but consist broadly of the following steps.

- Solvent extraction (liquid–solid or liquid–liquid depending upon sample).
- Concentration and column chromatography for clean-up.
- Further concentration for thin layer chromatography; use of at least two TLC systems for effective separation.
- Fluorescence spectroscopy of the eluted spots from the TLC plate. Where sufficient sample is available u.v. spectroscopy is used for confirmation of the identity of the compound.

A valuable review of PAH and foods (Howard and Fazio 1969) refers to the accepted A.O.A.C. procedure (Howard *et al.* 1966*a*) and the results obtained by a number of workers using similar methods.

Occurrence in foods

The ubiquity of PAH has been stressed (Tilgner 1971) and it would be difficult to produce certain foods in which the compounds were completely absent. Nevertheless, careless handling during processing may lead to greatly increased levels of PAH in food. It has been stated (Haenni 1968) that treatment of food directly or indirectly with petroleum products is the most common source of PAH contamination. In particular the use

Concentrations of benzo(α)pyrene (BAP) in foods and in the environment

	BAP (μg/kg)		Reference
(*a*) Food			
Fresh foods			
Lettuce and leaf vegetables	2·8–12·8		Tilgner 1971
Cabbage	12·6–24·5		Tilgner 1971
Plant leaves	8·0–40·0		Graf and Diehl 1966
*Smoked foods**			
Sausage and fish	0·1–1·5		Gorelova and Dikun 1965
Ham	3·2		Howard and Fazio 1969
Roasted and cooked foods			
Cereal	1·5 (town gas heated)	5 (brown coal heated)	Fritz 1972
Coffee	0·3–0·5		Fritz 1968
Malt	up to 15·8		Fritz 1968
Barbecued ribs	10·5		Lijinsky and Shubik 1964
Charcoal-broiled steak	5·0–8·0		Lijinsky and Shubik 1964
Vegetable oils	0·5–1·5		Howard *et al.* 1966*b*
Dehydrated foods			
Prunes	1·1–15·3		Ruchkovskii *et al.* 1969
Prunes	1·0–2·0		Barnett, unpublished data 1974
Sultanas	0·5–2·0		Barnett, unpublished data 1974
(*b*) Environment			
Soil in rural areas	0·4		Shcherbak and Kogan 1970
Soil in industrial areas	400		Shcherbak and Kogan 1970
Air, City of Sydney	(μg/1000 m³)		
Winter	8·22		Cleary and Sullivan 1965
Summer	0·57		Cleary and Sullivan 1965

* A useful review of the occurrence of BAP in smoked goods is given in Lenges (1972).

of flue gases for direct drying or heating has been shown to be hazardous. Up to a fifty-fold increase over the endogenous concentration of benzo(α)pyrene has been noted in foodstuffs roasted by flue gas (Fritz 1972). The accompanying table gives some idea of the range of concentrations of benzo(α)pyrene which have been found in foods, together with a few of the many reported environmental levels. The listing in this table is by no means exhaustive but does give some indication of the widespread nature of PAH contamination.

Safety and standards

The WHO Committee for Cancer Prevention (1964) reported that the setting of permissible levels for carcinogens was undesirable and that there should be no permitted level, i.e. zero level only permitted. A review of this situation with reference to U.S.S.R. and Europe is available (Shabad 1971). Whilst the ideal may be to have a zero level of carcinogens in any materials with which people come into contact, it is somewhat unrealistic at the present level of technology. The fact is that foods, together with air and water, are subject to PAH contamination. With foods, the contamination may be both endogenous and exogenous, i.e. arising in the farming environment and/or during processing and handling.

The only sensible approach would seem to be that of avoiding the growing and processing of foods in situations which would lead to the occurrence of PAH levels that are higher than necessary. In particular this would mean that exposure of foods to the following should be avoided or minimized:

- Petroleum-based additives
- PAH-contaminated air, e.g. by use of flue gases or direct-fired heating
- PAH-contaminated atmosphere and water (avoided possibly by suitable siting of plant outside heavy industrial areas)
- Excessive heating during roasting or grilling

Conclusions

Polycyclic aromatic hydrocarbons are known to occur in a wide variety of foods, as well as being present in the air and water of industrial areas. These compounds are known to cause cancer in animals and almost certainly affect humans similarly. Because of the ubiquity of PAH it is difficult to avoid contamination of human foods completely. The PAH carcinogenic risk to humans has probably existed at least since man first began to cook his food. It is the responsibility of the food technologist to design processes which minimize the danger of excessive PAH production. Only by care and vigilance in avoiding exposure of food to unnecessary contamination can the risk to the population be reduced.

References

Badger, G. M., and Novotny, J. (1963). The formation of aromatic hydrocarbons at high temperatures. XVIII. The pyrolysis of n-decane. *Aust. J. Chem.* **16**, 613–22.

Cleary, G. J., and Sullivan, J. L. (1965). Pollution by polycyclic aromatic hydrocarbons in the city of Sydney. *Med. J. Aust.* **1**, 758–63.

Cook, J. W., Hewett, C. L., and Heiger, I. (1933). The isolation of a cancer-producing hydrocarbon from coal tar. Parts I, II, and III. *J. Chem. Soc.* 395–405.

Fritz, W. (1968). Zur Bildung cancerogener Kohlenwasserstoffe bei der thermischen Behandlung von Lebensmitteln. 2. Das Rösten von Bohnenkaffee und Kaffee-Ersatzstoffen. (Formation of carcinogenic hydrocarbons during thermal treatment of foods. II. Roasting of coffee beans and coffee substitutes.) *Nahrung* **12**, 799–804.

Fritz, W. (1972). Zur technologisch und zubeseitungsbedingten Verunreinigung von Lebensmitteln mitt kanzerogenen Kohlenwasserstoffen. (A contribution to the contamination of foods with carcinogenic hydrocarbons during processing and cooking.) *Arch. Geschwulstforsch.* **40**, 81–90.

Graf, W., and Diehl, H. (1966). Uber den naturbedingten Normalpegel kanzerogener polycyclischer Aromate und seine Ursache. (The normal measure of naturally occurring carcinogenic polycyclic aromatics and their origin.) *Arch. Hyg. Bakteriol.* **150**, 49–59.

Gorelova, N. D., and Dikun, P. P. (1965). (3,4-Benzopyrene content of sausage and smoked fish prepared using fuel gas and coke.) *Gig. Sanit.* **30**, 120–2 (in Russian); *Chem. Abstr.* **63**, 10574e.

Grover, P. (1973). How polycyclic hydrocarbons cause cancer. *New Sci.* **58**, 685–7.

Haenni, E. O. (1968). Analytical control of polycyclic aromatic hydrocarbons in food and food additives. *Residue Rev.* **24**, 41–78.

Halaby, G. A., and Fagerson, I. S. (1970). Polycyclic aromatic hydrocarbons in heat-treated foods. Pyrolysis of some lipids, beta-carotene, and cholesterol. Proc. 3rd Int. Conf. Food Sci. Technol., Washington, 1970, pp. 820–9.

Howard, J. W., and Fazio, T. (1969). A review of polycyclic aromatic hydrocarbons in foods. *J. Agric. Food Chem.* **17**, 527–31.

Howard, J. W., Teague, R. T., White, R. H., and Fry, B. E. (1966*a*). Extraction and estimation of polycyclic aromatic hydrocarbons in smoked foods. I. General methods. *J. Assoc. Off. Anal. Chem.* **49**, 595–611.

Howard, J. W., Turicchi, E. W., White, R. H., and Fazio, T. (1966*b*). Extraction and estimation of polycyclic aromatic hydrocarbons in vegetable oils. *J. Assoc. Off. Anal. Chem.* **49**, 1236–44.

Lenges, J. (1972). Quelques considerations sur la fumaison des produits de viande. (Some considerations on the smoking of meat products.) *Rev. Ferment. Ind. Aliment.* **27**, 53–60.

Lijinsky, W., and Shubik, P. (1964). Benzo(α)pyrene and other polynuclear hydrocarbons in charcoal-broiled meat. *Science* **145**, 53–5.

Ruchkovskii, B. S., Borisyuk, Yu. P., Titkin, L. A., Popovskii, V. G., Mordkovich, M. S., and Silich, A. A. (1969). (3,4-Benzopyrene content in prunes dried by various processes.) *Gig. Sanit.* **34**, 134–5 (in Russian); *Chem. Abstr.* **72**, 2237t.

Shabad, L. M. (1971). Concerning the possibility of establishing maximum permissible doses and concentrations (MPDs and MPCs) for carcinogens. *Gig. Sanit.* **36**, 115–20.

Shcherbak, N. P., and Kogan, Yu. L. (1970). (Benzo(α)pyrene content in the soils of regions differing in their degree of industrialization.) *Tr. Permsk. Gos. Med. Inst.* **99**, 85–9 (in Russian); *Chem. Abstr.* **78**, 7470.

Schoental, R. (1964). Carcinogenesis by polycyclic aromatic hydrocarbons and by certain other carcinogens. *In* 'Polycyclic Hydrocarbons', ed. E. Clar, pp. 133–58. (Academic Press: New York.)

Tilgner, D. J. (1971). Cancerogene Kohlenwasserstoffe in Lebensmitteln. (Carcinogenic hydrocarbons in foods.) *Gordian* **71**, 2–4.

WHO Committee (1963) for Cancer Prevention (1964). WHO Tech. Rep. Ser. No. 276, 1964, p. 47.

Prawns—fresh and frozen

By Judith H. Ruello

CSIRO Division of Food Research, North Ryde, N.S.W.

This article describes the Australian prawn industry and advises how to handle and store prawns and what to look for to ensure that they are of good quality

Commercial prawning began in Australia during the 1790s, soon after the first European settlement was established at Sydney Cove. The industry remained small and insignificant during the 19th century because ice was scarce or unavailable. It grew spectacularly in the 1950s following the development of oceanic prawning in New South Wales and Queensland. Twelve years later new grounds were found in the Gulf of Carpentaria, Western Australia and South Australia, and these became the basis of a lucrative export industry (Fig. 1).

Although the catch has dramatically increased, there is often an undersupply to the domestic market. This is because most prawns are exported and because the domestic demand has increased at an even faster rate than the supply.

About eight species of economic importance are fished from estuaries and the continental shelf. Along the eastern coast the main species are the Eastern King, the School and the Greentail, while in northern tropical Australia the Western King, Tiger, Banana and Endeavour prawns are the most common.* The Western King is the species which is fished commercially in South Australia. In general, prawns caught in rivers, lakes or harbours tend to be small, whatever the species, but if they move to oceanic waters, as do Eastern and Western Kings, Banana, Tiger and School prawns, they will grow to a considerable size.

* Readers are referred to the article 'The Australian prawn industry', by W. A. Montgomery, G. S. Sidhu and Gwenda L. Vale, in *CSIRO Fd Preserv. Q.* **30**, 21–7 (1970), which presents colour plates of four of the species of prawn found in Australian waters.

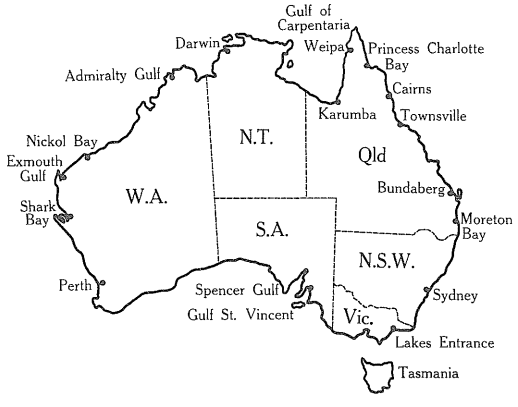


Fig. 1. Map of the principal fishing areas in Australia.

Seasons

During the summer months of November, December, January and February plentiful supplies of fresh boiled prawns are available from southern Queensland and northern New South Wales. Brisbane is well supplied with local 'bay' prawns from Moreton Bay during summer and Sydney has a small local summer fishery. Although limited, the Sydney fishery is unusual because the prawns are brought to market raw, and it is possible to purchase live prawns at the Sydney fish markets. During late autumn and winter many estuarine areas of New South Wales and Queensland are not fished commercially, but this is when fishing starts in northern tropical areas and enormous catches can be taken. Although most of the catch is exported, some frozen raw prawns are sold on the domestic market.

Australians are still reluctant to buy frozen raw prawns, partly because they

prefer to eat fresh boiled prawns, and also because they are unfamiliar with ways of preparing raw prawns. During winter, when freshly caught raw prawns are unavailable, merchants thaw frozen raw prawns and sell them as 'fresh' raw prawns, or boil them and market them as 'fresh' boiled prawns. As it is difficult to tell how long the prawns have been thawed or at what temperature they have been thawed and stored, consumers will find it better and cheaper to buy whole blocks of frozen raw prawns to thaw and cook at home. During glut years, raw prawns which are unsuitable for export (for reasons to be discussed later) are often 'dumped' on the domestic market. Consumers, particularly those in southern States, should be on guard during the winter months to ensure that they are buying a quality product.

Quality assessment of fresh prawns

Most Australian fishermen know how to supply first-quality fresh, boiled and raw prawns to all available markets, but loss of quality may occur if fishermen handle the catch poorly and when merchants do not transport and store the prawns correctly. It is unlikely that spoiled prawns will be offered for sale, but it is not uncommon for inferior prawns to reach the retail markets or to be served in restaurants. The consumer must know what to look for in order to get the best value for money, but this will be difficult for consumers who buy prawns infrequently and who are unfamiliar with the appearance, flavour and texture of freshly caught prawns. With practice, the consumer can determine the quality of prawns by careful examination.

Appearance

Appearance is one of the few factors considered by consumers before they buy prawns. Carefully handled prawns, whether boiled or raw, should be whole and undamaged. The heads should not be loose, broken or squashed; bodies should not be squashed or have the tail fan broken off. No part of the flesh should be exposed.

Raw prawns should be washed free of all mud and fish slime, and the flesh should be translucent and firm, not white or opaque. Once dead, raw prawns must be well iced or they will blacken as a result of a condition known as 'black spot' which is caused by enzymic reactions in the prawn. Although it is not harmful to eat prawns with black spot, it spoils their appearance and it is an indication to consumers that the prawns have been poorly handled after being caught.

Boiled prawns should not blacken and may be held somewhat longer than raw prawns, with or without ice. If undercooked, boiled prawns will blacken; these 'black head' prawns are considered unsafe to eat because contaminating bacteria may not have been killed by the mild heat treatment and may have multiplied to dangerous levels during storage. 'Black head' prawns are condemned by inspectors and it is unlikely that any would reach the retail trade. Sometimes a boiled prawn may have a 'brown head'; this is a result of the so-called 'liver' bursting when the prawn is cooked, giving the entire head region a brownish colour. It does not indicate poor handling or spoilage. Fresh boiled prawns should not feel slimy and should not be covered with 'dew'. This 'dew' is sometimes described as 'sweat'; most 'sweaty' prawns are frozen prawns which have been thawed.

Colour

The natural pigmentation of raw prawns differs for each species and within each species. For example, Eastern King prawns taken from rivers and estuaries of New South Wales are normally olive-green but the same species caught off southern Queensland is deep red. All prawns turn pink on boiling but not all will be the same colour. For instance, Eastern King prawns turn a rich red which is highly favoured by consumers, whereas other species such as the Western King and the School turn a paler dull pink. When these prawns are sold alongside bright red species some consumers tend to think, wrongly, that their colour has faded and that they are stale. The colour of boiled prawns does not noticeably change on storage and is therefore no guide to freshness. There is strong buyer resistance to pale pink boiled prawns, and it is not uncommon for some species, especially Western King prawns, to be dyed. Although this is not permitted, and some are condemned by inspectors, quantities of dyed prawns do find their way onto retail markets.

Fig. 2. School prawns being sorted by fishermen on the Clarence River, N.S.W. Photo: N. V. Ruello

Freezer burn

Freezer burn is the term used to describe the white patches which may appear on the shell of frozen prawns that have become dehydrated during storage. It cannot be disguised so if 'fresh' prawns have these white patches on the shell it indicates that they have been frozen, stored and then thawed before marketing. As prawns with freezer burn are partly dehydrated, their texture is drier and tougher than when freshly caught.

Soft shell

Normally, a prawn's shell is hard and shiny, but sometimes the shell has a dull appearance and feels soft and paper thin. The prawns may even look as if they have been slightly squashed. These are 'soft-shelled' prawns which have just moulted and have been caught before the new shell has hardened. Soft-shelled prawns are difficult to peel, but their eating quality is not diminished.

Flavour

The flavour of a cooked prawn is a good guide to freshness because prawn flavour disappears during storage. This is particularly true of prawns kept on melting ice; the flavour components are washed out by the melting ice and after 2 or 3 days the prawns will be flavourless. Consumers would have to be familiar with the flavour of particular species to be able to make meaningful judgments about the degrees of freshness. Freshly boiled prawns have a mild, pleasant and distinctive flavour which is slightly different for each species.

Live prawns have a low salt content of about 0·4%, and when freshly boiled without salt they do not have a salty taste. Most consumers prefer some salt to be added, and it is common practice to boil prawns in sea water or salted water. The added salt enhances the natural flavour and the consumer should barely be aware of a salty taste. Salt is sometimes added to the ice or brine in which the prawns are

stored or transported in order to increase their shelf life. These prawns become extremely salty, and as it is difficult to remove the saltiness they may be inedible. Sometimes, merchants add salt to stale prawns completely lacking natural flavour in order to add 'flavour', and all the consumer tastes is a mild saltiness in the prawns. Inexperienced consumers assume wrongly that this salty taste is the natural flavour of prawns.

Texture

Fresh prawns have a firm texture and should not be mushy, chewy or tough. It is not true that large prawns are tougher than small prawns; when freshly caught they have the same eating qualities as small prawns. Toughness develops in prawns that have been frozen and thawed, in frozen prawns that have become dehydrated under frozen storage, in prawns containing more than 4% salt and in prawns stored in acidic solutions. Most of the prawns from the northern fisheries are frozen at least twice, and the processed prawns have a noticeably tougher texture than freshly caught prawns. Many consumers have now become accustomed to the tougher texture and prefer the processed prawns to freshly caught prawns which they consider to be 'too soft'. Some consumers think that prolonged cooking toughens prawns. This can be true for prawns that have been frozen or cooked already, but is not true for freshly caught raw prawns.

Bacterial contamination

Raw prawns must be boiled long enough to kill contaminating bacteria and inactivate enzyme systems. The boiled prawns must then be cooled quickly in clean water, iced and placed in clean containers to restrict the growth of bacteria. Nearly all the prawns which are caught for the domestic market are boiled and iced aboard the trawler soon after catching. In most instances the prawns are unloaded the same day that they are caught. Many people think, incorrectly, that it is unnecessary to be scrupulously clean when handling boiled prawns because the shell protects the flesh from bacterial contamination. However, it is easy to contaminate the flesh when peeling a prawn because most of the bacteria are found on

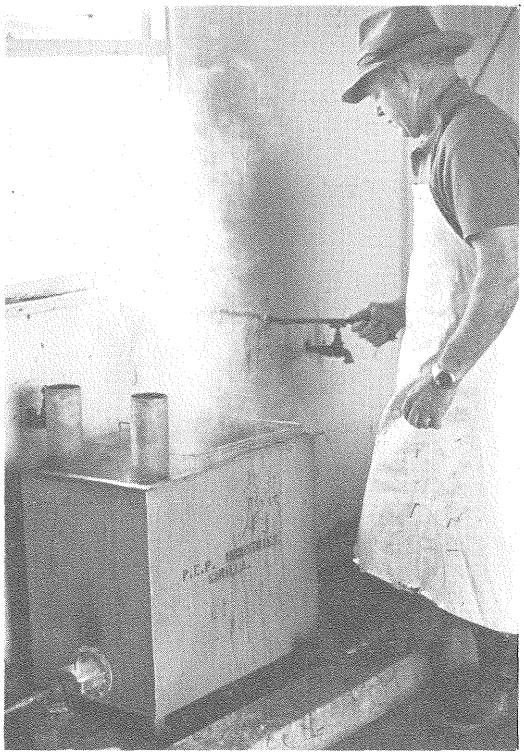


Fig. 3. Fisherman boiling prawns on a gas cooker. Photo: N. V. Ruello

the shell and head. As boiled prawns are intended to be eaten without further cooking, they must remain chilled while on retail display. Most modern shops now display prawns inside refrigerated cabinets which protect them from airborne bacteria and handling by the public, but it is still considered quite acceptable, if not traditional, to buy from a large heap of prawns which is often not iced and completely exposed to dust, flies and handling by the public.

Many prawns are taken from lakes at night by commercial fishermen using set pocket nets or by amateur fishermen using drag nets or hand-held scoop nets. It is common to cook and cool these prawns in the lake water. This water is often dirty, and sometimes the prawns can become heavily contaminated with bacteria. Outbreaks of food poisoning resulting from eating contaminated prawns have occurred, particularly in New South Wales during the late 1940s. Handling techniques have improved, but during glut periods large

quantities of prawns are still condemned because of 'black head'.

Quality of frozen prawns

Following the development of an export market, limited supplies of frozen raw prawns are now available on the domestic market. These are usually very large Banana prawns from northern Australia. The 'quality' of export prawns does not refer to their freshness, flavour and texture, but to the size and appearance of the prawns; small prawns are not exported regardless of their degree of freshness. 'Top quality' large prawns are those that only require heading before freezing and therefore the tail must appear perfect. This means that it must be free of discolorations and any signs of breakage. These defects often disappear when the shell is removed; thus so-called 'inferior quality' prawns are headed and partly shelled to form a cutlet. If the tail is broken or black, they are completely shelled to form meat.

The freshness and eating quality of tropical prawns mainly depends on how they are handled on the trawlers. Many problems were encountered in handling large catches of raw prawns caught in remote areas, but these have been overcome by freezing the prawns at sea. At the factory the prawns are thawed, headed and refrozen in export packs. Usually the prawns retain their freshness and eating quality despite double freezing. The exporters themselves apply strict quality standards for export prawns and sell their reject material to merchants who supply the domestic market. Sometimes, particularly in remote areas, reject prawns are processed with inadequate equipment under unhygienic conditions. Stale or spoiled prawns can be treated with chemicals which bleach black spot and remove 'off odours', and the treated prawns then pass as 'fresh' prawns. These chemicals cause changes in the appearance of the flesh and pigments but most consumers would not notice them and they are best detected by chemical analysis.

The availability and cost of 'top quality' prawns often only reflect export demand, so not all frozen prawns sold locally are of inferior quality. Freezing itself should not noticeably affect eating quality; it causes marginal loss of flavour and only slightly firms the texture if the prawns are well wrapped and kept at −20°C or below. Nevertheless, it is not uncommon for reject prawns to be tough, completely lacking natural flavour or to be excessively salty; but, regardless of their poor eating quality, they are very popular because most consumers are unfamiliar with freshly caught prawns. While the domestic demand for prawns remains strong it is unlikely that the quality of tropical prawns sold locally will improve as a result of buyer resistance to tough, tasteless or salty prawns.

Other frozen products

Some companies are producing breaded prawns, i.e. raw prawns that have been coated with bread crumbs and then frozen. The prawns are nearly always those that are too small for export but are often of excellent eating quality. Limited quantities of small prawns are boiled and marketed frozen. Packs of *i*ndividually *q*uick *f*rozen (IQF) boiled prawns of excellent eating quality are usually available in the large cities. IQF prawns should not be confused with the blocks of frozen imported cooked prawn meat from Asia. The latter are popular because the prawns are completely prepared and cheap, but unfortunately they are often of very inferior eating quality, being tough and tasteless, and in some instances carrying high numbers of bacteria.

Marketing research techniques applied to sensory evaluation in the food industry

By K. Le Lievre

School of Marketing, University of N.S.W., Kensington, N.S.W.

This article is based on a talk given at the Specialist Course for the Food Industry No. 4 on 'Sensory Evaluation of Food and Beverages' held at CSIRO Division of Food Research, North Ryde, 16–18 October 1973. The author lectures on consumer behaviour and marketing research at the University of New South Wales and for 14 years has been engaged in practical marketing both in Australia and U.S.A., with particular emphasis on research. He is currently engaged in a project on the consumerism phenomenon in Australia

These days, most manufacturers and processors of food employ quality control checks to help maintain appropriate standards in their products. Panel taste and sniff tests by specially trained personnel are often part of these control programs. However, whilst such practices may ensure the continuing quality of current products (by matching predetermined standards), any firm manufacturing foods or beverages that is bent on developing new products must explore the market if it wishes to obtain valid measures of customer acceptance for a new product. This last contention is based upon the accepted marketing axiom that customers are the ultimate arbiters of any product's acceptability; and if given appropriate testing circumstances they are usually able to communicate fairly accurately, in terms of preferences, avoidances etc., the degree of acceptance that will be accorded a new product or formulation.

Whilst many manufacturers and processors of food products may be well versed in the theory and practice of intra-company quality control, panel testing etc., apparently a sizable proportion remains relatively unacquainted with the application of marketing research techniques in sensory evaluation—particularly with respect to the development of new products.

This paper aims in very broad terms to present for the marketing lay person the underlying theory and practical applications of a marketing research program suited to sensory evaluation of alternative food products.

What is marketing research?

Classic definitions of marketing research are in terms of the systematic collection and analysis of data, which is helpful to marketers in making marketing decisions. Such definitions rarely specify the sort of data to be collected, but they do imply that marketing research does not obviate the need for a decision maker's judgment: it merely provides him/her with better information upon which to act.

Sensory evaluation in the laboratory* can be concerned with either difference tests or preference tests. Marketing research usually concentrates on the latter to the virtual exclusion of the former.

In terms of design, marketing research is often no more than a replication of a laboratory evaluation using as respondents a sample of consumers drawn from the market for the particular food† product under consideration. In such a replication

* In the rest of this paper I will use the term 'laboratory evaluation' to denote any in-company sensory testing whether it actually occurs in the laboratory or not.

† The term 'food' will be used to denote both food and beverages.

much of the laboratory test design and method of analysis could remain unaltered. However, a few points of difference are worth noting.

- Marketing research usually lends itself to considerably larger samples of respondents —hundreds perhaps rather than tens, thereby enabling more accurate extrapolation of results.
- The consumers in such samples would no doubt be unsophisticated in sensory evaluation techniques. If more than the mere hedonic response ('like it/don't like it') was wanted, it would obviously be necessary to familiarize respondents with the measuring devices or scales used. Consumers are surprisingly educable in this regard if given appropriate instructions. True, they may not possess the finely tuned nose or palate of the laboratory panel member, but they are quite capable of evaluating and reporting their perceptual experiences.
- Unlike members of a regular laboratory panel, consumers tend to have a high spontaneous interest in the test situation. This interest is partly a function of innate curiosity, and also of heightened self esteem at having their opinion solicited. However, consumers may be subject to time constraints not normally encountered by laboratory personnel, and thus be less amenable to lengthy test programs.
- An attempt is usually made to obtain a sample which is broadly representative of the market under consideration. Thus, for instance, an evaluation of lemonade might be confined to those people who have partaken within the past month. By way of contrast, laboratory panel members are often recruited on the basis of their ability to discriminate.
- Because the evaluation is undertaken in the field, control of the various test conditions such as rotations, temperature of food etc. may not be quite as rigorous as in the laboratory.
- In marketing research, respondents are nearly always asked *why* they like (or dislike) the food samples under consideration. Sometimes they are required to complete a check list of adjectives or suchlike as a means of establishing the believed reasons underlying their expressed preferences.

When to research?

Much unrewarding marketing research is commissioned in Australia every week, often because the problem in hand has not been subjected to sufficient prior study and analysis. The following techniques and policies show how to minimize the chances of undertaking a fruitless marketing research project:

- Assume there is no need, i.e. play the Devil's Advocate by having your colleagues present a case to convince you that the project in hand should be undertaken.
- Consult secondary sources of data: it is possible that the answers to your questions lie in some library or other repository of knowledge.
- Modify the project, perhaps by making warranted assumptions with regard to some facets of the problem, thereby reducing the total amount of research needed by reducing the number of variables involved.
- Treat each individual project as part a total continuing program. It is often possible to solve two or more different problems within the scope of a single marketing research project.
- Keep a master file of completed projects. Reference to this before commissioning a new study may save you from reinventing the wheel!

Research objectives

One can hardly overstress the importance of setting up a clear-cut list of objectives for each job, after getting the agreement of all who are involved. The following checklist may help in achieving this aim.

Seven key questions to help set research objectives

1. What *need* we know (as opposed to what is 'nice to know')?
2. Is it really a marketing research operation or can we mount an appropriate in-company test?
3. What company personnel should be involved? Has their cooperation been solicited?
4. Are the resources (including time) adequate for a quality job?
5. Will some action be possible, whatever the results of the operation?
6. Have the standards for action been agreed upon? *In advance?*

7. Are the objectives clearly understood by all involved?

Who should do it?

Presumably the services of a professional research supplier will be sought. However, selection of a marketing research agency is a highly personal matter, and many points should be considered before making a decision. Moreover, I strongly recommend that once you select an agency, you should *stick with it.* Chopping and changing supplier from job to job is profitable neither to the agencies concerned nor to the client. Therefore, careful choice in the first place is mandatory.

Preferably you should seek

- A collaborator or cooperator, *not* someone to make the decisions for you and not a yea-sayer who merely mirrors your own biases and prejudices.
- A person with the visceral fortitude to tell you when you are wrong, even if to do so is unpalatable to you.
- A person with both a broad, deep understanding of research methodology and techniques, and a clear understanding of *your* problem.
- A person who will be available over a long term, rather than merely during a short term—in keeping with the concept of a commitment to a continuing sequential research program.

You will no doubt notice that nowhere have I suggested cost as a criterion. I feel very strongly that in this matter there is *no substitute for quality*, and the cheapest quotation can often lead to very expensive errors. Nevertheless, there is no guarantee that the highest quote is necessarily the best.

Quality in marketing research

How then does one assess the quality of potential suppliers? There are many yardsticks and each supplier will point to his professed area of expertise. However, let us consider briefly the following points.

- How is the study design drawn up?
- How is the sample of respondents picked?
- What sort of field-work control and supervision is proposed?
- How are interviewers selected and trained?
- How is their work validated?
- How adequate is the questionnaire?
- How is the raw data to be edited, coded, tabulated and analysed?

Examination of such points may not guarantee quality, but at least it will serve to eliminate less-than-adequate suppliers from consideration. Field work tends to be the Achilles' heel of marketing research, as no amount of sophisticated analysis can redress errors arising from inaccurate data from the field.

How is marketing research conducted?

Typically, a marketing research study is set up and conducted by one of the marketing research agencies in Sydney or Melbourne. In the Yellow Pages of the Sydney Telephone Directory there are more than a hundred listings‡ under the heading market research. These suppliers range in size from one-man operations through to large-scale companies with turnovers approaching seven figures.

A hypothetical average agency might comprise a Managing Director, two Project Directors, two or three Analysts, several clerks (either part or full time), a Field Director, two or three secretaries and, say, 30 or more part-time interviewers. A typical study might be planned by or under the supervision of a Project Director. Field work is the responsibility of the Field Director. Usually the study design nominates specific groups of respondents according to personal characteristics: there is no point asking non-drinkers to evaluate different whiskys!

The interviewing may take place at central locations such as shopping centres, using special vans or rented shops; or it may be in the home. The former lends itself to any sensory evaluation where the product is marketed ready or near-ready for consumption: such as snack foods, soft drinks etc. This type of evaluation is usually called a *Taste Test.* Products requiring preparation by the consumer may sometimes be evaluated at a central location: for instance where a flavour change in canned soup is mooted. However, usually it is best to have the consumer prepare such products in the accustomed way, at leisure, in the

‡ This figure does not include the many large companies with their own marketing research departments.

home. This lends actuality to the situation as most consumers are notorious for not following directions and accordingly each demonstrates her own idiosyncracies in food preparation, allowance for which should be made in evaluating the final results.

Also, some foods and beverages are consumed by the whole family, and it is far easier to obtain an accurate sample of families by interviewing at home rather than at a central location. This type of evaluation in the home is usually called a *Product Test.* However, a major problem is that it is extremely difficult to obtain an accurate cross section of the community as many people are out when the interviewer calls. This can be overcome by having the interviewer call back later, but it adds considerably to the cost.

Designing a test

Typically, product test design is either

1. Two call—(*a*) monadic or (*b*) paired comparison; or
2. Three call—sequential monadic.

You will notice that the more elaborate triangular tests are not normally undertaken in the home, mainly because of difficulties in controlling rotations correctly.

1.(*a*) *Two call monadic.* This is the simplest form where a sample of a *single* product is left with each respondent by the interviewer on the first call. After a suitable trial period a second call is made to record the respondent's opinions. At first glance this technique would seem somewhat barren, insofar as the respondent has no opportunity to compare one test product with another. On the other hand, it will be appreciated that this situation is closest to *reality.* In the course of normal living people usually prepare and eat one soup at a time: rarely if ever are two different soups consumed at the one meal. Thus the monadic placement is thought to simulate everyday living conditions fairly well and preferences, if sought, are judged from memory against the brand normally used.

1.(*b*) *Paired comparison preference technique.* Two products are left in the home and comparisons are sought. The main advantage of this technique is that it provides a quick assessment of two products economically. A major drawback is that differences between the two products tend to be magnified beyond what would be expected in the actual market place.

2. *Three call—sequential monadic.* This is merely two monadic tests in sequence, one following the other. It carries the dual advantages of a close approximation to marketing reality plus the opportunity to compare two test products presented in close succession. The main disadvantage lies in the cost of a three-call test.

Marketing research as currently practised involves the application of certain scientific principles. In keeping with scientific method, the completion of one project typically transpires to be the prelude or overture for the next project. Do not be surprised when research fails to answer all your questions: be glad that it can answer some.

Further reading

American Society for Testing and Materials (1973). 'Manual on sensory testing methods.' Special Tech. Publ. No. 434, eds D. R. Peryam, Isabel Shillestad and J. F. Elrod.

David, H. A. (1963). 'Method of Paired Comparisons.' Griffin's Statistical Monographs and Courses, vol. 12. (Haddonfield: New Jersey.)

Elliott, K., and Christopher, M. (1973). 'Research Methods in Marketing.' (Holt, Rinehart, Winston: London.)

Games, P. A., and Klare, G. R. (1967). 'Elementary statistics: data analysis for the behavioural sciences.' (McGraw-Hill Inc.: New York.)

Rosenberg, M. (1968). 'Logic of Survey Analysis.' (Basic Books: New York.)

News from the Division

Appointments

Dr G. W. Jameson has joined DRL to work initially on the manufacture of hard and semi-hard cheeses from milk concentrated by ultrafiltration processes. Dr Jameson has a B.Sc. degree from the University of Melbourne and was awarded a Ph.D. by the same University in 1969.

Mr H. Chua is a new experimental officer in the Industry Section, MRL. He will investigate material handling techniques and new processes. Mr Chua has a B.Mech.Eng. degree from the University of Queensland (1973). He was previously employed as a quality control officer with an Australian plywood manufacturing firm.

Visiting worker

Dr C. J. Leaver of the Department of Botany, University of Edinburgh, visited the Plant Physiology Unit in October.

Dr R. A. M. Delaney, of the Agricultural Research Institute, Moorepark, Ireland, spent several weeks from late November 1975 to early February 1976 at DRL. Dr Delaney's main interests are the functional properties of whey proteins.

Work overseas

During the course of travel overseas, members of staff frequently visit research centres and attend meetings connected with their CSIRO interests. For instance, Mr M. V. Tracey attended meetings of the Food Section of IUPAC, held in Madrid in September 1975; Mr J. Middlehurst (Physics Section, FRL) participated in a symposium organized by the International Institute of Refrigeration in Moscow in September 1975; Mr R. L. McBride (Food Technology Section, FRL) represented Australia on the ISO working group on sensory analysis in Berlin in June 1975 as well as visiting food science laboratories in the U.K. and Europe; Ann Ford (Meat Science and Technology Section, MRL) visited meat research and agricultural establishments in the U.K. and the U.S.A.

At the request of the Australian Dairy Corporation, Messrs L. A. Hammond and J. G. Zadow of DRL joined technical missions to Iran to survey markets and technical requirements for dairy products for that country.

Dr G. R. Jago of DRL visited research institutes in New Zealand, U.S.A., England, Ireland, Germany, Holland and France to learn of recent work on starter cultures used in the manufacture of cultured dairy products.

General

Dr J. R. Vickery, Dr June Olley, Mr M. V. Tracey and Dr J. H. B. Christian have become Foundation Fellows of the Australian Academy of Technological Sciences.

Dr J. H. B. Christian was appointed a member of the WHO Expert Advisory Panel on Food Hygiene to serve for a 5-year period.

Mr K. C. Richardson was the Australian delegate to the 10th Session of the joint Codex–ECE group of experts on quick-frozen foods, held in Geneva in October 1975.

Symposium

A research seminar on whey utilization was conducted jointly by DRL and the Victorian Department of Agriculture in Melbourne in December 1975. The Proceedings of the Whey Research Workshop held in October 1975 at Columbus, Ohio, U.S.A., under the U.S.A./Australia Science Agreement were reviewed at the seminar.

Workshop

A workshop on specifications for milk powders was conducted at DRL in November 1975 for marketing personnel in the dairy industry.

Selected publications of the Division

Reprints of most of the papers listed below can be supplied by the Librarian of the laboratory from which they were published.

From the Dairy Research Laboratory

Hill, R. D. (1975). Superoxide dismutase activity in bovine milk. *Aust. J. Dairy Technol.* **30**, 26–8.

Kieseker, F. G. (1975). Dried ingredients for recombined products. Winter School on Spray Drying, Australian Society of Dairy Technology, pp. 46–51.

Kieseker, F. G. (1975). Polyunsaturated milk fat products. *Aust. J. Dairy Technol.* **30**, 7–10.

Kieseker, F. G., and Eustace, I. J. (1975). Manufacture by conventional churning of butter high in linoleic acid: technology, physical properties and sensory evaluation. *Aust. J. Dairy Technol.* **30**, 17–22.

Lawrence, A. J. (1975). Determination of lactic acid in cream. *Aust. J. Dairy Technol.* **30**, 14–5.

Muller, L. L. (1975). Role of membrane processing in the manufacture of dairy products. Winter School on Spray Drying, Australian Society of Dairy Technology, pp. 81–8.

Zadow, J. G., and Hill, R. D. (1975). The precipitation of proteins by carboxymethyl cellulose. *J. Dairy Res.* **42**, 267–75.

From the Food Research Laboratory

Hood, R. L., and Allen, C. E.* (1975). Bovine lipogenesis: effects of anatomical location, breed and adipose cell size. *Int. J. Biochem.* **6**, 121–31.

Johnson, A. R., and Tracey, M. V. (1975). Altering fatty acid composition of ruminant products. *Cereal Foods World* **20**, 77–80, 99–100.

Parker, N. S., and Hibberd, G. E.* (1974). The interpretation of dynamic measurements on non-linear viscoelastic materials. *Rheol. Acta* **13**, 910–5.

Pitt, J. I. (1974). A synoptic key to the genus *Eupenicillium* and to schlerotigenic *Penicillium* species. *Can. J. Bot.* **52**, 2231–6.

Shenstone, F. S., and Burley, R. W. (1975). Variable effects on egg yolks and yolk lipoprotein fractions of feeding methyl sterculate to hens: periodic changes in lipid composition and gelation temperature. *J. Sci. Food Agric.* **26**, 285–94.

Sidhu, G. S., Brown, M. A., and Johnson, A. R. (1975). Autoxidation in milk rich in linoleic acid. I. An objective method for measuring autoxidation and evaluating antioxidants. *J. Dairy Res.* **42**, 185–95.

Sidhu, G. S., Montgomery, W. A., and Brown, M. A. (1974). Post mortem changes and spoilage in rock lobster muscle. I. Biochemical changes and rigor mortis in *Jasus novae-hollandiae*. *J. Food Technol.* **9**, 357–70.

Sidhu, G. S., Montgomery, W. A., and Brown, M. A. (1974). Post mortem changes and spoilage in rock lobster muscle. II. Role of amino acids in bacterial spoilage and production of volatile bases in the muscle of *Jasus novae-hollandiae*. *J. Food Technol.* **9**, 371–80.

Smith, M. B., and Back, J. F. (1975). Thermal transitions in the low-density lipoprotein and lipids of the egg yolk of hens. *Biochim. Biophys. Acta* **388**, 203–12.

Smith, M. B., and Rose, S. J. (1975). A scanning calorimeter for thermal analysis of biological materials. *J. Phys. E* **8**, 377–8.

From the Food Research Unit, Hobart

James, D. G. (1975). The contribution of the fish technologist to improvement of fish products in developing fisheries. *Food Technol. Aust.* **27**, 324–6.

James, D. G. (1975). Prospects for marketing fresh tuna in Japan. *Food Technol. Aust.* **27**, 29–30.

James, D. G. (1975). Total utilization of fish protein. *J. Aust. Inst. Agric. Sci.* **41**(2), 27–30.

James, D. G., and Thrower, S. J. (1975). Toxic atmospheres in fish holds: dangers and safety measures. *Aust. Fish.* **24**(4), 17–9, 36.

Quarmby, A. R. (1974). Sampling of potato tubers—a method based on a mathematical interpretation of gross potato tuber anatomy. *J. Food Technol.* **9**, 477–89.

From the Meat Research Laboratory

Ford, A. L., Park, R. J., and McBride, R. L. (1975). Effect of a protected lipid supplement on flavour properties of sheep meats. *J. Food Sci.* **40**, 236–9.

Park, R. J., Ford, A., Minson, D. J.,* and Baxter, R. I.* (1975). Lucerne-derived flavour in sheep meat as affected by season and duration of grazing. *J. Agric. Sci.* **84**, 209–13.

Rowe, R. W. D. (1974). Collagen fibre arrangement in intramuscular connective tissue. Changes associated with muscle shortening and their possible relevance to raw meat toughness measurements. *J. Food Technol.* **9**, 501–8.

Walker, D. J., and Nader, C. J.* (1975). Measurement *in vivo* of rumen microbial protein synthesis. *Aust. J. Agric. Res.* **26**, 689–98.

* Not a member of the Division.