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Changes in CSIRO Food Divisions

Many readers will already be aware of some organizational changes that were implemented towards the end of January 1971, following the CSIRO Executive's decision that all CSIRO laboratories operating in the field of food research would become part of a new Division of Food Research.

The new Division includes the former Division of Dairy Research at Highett, Vic., the Meat Research Laboratory at Cannon Hill, Qld., and the former Division of Food Preservation based at Ryde, N.S.W.

Headquarters of the Division of Food Research are at Ryde and the Chief is Mr M. V. Tracey. Dr J. H. B. Christian has been appointed Associate Chief. The Division also has three Assistant Chiefs: Mr J. F. Kefford at the Food Research Laboratory (FRL), Ryde; Dr W. J. Scott, Officer-in-Charge of the Meat Research Laboratory (MRL), Cannon Hill; and Mr J. Czulak, Acting Assistant Chief and Acting Officer-in-Charge of the Dairy Research Laboratory (DRL), Highett.

The new arrangement is designed to benefit all three laboratories, and thus, it is hoped, the industries which they serve. There are already areas of common interest, particularly in flavour chemistry, packaging, and the problems of process engineering. Better access to instrumental facilities and more active collaboration between research staff should also result from the amalgamation.

DRL has a total staff of 70, 22 of whom are professional scientists. In the 1969/70 financial year the operating budget was almost $569,000, of which nearly $200,000 was contributed by industry organizations. It carries out applied and fundamental research on the processing of milk and the manufacture of dairy products. It has done much towards the mechanization of cheddar making, has developed the Australian milk biscuit for use in countries where people suffer from lactase deficiency, and is investigating flavour problems in butter and cream.

The Editorial Committee hopes to include contributions from DRL in future issues of the *Food Research Quarterly*. Readers wishing to send enquiries concerning dairy products may direct them to Mr L. L. Muller, Chairman of the Liaison Committee at Highett.

The addresses of the three laboratories of the Division of Food Research appear inside the front cover of this issue.

Vegetable Processing in Australia

Present and Future Trends

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This article is based on talks given to the Australian Vegetable Research Conference, Terrigal, November 1969, and to the 13th Annual Conference of the Australasian Association of Agricultural Faculties, Hobart, May 1970. Australian research on vegetable processing is reviewed and some predictions are made about the likely directions of technical progress in the industry.

The major aims of vegetable processing are preservation and convenience—preservation of the vegetables against deterioration and spoilage, and convenience because in this prosperous age housewives are willing to pay for the privilege of avoiding kitchen chores, such as peeling potatoes, shelling peas, and the many other operations that are carried out mechanically in vegetable processing plants.

The techniques that are available for the long-term preservation of vegetables are canning, freezing, pickling, and dehydration. No new principle of food preservation has appeared on the research horizon. Nuclear radiation, as a new method of microbial destruction, was expected to find important applications in the food industry, but it has not fulfilled its early promise because of adverse effects on quality and doubts about the wholesomeness of irradiated foods.

Technical trends in vegetable processing are therefore mainly in the direction of improved efficiency in processing operations and improved quality in vegetables preserved by the well-established procedures.

Technical Trends

Canning

The quality of canned vegetables is limited by the requirements for safe processing, and improvement is possible only by applying processes that are bacteriologically adequate but cause less heat damage. One approach is to rotate the cans during retorting so that the contents are stirred and heat penetration is accelerated (Casimir 1970).

Very rapid heating of canned foods may be achieved by direct exposure to gas flames, the cans being rotated rapidly to avoid burning. Flame sterilization is used commercially in Europe for vegetables and mushrooms (Casimir 1970), and in Australia for milk products and mushrooms (Anon. 1970). In the Division of Food Research we have confirmed improved quality in canned mushrooms processed in this way.

A significant innovation in processing that is beginning to be practised overseas is biologically stable bulk storage of processed vegetables (Leonard 1969; Stevenson 1969). In orthodox canning, the larger the container the longer the heat process and the more quality suffers. But if the product is sterilized continuously, then cooled and filled aseptically, there is theoretically no limit to the size of the container. Already in Canada tomato pulp is being stored in tanks holding 3000 gallons (Board 1968), whereas 44-gallon drums are the biggest containers that have been used in Australia. At present aseptic bulk storage is restricted to liquid foods, but it is predicted that it will be extended to whole tomatoes and perhaps other vegetables.

An essential step in the preservation of vegetables, whether by canning, dehydration, or freezing, is blanching—a preliminary heat treatment to inactivate enzymes and to expel intercellular gases. Critical studies of the blanching process in the CSIRO Division of Food Research demonstrated that blanching treatments commonly used are excessive and may be reduced in severity with consequent improvement in product quality (Mitchell, Lynch, and Casimir 1969). A continuous fluidized-bed blancher was designed to achieve efficient short-time blanching (Mitchell, Board, and Lynch 1968).

Dehydration

In recent years there has been a major revival in vegetable dehydration, with the application of new drying techniques that are designed to remove water with minimum heat damage to the product. Several different drying techniques may be applied in succession, so as to achieve the maximum efficiency of water removal at different stages of dryness of the product.

In fluidized-bed drying, particulate vegetables, such as peas, are suspended in a stream of hot air at high velocity, so that all surfaces are exposed and removal of water is rapid (Casimir, McBean, and Shipton 1968; Anon. 1969*a*). In puff drying, vegetables are heated in steam under pressure and then released explosively to atmospheric pressure, so that they puff into a porous form from which water is readily lost in subsequent drying, and by which it is readily taken up again during reconstitution. For instance, at the Army Food Research Station at Scottsdale, the drying time for carrot dice has been considerably shortened by explosive puffing, and the puffed dice have been rehydrated in about 25% of the time required for non-puffed dice (Klein and Edwards 1970).

The ultimate procedure for reducing heat damage in drying is freeze drying, where the product is dried from the frozen state and the water is removed by sublimation under high vacuum. Because freeze drying requires refrigeration and vacuum it is inherently expensive, so that it is being used mainly for products that are able to carry high processing costs. There is a plant in New Zealand supplying freeze-dried vegetables to the Australian market, but there are none produced in Australia yet.

Freeze drying is an active field of investigation in the Division of Food Research and a procedure of cyclic-vacuum freeze drying has been developed which cuts the drying time by about one-third (Mellor and Irving 1970). This procedure has been applied to green peas in a number of test runs, and the process is judged to be on the brink of economic viability.

There are now available in Australia a range of dehydrated vegetables used mainly in formulated foods and also several brands of dehydrated mashed potato. The most notable commercial success, however, has been in marketing dehydrated green peas (Anon. 1969*a*), which according to an industry estimate now account for 11% on a fresh weight basis of the total market for peas in the various processed forms including imports. In the drying of peas one essential step is the breaking of the skin, either by pricking with a pin, slitting, or by damage in some other way. This breaking of the skin increases the rate of drying, but in particular it greatly increases the rate of reconstitution when the dried pea is soaked in water.

Freezing

The principle of the fluidized bed is now widely applied for freezing vegetables, especially peas, which are readily amenable to rapid freezing in a stream of cold air at high velocity (Casimir, McBean, and Shipton 1968).

Vegetables may also be frozen by direct immersion in a refrigerant, and Freon 12 has recently been approved by the Food and Drug Administration in the U.S.A. for immersion freezing (Anon. 1969*b*). For this refrigerant the operating temperature is about −22°F. A refrigerant giving far lower temperatures (−320°F) is liquid nitrogen, which is already being used in Australia for the freezing of prepared meals. Since, however, it takes about a pound of liquid nitrogen to freeze a pound of food, the economics of the process depend heavily on the price of liquid nitrogen (Shipton 1965).

Vegetables frozen by these various techniques do not differ greatly in quality. Some workers report improvements in texture by fast freezing, but on the other hand some products are subject to splitting if frozen too fast.

In the course of work on frozen peas in the Division of Food Research, it was observed that the appearance of the product at serving was frequently marred by wrinkling of the skins, which could be eliminated by puncturing the skins of the peas before freezing (Lynch *et al.* 1968).

By puncturing the skin of the pea, a vent is provided for internal gases to be expelled during cooking and blanching (Mitchell, Casimir, and Lynch 1969) and replaced by water in the space between the skin and cotyledons. This is the same function as that served by the puncture in the skin of a dried pea when it aids reconstitution.

Other innovations in frozen vegetables are concerned with packaging and presentation. The products described as 'boil in the bag' provide the housewife with the convenience of preparing vegetables in an attractive sauce, simply by dropping the intact package into boiling water. They are well established overseas but have been slow to move on the Australian market (Thompson 1970). A further development along the same lines is 'bake in the oven' frozen vegetable casseroles. In this case the product is packaged in an aluminium tray and covered with a heat-sealed polyester film, which resists baking in the oven at 400°F for 35 minutes. So far the products packaged in this way are gourmet foods in which the vegetable is accompanied by a sauce and topping, e.g. broccoli and noodle casserole, brussels sprouts au gratin, and Hawaiian cauliflower casserole.

Mention might be made here of the rapidly growing business in prepared salads, such as potato salad and cole slaw, distributed to delicatessens, supermarkets, and eating-houses as chilled products (Anon. 1969*c*). This is short-term preservation only — microbial growth is inhibited for a few days by the chilling temperatures and the low pH of the salad dressings. The food technologist must confess to a notable failure in the long-term preservation of salad vegetables. There is no way of preserving the crisp vegetables—lettuce, celery, cucumbers, and radishes—for long periods so that they retain the essential quality of fresh crispness. American processors have claimed that dried celery when reconstituted is satisfactory for use in salads, but celery is notably difficult to rehydrate (Neubert, Wilson, and Miller 1968).

Pickling

In traditional procedures, vegetables are pickled in a salt brine which controls putrefactive organisms but allows fermentation by lactic acid bacteria. There are now various short-cut procedures for preparing pickled vegetables, in which acid is added as acetic acid rather than supplied by natural fermentation.

In California, an interesting development has arisen from the problem of disposing of strong salt brines from pickling operations. Vaughn *et al.* (1969) successfully stored vegetables for eight months in 'brines' without salt but containing $1 \cdot 2\%$ of a mixture of lactic and acetic acids (4:3) together with $0 \cdot 3\%$ benzoic acid. Anaerobic conditions were maintained by sealing the vats with plastic sheets. Onions, green tomatoes, cucumbers, carrots, celery, and chilli peppers were successfully pickled in this way and retained satisfactory firmness.

The principal vegetables pickled in Australia are onions, cucumbers, and cauliflower, with cabbage fermentation to sauerkraut as a special case. The pickling industry has never been a large one in Australia, but in other parts of the world it is a highly important outlet for vegetables. Lately there has been some expansion of the industry here, prompted by migrants from Europe, so that there is now a greater variety of pickled vegetables available in our markets. There have also been some recent innovations in packaging, such as the use of flexible film pouches for pickled onions and gherkins.

Trends in Quality Assessment

A prominent present trend that is likely to become more significant is the increasing use of objective methods for assessing the quality of vegetables, both raw vegetables for processing and also the processed products. As knowledge accumulates about the compositional factors that contribute to quality, the possibilities for objective assessment are extended.

For each of the important quality attributes—colour, flavour, and texture—there are now available quantitative methods of assessment involving either physical or chemical parameters or objective measurements by means of empirical instruments.

Colour

Green vegetables contain the photosynthetic pigment, chlorophyll, which unfortunately is unstable in heat processing. The bright green colour changes to olive green because when chlorophyll is heated in the presence of hydrogen ions it is hydrolysed to pheophytin. During storage of canned vegetables there may be further degradation of the pigments. Studies in the Department of Food Technology at the University of New

South Wales have demonstrated that chlorophyll retention is improved by high-temperature, short-time processing, elevated pH, and low storage temperatures (Buckle and Edwards 1969, 1970).

Much work has been done on the application of photoelectric colour-measuring instruments to assess the colour of vegetables (Francis 1970). In a Ph.D. project at the University of New South Wales, Rahman (1969) made a critical assessment of objective measures of the colour of tomatoes by correlating them with desirable tomato colour as determined by a panel of observers. The index most closely correlated was one known as Yeatman's TC (tomato colour) index:

$$\mathrm{TC} = \frac{2000a}{L(a^2+b^2)^{\frac{1}{2}}}$$

where a, b, and L are the Hunter colour space coordinates. On the other hand, this index showed a low correlation with intensity of redness. In other words, the most intensely red tomato was not considered by the panel to be the most desirable. Evidently the panel had a mental picture of desirable tomato colour which lay in the orange-red range rather than towards the crimson-red. This is a problem frequently encountered in colour measurement—the reconciling of instrumental values with visual impressions.

Flavour

Objective measurement of flavour of vegetables has advanced greatly, but has not yet reached the point of providing a flavour-measuring instrument that can match the human palate.

The flavour of vegetables is made up of the basic tastes—sweet, sour, salt, and bitter—which are contributed by non-volatile constituents such as sugars, acids, and amino acids, together with a superstructure of characteristic flavour notes which are due to volatile compounds (Stevens 1970).

The technique of gas chromatography has permitted the volatile constituents of vegetables to be examined in great detail, so that it is common to find 50 or even 100 individual compounds. There is then the problem of deciding which of these contribute significantly to the flavour.

Many vegetables contain a group of compounds that are mainly saturated and unsaturated alcohols and aldehydes with six to nine carbon atoms. As a group these compounds have aromas often described as 'raw' or 'green' odours. Against this background individual vegetables may have unique aromas attributable to particular volatile constituents. For instance, vegetables of the *Allium* group owe their character to organic sulphides and polysulphides: garlic contains mainly allyl, onions mainly n-propyl, and chives mainly methyl radicals; so these vegetables have similar, yet different flavours (Anon. 1969*d*). Many more examples could be given. Recent work in the Division of Food Research (Murray, Shipton, and Whitfield 1970) has revealed the presence in green peas of three pyrazine derivatives: 3-isopropyl, 3-s-butyl, and 3-isobutyl-2-methoxypyrazines. Although present in minute amounts these compounds have very strong odours characteristic of peas.

So we may foreshadow the time when both vegetable processors and buyers of processed vegetables may lay down specifications for flavour based on the concentration of specific volatile constituents.

Texture

Already objective specifications have been written for texture in some vegetables. For example, in the procurement of peas for processing in Australia the price to the grower is determined by the tenderness of the vined peas as measured by the maturometer (Mitchell, Casimir, and Lynch 1961).

In fact a great variety of instruments is used for assessing texture, ranging from simple gadgets to very sophisticated machines such as the Instron Universal Testing Machine that is widely used in the U.S.A. (Bourne, Moyer, and Hand 1966; Bourne and Moyer 1968).

An example of an ingenious empirical device is an asparagus texture meter designed in the workshops of an Australian canner, which consists of a tiny circular saw on a swing arm with provision for measuring the power required to cut through an asparagus spear to a fixed depth.

For all three quality attributes, therefore, of vegetables both before and after processing, we may expect to move towards objective specifications rather than the imprecise verbal descriptions on which we now mainly depend. Any move in this direction should greatly assist processors to communicate their needs to plant breeders and growers.

Table 1
Production of Processed Vegetables, excluding Potatoes and Tomatoes (million lb)

Australia

	Canned[a]			Frozen[b]			Total Processed[c]		
	1966/67	1967/68	1968/69	1966/67	1967/68	1968/69	1966/67	1967/68	1968/69
All vegetables	195	182	190	118	101	142	313	283	332
Asparagus	9	12	9	—	—	—	9	12	9
Beans, dry, baked	39	42	41	—	—	—	39	42	41
Beans, green	12	10	10	19	22	35	31	32	45
Beetroot	43	40	40	—	—	—	43	40	40
Peas, green	31	24	30	82	64	80	113	88	110
Sweet corn	11	8	10	n.a.[d]	n.a.	1[e]	—	—	11

Britain

	Canned[f]		Frozen[g]		Total Processed[c]	
	1967	1968	1967	1968	1967	1968
All vegetables	1644	1597	264	267	1908	1864
Beans, broad	25	9	4	n.a.	29	n.a.
Beans, dry, baked	578	605	—	—	578	605
Beans, green and butter	52	45	52	36	104	81
Brussels sprouts	n.a.	n.a.	22	13	22	13
Carrots	175	148	n.a.	n.a.	175	148
Peas, green	104	152	148	146	352	198
Peas, processed	390	392	—	—	390	392

U.S.A.

	Canned[h]		Frozen[j]		Total Processed[c]	
	1967	1968	1967	1968	1967	1968
All vegetables	8790	9330	2016	1900	10806	11230
Asparagus	210	210	33	34	243	244
Beans, dry, baked	2280	2280	—	—	2280	2280
Beans, snap	1590	1560	238	232	1828	1792
Beans, lima	120	120	161	166	281	286
Broccoli	—	—	167	173	167	173
Peas, green	1140	1080	424	429	1564	1509
Sweet corn	1470	1770	360	410	1830	2180

[a] Net weight of can contents, from Commonwealth Bureau of Census and Statistics (1971, Table 11).
[b] Net contents from *ibid.*
[c] Crude totals of canned and frozen vegetables.
[d] Not available.
[e] Estimated.
[f] Net can contents, calc. from Lawson (1969*a*, Table III).
[g] Net contents, from *ibid.*, Table XVII.
[h] Calc. from U.S. Department of Agriculture (1969, Table 291) on the basis: 30 lb net can contents in standard case of 24 No. 303 cans. (Similar data in Anon. (1969*e*).)
[j] From *ibid.*, Table 294.

Production Trends

Some statistics illustrating the production and consumption of processed vegetables in Australia are given in Tables 1 and 2, together with comparative information from Britain and the United States. For each country only the major vegetables processed are listed, and potatoes and tomatoes are excluded.

Potatoes are not vegetables within the terms of reference of the Australian Vegetable Research Conference, and in the State Departments of Agriculture they are generally regarded as a major field crop rather than a horticultural crop. The consumption of potatoes per head in 1968–69 was 133 lb.

Tomatoes are also regarded as a special segment of the industry because they are processed in a variety of forms. In addition to whole tomatoes and tomato juice, there are the concentrated products, tomato pulp, purée, and paste, and the secondary products prepared from them, such as tomato sauce and soup. The consumption of tomatoes per head in Australia is around 30 lb, and about one-third of this is in processed form.

Tables 1 and 2 should be used only to draw broad and relative conclusions because of the mixed nature of the data. For instance, canned food statistics report net weights of can contents, whereas the relevant quantity to indicate the amount of edible material in canned vegetables is the drained weight. As a rough guide, the drained weight for most of the products listed is about two-thirds of the net weight. However, in the crude totals shown in Tables 1 and 2, net weights of can contents, net contents of frozen foods, and raw weights of fresh vegetables have been added together. Information about processed vegetables is restricted to canned and frozen products because detailed data about dehydrated vegetables are not reported by any of the countries.

Australian production of processed vegetables has increased steadily in recent years except for a set-back in 1967–68, a drought year (Table 1). Processed vegetables still, however, make up less than 20% of the total consumption of the vegetables listed in Table 2, whereas in the U.S.A. they account for more than 40%. Since Australia tends to follow American patterns in food habits and food production we may reasonably expect the production of processed vegetables in Australia to continue to increase in both absolute amount and relative proportion.

Further support for the likelihood of this trend may be found in the fact that Australia is importing significant quantities of processed vegetables; for instance, in 1968–69 13 million lb of frozen vegetables were imported, and also 1·6 million lb of dried vegetables, which represents 10–12 million lb of the raw materials (Commonwealth Bureau of Census and Statistics, private communication, 1970). There are no technical reasons why Australia should not be self-sufficient in vegetable processing.

Each of the preservation methods that has been mentioned will continue to be applied because it is uniquely suitable for certain vegetables (see this issue, pp. 11–15). Some time ago preservation of peas and beans by freezing overtook canning in amount of production but the total production of canned vegetables still exceeds that of frozen vegetables (Table 1).

Dehydrated products will increase their share of the market because with improved quality the economies offered in packaging, storage, and transport can be exploited. Reported production of dehydrated vegetables in Australia is about 1·5 million lb (Commonwealth Bureau of Census and Statistics 1969), which represents less than 5% of the total production of processed vegetables on a fresh-weight basis.

Peas Dominant

Among the vegetables that are processed, tomatoes and green peas far outstrip the other varieties. The dominance of green peas is most marked among the frozen vegetables where they account for 56% of the total production (Table 1). An almost identical situation exists in Britain where green peas make up 55% of the frozen vegetable production. In the U.S.A., however, the frozen vegetable industry reveals a much more diverse and balanced distribution of production. Peas again head the list, but with only 22% of production, and they are followed closely by sweet corn, then by snap beans, broccoli, and lima beans (Table 1). In the total production of canned and frozen vegetables, sweet corn and snap beans are ahead of peas.

When the consumption of vegetables per head is compared for different countries (Table 2), it is apparent that the consumption of peas in Australia and Britain is much higher than in the U.S.A. Moreover the consumption of peas in Australia has doubled in the last 20 years, while the consumption of the brassica vegetables has been halved (Table 2). Further, the consumption of peas in Australia and the U.S.A. is almost entirely in the processed form.

Why are peas so dominant in the production of processed vegetables? I believe the reasons are these:

- Peas have a high level of consumer acceptance. In the survey already mentioned (Christie and Pupo 1971) peas were the only vegetables that were universally acceptable to a group of 215 Australian consumers, although they were not significantly different in acceptability from tomatoes and potatoes.

- Peas are horticulturally successful. They are amenable to mechanical operations in planting, cultivation, and harvesting, and they yield well enough to give the grower profitable use of his land and the processor his raw material at a reasonable cost.

- Peas are technologically successful. As small, hard spheres, they are uniquely suitable and convenient for all the operations of handling and processing. After vining, peas are cleaned by winnowing. Then they may be conveyed pneumatically into the processing plant where they are graded, blanched, and frozen or dried by fluidizing. Pneumatic conveyors may again take the frozen or dried peas into storage silos from which they may be transported in bulk and finally automatically packaged.

Table 2

Consumption of Vegetables, excluding Potatoes and Tomatoes (lb per head per year)

Vegetable	Australia 1948/49 Total[a]	Australia 1968/69 Total[b]	Australia 1968/69 Processed[c]	U.S.A. 1968 Total[d]	U.S.A. 1968 Processed[e]	Britain 1968 Total[f]	Britain 1968 Processed[g]
Peas, green[h]	4·2	8·4	9·2	6·4	6·3	12·6	5·5
Beans, snap	5·5	7·4	3·8	8·2	6·4	3·4	1·5
Brassica veg.[j]	48·6	25·6	n.a.	13·4	2·7	n.a.	0·2[k]
Root and bulb veg.[l]	42·1	39·6	3·3[m]	21·6	2·5	17·5[n]	2·7[n]
Cucurbit veg.[o]	23·1	20·6	n.a.	11·0	8·1	n.a.	n.a.
Sweet corn	0·9	2·4	0·9	14·4	7·3	—	—
Asparagus	n.a.	1·1	0·8	1·4	0·5	n.a.	n.a.
Total	124·4	105·1	18·0	76·4	33·8	33·5	9·9

[a] Average 3 yr ended 1948/49, from Commonwealth Bureau of Census and Statistics (1970, p. 26).
[b] *Ibid.* pp. 26, 41.
[c] Calc. from Table 1 on basis of population of 12 million; no account taken of changes in stocks or imports.
[d] Calc. from U.S. Department of Agriculture (1969): Crude totals of fresh (Table 290), canned (Table 292), and frozen vegetables (Table 295). (More detailed but slightly different data for frozen vegetables are given by Franklin and Martin (1970).)
[e] *Ibid.*: Crude totals of canned and frozen vegetables.
[f] Calc. from Lawson (1969*b*): Suppl. XIV (peas), XV (carrots), and XVI (beans).
[g] Calc. from Table 1 on basis of population of 54 million; no account taken of changes in stocks or imports.
[h] Edible (shelled) wt. Quantities given in Australian tables [a,b] represent peas in pod; yield of shelled peas taken as 40%.
[j] Cabbage, cauliflower, brussels sprouts, broccoli, kale.
[k] Brussels sprouts only.
[l] Beetroot, carrots, parsnips, turnips, onions.
[m] Beetroot only.
[n] Carrots only.
[o] Pumpkin, marrow, squash, cucumber.

Need to Diversify

Already in recent seasons there has been serious overproduction of frozen green peas in Australia, and the industry would be well advised to seek more stable production based on a broad rather than a narrow range of products.

Green beans are the only other vegetables frozen in a major way. I believe that consumer acceptance of green beans would be increased if the industry abandoned the French cut style in favor of cross-cut beans. The French cut was designed to make more acceptable the former varieties of string beans with high fibre content, and it is quite unnecessary for current lines of tender stringless beans. On the other hand it has positive disadvantages in encouraging loss of seeds, breakage of seeds, and leaching of nutrients and flavour during blanching and cooking; these disadvantages would be minimized in cross-cut beans and there is little doubt that consumers would soon accept them readily.

To challenge the dominant position of peas, other vegetables must match their virtues—organoleptic, horticultural, and technological. Sweet corn is one vegetable well accepted, mechanically harvested, and readily processed that should be capable of increasing its share of the Australian market. Table 2 shows that American consumption of sweet corn is many times that in Australia in both fresh and processed forms.

Lima beans and broccoli are the other vegetables that stand high on the list of frozen vegetables in the U.S.A., and broad beans and brussels sprouts fill the corresponding niches in the British industry. Lima beans and broad beans are handled in the field and in the factory in much the same equipment as peas. Broccoli and brussels sprouts are inherently more difficult to handle, but mechanical methods of harvesting and preparation of sprouts are well advanced.

In the recent survey (Christie and Pupo 1971), 86% of the Australian consumer group liked brussels sprouts, 73% liked broad beans while 11% had never tried them, 46% had never tried lima beans, and 21% had never tried broccoli. Obviously some promotion would be needed to encourage wider consumption of these vegetables.

In this bicentenary year of Captain James Cook's discovery of the eastern coast of Australia it is appropriate to recall that the successful outcome of Cook's long ocean voyages was due in no small way to the fact that he avoided scurvy in his crews; and he did this by encouraging them to eat any kind of fresh vegetable material that came to hand. In the words of the quartermaster of the *Discovery* (Beaglehole 1967, quoted from Fleming 1969), 'Captain Cook raised this spirit amongst us by his Example for scarcely any thing came wrong to him that was Green . . . It was his practise to cause great Quantitys of Green Stuff to be Boiled amongst the pease soup—and (he) care'd Not Much wether they were Bitter or Sweet so as he was but Certain they had no Pernicious Quality.'

Obviously, in our national attitudes to vegetables we have lost Cook's spirit of enterprise. We are merely eating more and more peas.

In conclusion, I would make the long-term prediction that we will all be forced to eat more vegetable foods before the century is out, simply because of the pressure of population on the world's supply of animal foods.

Australia and New Zealand may well be the last countries in the world to be short of animal protein, but we too should consider vegetable crops more seriously as sources of protein. N. W. Pirie pioneered the recovery of leaf proteins for human consumption (Kinsella 1970), and seed proteins, notably from soya beans, are being widely used in a variety of human foods (Altschul 1967). Entry into these fields may involve the food industry in rather different procedures of vegetable processing—processes that lie in the domain of chemical engineering.

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Consumer Acceptability of Vegetables

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In conjunction with a recent analysis of trends in the production of processed vegetables (Kefford 1971 (this issue, pp. 2–10)), it was thought of interest to examine the attitudes of Australian consumers to vegetables. Accordingly a consumer survey was conducted among about 200 members of the staff of several CSIRO laboratories located at Ryde, N.S.W. This group of consumers was chosen for convenience and must be regarded as a small and special sample of the population rather than as representative of the total population of Australian consumers.

The survey was conducted by asking the consumers to complete two questionnaires on separate occasions. In the first questionnaire (Table 1) they were asked to rate 48 vegetables according to a six-point hedonic scale. There was also a column to indicate unfamiliarity with a vegetable.

The percentages of the 215 consumers who replied to the questionnaire in the various categories are given in Table 1. In Table 2 these results are summarized by listing the 10 vegetables that were most liked, the 10 that were most disliked, and the 10 that were most unfamiliar.

Only one vegetable, green peas, was liked by every consumer, i.e. there were no entries in the 'dislike' categories. Several other vegetables, however, received almost universal acceptance, and tomatoes and potatoes were not significantly less acceptable than peas.

No vegetable was disliked in the same universal way. In fact the vegetables most disliked were liked by more consumers than disliked them (Table 2). Obviously consumers have strong views one way or the other about these vegetables.

Processed Vegetables

Following the survey of attitudes to vegetables in general, the same consumers were asked to indicate their attitudes to processed vegetables by completing a second questionnaire (Table 3). The 13 vegetables most liked in the first survey were listed, each in several processed forms as well as fresh, raw, and fresh, cooked where appropriate. They were rated according to the same hedonic scale and the percentages of consumers replying in the various categories are included in Table 3.

Among the processed vegetables only asparagus showed as high a percentage 'liking' as the fresh vegetable whether raw or cooked.

In Table 4 are listed the 10 processed vegetable products that were most liked and also the 10 that were most disliked.

The results of the survey show that each of the techniques for the preservation of vegetables gives processed products of high acceptability with some vegetables, but is less satisfactory for others. Thus canned beetroot is well liked because it does not suffer in quality in the severe heat treatment of the canning process. Canned asparagus is also well liked; in fact it is known to derive some of its character from tin dissolved from the can. Peas and beans, however, suffer greatly in quality when canned, but when preserved by freezing they are well liked. So Table 4 shows a paradoxical situation with frozen green peas most liked among the processed vegetables and canned green peas most disliked.

In the second survey consumers again showed strongly opposing attitudes to some processed vegetables since they appear in both lists in Table 4, viz. pickled onions and gherkins and canned tomato juice. Table 4 shows, however, that again the processed

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Table 1

Consumer Attitudes to Vegetables

This is *not* a tasting test; it is merely a survey.

Please complete the following questionnaire regarding your attitude towards the vegetables listed, as food items in your own experience, i.e. fresh or processed, raw or cooked, in the form most familiar to you.

	Percentage Responses from 215 Consumers						
	Like very much	Like fairly well	Like but not very much	Mixed feel-ings	Dislike a little	Dislike a lot	Never tried, or not often enough to give an opinion
Artichoke, globe	4·2	11·2	7·0	4·2	2·8	9·3	61·4
,, Jerusalem	4·6	4·2	3·7	5·1	2·2	12·6	67·4
Asparagus	56·7	20·9	7·9	3·7	3·1	6·0	0·9
Beans, french (green, runner)	58·1	33·0	3·2	0·9	0·9	0·0	3·7
,, broad	27·4	30·2	14·9	7·4	6·0	2·8	11·2
,, lima	14·0	15·8	11·2	7·4	3·7	1·9	46·0
,, dry (haricot, navy)	8·4	20·9	11·2	9·3	7·0	8·8	34·4
,, soya	5·1	11·6	9·3	6·0	5·6	5·6	56·7
Beetroot	45·6	33·0	10·2	4·6	4·2	1·9	0·5
Broccoli	28·8	25·6	14·4	6·5	2·8	1·4	20·5
Brussels sprouts	41·9	29·8	14·4	4·2	5·1	3·2	1·4
Cabbage	34·4	41·4	12·1	4·2	4·6	3·2	0·0
Capsicum (sweet pepper)	34·4	28·4	11·6	5·1	2·2	4·6	13·5
Carrots	56·7	29·3	10·2	1·4	1·9	0·5	0·0
Cauliflower	57·7	31·6	7·0	2·2	0·9	0·5	0·0
Celery	57·7	24·6	7·0	3·7	4·6	2·3	0·0
Chicory	2·8	4·2	5·1	4·2	3·2	3·7	76·7
Chives	24·6	20·9	7·4	5·1	1·4	1·4	39·1
Choko	24·6	23·7	12·6	7·0	7·0	14·4	10·7
Cucumber	39·1	33·0	10·2	2·2	6·5	7·4	1·4
Egg-plant	11·2	14·9	7·0	7·0	5·6	4·2	50·2
Endive	2·2	7·0	7·9	6·0	2·8	4·2	69·8
Kale	1·9	3·2	6·0	3·2	1·9	1·9	81·9
Kohlrabi	5·1	5·6	5·1	5·1	3·7	2·8	72·6
Leeks	17·7	22·8	9·3	7·0	3·2	6·0	34·0
Lentils	10·7	16·7	9·8	8·8	3·7	3·7	46·5
Lettuce	52·6	34·4	7·4	3·2	2·2	0·0	0·0
Marrow	17·2	28·8	18·6	5·6	7·4	13·5	8·8
Mushrooms	69·8	12·6	6·5	1·9	2·2	5·6	1·4
Okra (ladies' fingers)	4·6	4·6	1·9	1·4	0·0	1·4	86·0
Onions	59·1	27·0	4·2	5·6	1·4	2·8	0·0
Parsnips	26·0	29·3	15·8	6·0	8·4	9·8	4·6
Peas, green	79·1	17·7	3·2	0·0	0·0	0·0	0·0
,, dry (blue boiler)	9·8	20·0	13·5	8·4	8·4	7·9	32·1
,, split	17·7	23·2	19·5	9·3	9·3	7·0	14·0
Potatoes, white (Irish)	74·0	19·5	4·2	0·5	1·4	0·5	0·0
,, sweet	41·4	27·0	13·5	3·7	6·5	7·4	1·4
Pumpkin	37·7	31·2	16·3	6·0	4·2	4·2	0·5
Shallots	37·7	29·3	8·8	5·1	3·7	5·6	9·8
Silver beet (chard)	20·9	26·0	7·4	7·0	4·2	5·1	29·3
Spinach	34·9	29·8	10·7	6·0	5·6	8·4	4·6
Squash	12·6	18·6	13·0	9·8	9·8	8·4	27·9
Sweet corn	56·7	23·2	6·5	4·2	3·2	3·2	2·8
Tomatoes	78·6	18·1	1·4	0·5	0·9	0·5	0·0
Turnips, white	14·0	28·4	17·7	9·3	10·2	14·4	6·0
,, swede (rutabagas)	13·0	22·3	15·8	7·4	10·2	17·7	13·5
Watercress	15·8	11·2	10·2	8·4	1·9	1·4	51·2
Zucchini	20·5	9·3	3·7	1·4	1·9	1·9	61·4

Table 2

Consumer Attitudes to Vegetables — Summary

Most Liked*		Most Disliked†			Most Unfamiliar‡	
Green peas	97	Swede turnips	28	(35)	Okra	86
Tomatoes	97	White turnips	25	(42)	Kale	82
Potatoes	94	Choko	21	(48)	Chicory	77
Green beans	91	Marrow	21	(46)	Kohlrabi	73
Cauliflower	89	Parsnip	18	(55)	Endive	70
Lettuce	87	Squash	18	(31)	Artichoke, Jerusalem	67
Onions	86	Dry beans	16	(29)	Artichoke, globe	61
Carrots	86	Dry peas	16	(30)	Zucchini	61
Mushrooms	82	Spinach	14	(65)	Soya beans	51
Celery	82	Cucumber	14	(72)	Egg-plant	50

* Total percentage of 215 consumers replying in categories 'like very much' and 'like fairly well'.

† Total percentage of 215 consumers replying in categories 'dislike a little' and 'dislike a lot'. Figures in parentheses indicate percentage of consumers who 'like very much' or 'like fairly well'.

‡ Percentage of 215 consumers replying in category 'never tried, etc.'

Table 3

Consumer Attitudes to Processed Vegetables

In the previous survey, the following vegetables were liked very much or fairly well by about 75% of consumers. We would now be grateful for your opinion on the acceptability of these vegetables in various processed forms.

	Percentage Responses from 195 Consumers						
	Like very much	Like fairly well	Like but not very much	Mixed feel-ings	Dislike a little	Dislike a lot	Never tried, or not often enough to give an opinion
Green peas							
fresh, cooked	76·4	17·9	4·6	0·0	0·0	0·5	0·5
frozen, cooked	42·6	41·0	8·2	2·1	3·6	2·1	0·5
canned	13·3	22·1	24·1	8·7	11·8	16·9	3·1
dehydrated	14·4	24·1	12·8	7·2	4·1	7·2	30·3
Tomatoes							
fresh, raw	79·5	15·4	3·6	1·0	0·0	0·0	0·5
fresh, cooked	51·8	30·3	9·7	3·1	3·6	1·5	0·0
canned, whole	17·9	28·2	13·3	8·7	5·6	4·6	21·5
canned juice	40·0	23·6	16·4	5·1	4·1	8·7	2·1
Potatoes (white)							
fresh, cooked	70·8	23·1	4·1	0·5	0·5	0·5	0·5
frozen French fries	34·4	24·6	9·7	5·6	1·5	1·5	22·6
canned	4·6	9·7	6·7	3·6	6·2	3·1	66·2
dehydrated	9·7	22·1	14·9	12·8	8·2	9·7	22·6
potato crisps	41·0	40·0	9·7	6·2	0·5	1·0	1·5
French beans							
fresh, cooked	71·8	23·1	1·5	1·5	0·0	0·0	2·1
frozen	27·7	37·9	18·5	4·6	3·1	1·0	7·2
canned	6·7	22·1	15·9	9·2	10·8	7·7	27·7
dehydrated	6·7	9·2	6·7	6·7	4·6	5·1	61·0
Cauliflower							
fresh, cooked	67·2	19·5	8·7	1·5	0·5	1·5	1·0
frozen	10·3	16·9	6·7	1·5	3·1	1·5	60·0
canned	1·5	3·1	4·1	1·5	2·6	6·2	81·0

Table 3 (continued)

	Percentage Responses from 195 Consumers						
	Like very much	Like fairly well	Like but not very much	Mixed feel-ings	Dislike a little	Dislike a lot	Never tried, or not often enough to give an opinion
Onions							
fresh, raw	52·8	17·4	9·7	3·6	4·6	8·7	3·1
fresh, cooked	67·7	17·4	5·1	3·6	2·6	3·1	0·5
canned	1·0	2·6	4·6	3·1	1·0	5·6	82·1
dehydrated	2·1	13·8	5·1	5·1	1·5	5·1	67·2
pickled	40·0	26·2	11·8	4·1	3·1	9·2	5·6
Carrots							
fresh, raw	49·2	34·4	8·2	4·6	1·0	1·5	1·0
fresh, cooked	53·3	33·8	5·6	2·6	2·1	2·1	0·5
frozen	12·3	20·0	9·7	3·6	4·1	3·6	46·7
canned	10·8	21·0	10·8	5·1	5·1	6·2	41·0
dehydrated	1·5	6·7	2·6	3·6	5·6	3·6	76·4
Mushrooms							
fresh, cooked	68·7	13·8	2·6	2·6	3·1	5·1	4·1
frozen	8·7	9·2	3·6	0·5	3·6	4·1	70·3
canned, in sauce	31·3	31·8	10·3	4·1	3·6	6·2	12·8
in brine	19·0	19·5	6·2	3·6	5·1	4·1	42·6
dehydrated	7·2	9·2	4·1	2·6	3·1	4·1	69·7
Sweet corn							
fresh, cooked	70·8	8·7	6·2	2·1	2·6	5·1	4·6
frozen	30·3	13·3	3·1	1·5	4·6	4·1	43·1
canned, whole kernel	31·3	27·2	10·3	7·2	2·6	5·6	15·9
cream style	23·6	24·6	13·3	6·7	6·7	9·7	15·4
Beetroot							
fresh, cooked	54·9	24·1	6·7	2·6	1·5	5·1	5·1
canned	42·6	31·8	11·3	3·1	2·6	5·1	3·6
pickled (delicatessen)	20·5	21·5	5·1	4·6	3·1	6·7	38·5
Asparagus							
fresh, cooked	40·0	17·9	6·7	3·1	1·0	9·2	22·1
canned	55·4	17·9	7·7	3·1	1·5	9·7	4·6
Cabbage							
fresh, raw (slaw)	49·7	25·1	7·7	4·1	3·1	4·6	5·6
fresh, cooked	43·6	31·3	11·8	4·6	3·1	5·1	0·5
canned	4·6	7·2	4·1	1·5	4·6	6·2	71·8
dehydrated	1·5	1·5	3·6	1·5	2·1	4·6	85·1
pickled (sauerkraut)	18·5	22·1	11·3	6·2	2·6	11·3	28·2
Cucumber							
fresh, raw	53·8	19·5	10·3	2·1	1·5	8·7	4·1
pickled (sweet and sour)	31·8	22·1	8·7	5·6	2·6	7·7	21·5
pickled (gherkins)	39·0	30·3	7·7	4·6	4·6	9·7	4·1

vegetables most disliked were liked by higher percentages of consumers than disliked them.

The percentages of consumers unfamiliar with some processed vegetables were surprisingly high. Dehydrated green beans have appeared on the Australian market only recently so it is not surprising that 61% of consumers have not tried them. Similarly, canned potatoes are not familiar to Australian consumers although they have recently become very popular in Britain and Europe. It was unexpected, however, to find that more than 20% of the consumers surveyed had not tried canned whole tomatoes and frozen French-fried potatoes.

A number of surveys of consumer attitudes to vegetables conducted in the U.S.A. and Britain have been summarized by Harper (1963). In general the results are in line with those of the surveys here reported. For instance the U.S. Army Quartermaster Corps examined the food preferences of 30,000–

Table 4
Consumer Attitudes to Processed Vegetables — Summary

Most Liked*		Most Disliked†	
Green peas, frozen, cooked	84	Green peas, canned	29 (35)
Potato crisps	81	Green beans, canned	19 (29)
Beetroot, canned	74	Potatoes, dehydrated	18 (32)
Asparagus, canned	73	Sweet corn, cream style	16 (48)
Gherkins, pickled	69	Gherkins, pickled	14 (69)
Onions, pickled	66	Cabbage, sauerkraut	14 (41)
Green beans, frozen	66	Tomatoes, canned juice	13 (64)
Tomatoes, canned juice	64	Onions, pickled	12 (66)
Mushrooms, canned in sauce	63	Green peas, dehydrated	11 (39)
Potatoes, frozen French fries	59	Carrots, canned	11 (32)

* Total percentage responses in the categories 'like very much' and 'like fairly well'.

† Total percentage responses in the categories 'dislike a little' and 'dislike a lot'. Figures in parentheses indicate percentage of consumers who 'like very much' or 'like fairly well'.

40,000 U.S. servicemen during the period 1953–60 and found that the vegetable dishes disliked by less than 10% of servicemen were prepared from tomatoes, potatoes, green peas, green beans, and sweet corn, while the vegetable dishes disliked by more than 40% of servicemen were prepared from squash, parsnips, brussels sprouts, broccoli, egg-plant, spinach, white and swede turnips, and cauliflower. No vegetable was disliked by more than 28% of the Australian group of consumers, which may mean that they are more tolerant than U.S. servicemen.

Surveys of British consumers showed parsnips, turnips, spinach, and marrow to be disliked while tomatoes and potatoes were liked by most consumers, and the brassica vegetables—cauliflower, cabbage, and brussels sprouts—were quite highly acceptable. In this respect Australian attitudes to vegetables correspond more closely to the British than to the American attitudes.

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Processed Lemon Products

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This article is based on a talk given by the author to a meeting of the Agricultural Bureau of New South Wales at Arcadia, October 1970, and incorporates some observations he made during a visit to citrus processing plants in the Mediterranean and North American areas in March–June 1970.

Though rarely eaten as a table fruit, the lemon has an appealing individual flavour, and in addition enhances and develops flavours inherent in other foodstuffs, with the result that in the fresh form it has been a universally popular component of many dishes and drinks for at least 1000 years. Nowadays, however, about one-half of the world's lemon production is processed, and Australia, which uses about two-thirds of its lemons in this form, is one leading exponent of such indirect utilization of the crop.

Of all citrus fruits, the lemon provides the greatest opportunity for the maximum utilization of the raw material in the widest range of economically profitable products. Indeed, in contrast to the orange and the grapefruit, the lemon has been the source of such important by-products that only in recent years has juice extraction come to play the dominant role it has always occupied in the processing of the other two fruits. Nevertheless in many areas lemon oil is still the paramount factor in the economic operation of the industry, and its extraction is a prime consideration in the utilization of the fruit, leading to the design of equipment which permits maximum oil recovery as well as high juice yields.

Apart from methods of peculiarly local importance based on the economics of the area, there are three main methods for handling lemon fruits for processing: the juice and oil are extracted simultaneously but separately, the juice is extracted before the oil, or the oil is extracted before the juice. Each of these methods should retain its place in the Australian lemon industry, enabling this country to be self-sufficient for lemon juice and lemon oil, except perhaps for high-quality hand-pressed oils and distilled oils for special usage.

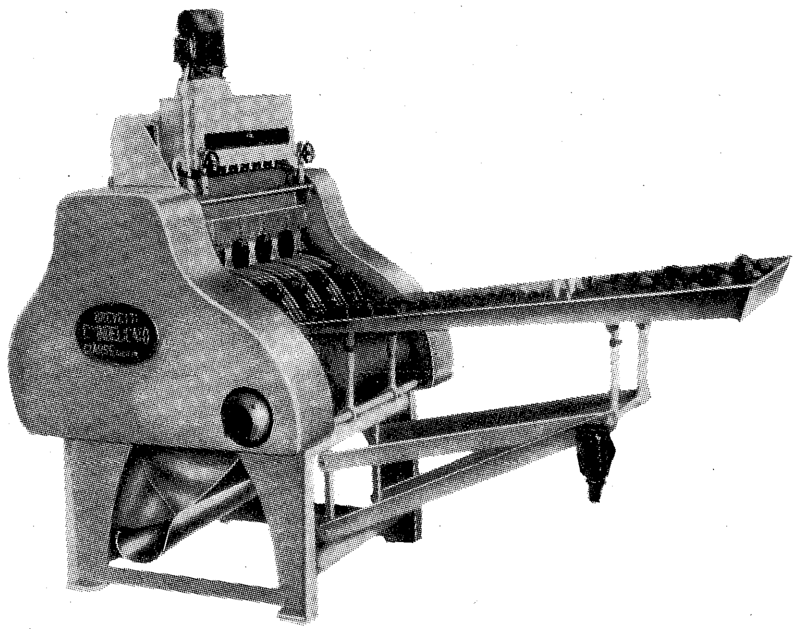
Juice Production

Simultaneous Extraction of Juice and Oil

Until comparatively recently, lemon juice and lemon oil were extracted simultaneously by crushing the halved fruit between rollers, screening off the pulp, and separating the juice–oil mixture by centrifugation. Not only was final separation difficult but the prolonged contact of oil and juice was detrimental to both products, and the modern method of simultaneous extraction ensures that such contact is greatly minimized. This result is achieved with the FMC* In-line Whole Fruit juice extractor. In this machine, the fruit is held in a cup in which prongs act as the retaining wall much in the same way as fruit is held in the half-open hand. A similar cup with intermeshing prongs descends, squashing the fruit; simultaneously a stainless steel tube passes up into the fruit, and the juice is forced down this tube by the squashing action on the fruit, flowing out through a built-in self-clearing filter. At the same time water is sprayed over the fruit as it is squashed, and the oil released from the burst oil cells on the outside of the fruit is washed down to be collected separately in an oil–water emulsion. Thus, separation of juice, oil, and rag is achieved simultaneously with little contact of juice with oil or rag, while peel residues are discharged at yet another outlet.

Because of the rapidity of the action, each cup handling up to 75 lemons per minute, oil recovery may be lower than by other methods, and in addition the peel is damaged by the squashing between the two sets of prongs so that it is not in the best form for conversion into the other most profitable lemon by-product, candied peel. Thus, although the

*FMC Corporation, San José, California, 95108, U.S.A.



The Fratelli Indelicato Super-automatic Citrus Juice Extractor AZ104. The fruit enters from the rotating distributing table and is lifted up onto the cutting knives from which the halves pass under the high-speed nylon reaming heads.

FMC extractor finds considerable use in plants where juice recovery is the prime consideration, particularly where oranges are the main citrus fruit being extracted, some but by no means all lemon processors prefer other types of juice extractors.

Mechanical Reamers

The basic principle behind the operation of other types of juice extractors is that employed in the kitchen lemon squeezer: the fruit is halved, and the halves are held on rotating reaming heads, the essential difference between the various machines being the way the halves and the heads are automatically positioned to receive each other. The two such extractors most frequently encountered are the Brown* extractor from California and the Indelicato† extractor from Italy and it is noteworthy that they originate in areas where the lemon represents a very significant proportion of the citrus crop. Oil can be extracted either by treatment before the fruit is halved or by treatment of the reamed-out halves, and the extracted peels, which remain intact in machines of this type, give candied peel of superior quality.

*Brown International Corporation, Covina, California, 91722, U.S.A.

†Fratelli Indelicato, Giarre, Sicily, Italy.

Both the Brown and the Indelicato extractors permit the use of fruit that has not been size-graded or maturity-graded, since the extractor pressure automatically adjusts itself to give optimum juice yield with minimum peel damage. On the other hand, they give juice products with higher oil contents than the FMC machine, and each extractor head handles only about 50 lemons per minute, a slower rate than can be obtained with the evenly shaped orange. Yields of juice from the three types of machine are not very different under modern extraction methods, usually ranging from 60 to 70 gallons per ton.

Processing Treatments

After extraction, pulp, rag, and seeds are removed from the juice by screening, or by centrifugation in machines such as the Hydroclone*. This operation should be performed as rapidly as possible to minimize the solution of undesirable constituents from the pulp into the juice, and also to reduce the time that elapses before the juice receives the heat treatment necessary to inhibit enzyme action. Whatever the subsequent treatment of the juice, even if it is to be preservatized

*Brown International Corporation, Covina, California, 91722, U.S.A.

chemically, it should be given a flash pasteurization for 30 sec at 180°F which will simultaneously destroy spoilage microorganisms and deactivate the pectic enzymes, which would otherwise cause cloud separation in the product.

After pasteurization, the juice may be filled hot directly into cans or bottles which are then closed and rapidly cooled; in practice, storage at temperatures near to 40°F is found satisfactory, but frozen storage would give a superior product. Because the flash pasteurization has sterilized the juice, chemical preservatives are not essential to maintain freedom from bacterial spoilage, but many processors add preservatives after the heat stabilization as a precaution against recontamination and to inhibit discoloration. Bulk storage of pasteurized lemon juice in casks with the addition of sulphur dioxide is still widely practised in the industry, and again the lower the storage temperature the better is the quality of the product.

Processed Lemon Juice Products

Frozen Concentrated Lemon Juice and Lemonade

Although concentrated lemon juice suitable for use in bottlers' bases and similar products is still prepared in some regions by concentration in jacketed vacuum evaporating pans in a batch process, a vastly superior product is nowadays obtained in a continuous process by concentrating heat-stabilized juice under greatly reduced pressures at temperatures about 100°F in evaporators with very short residence times, in some instances down to a few seconds. The process is the same as that used in the production of frozen orange juice concentrate, although the nature of lemon juice limits its concentration to a lower degree (about 5:1) than is possible with orange juice (up to 8:1). The concentrated lemon juice is chilled to 30°F by passage through a heat exchanger, filled into polyethylene-lined drums or into cans, and frozen during storage at 0 to −10°F.

Even more popular in the U.S.A., ranking third after orange juice and blended juices among the frozen concentrates, is frozen 'lemonade' concentrate. This product is not a concentrated form of the Australian-style 'lemonade', which is clear and carbonated, but, in conformity with American usage of the term as meaning 'diluted, sweetened lemon juice', it is a cloudy product used in many ways for the preparation of beverages but generally mixed with water for consumption in the home. It is prepared in refrigerated tanks by blending concentrate, single-strength juice, and sugar in the desired proportions, the product being filled into drums or cans, quick-frozen at −40°F, and stored at −10°F.

The production of these two lines, frozen concentrated lemon juice and frozen concentrated lemonade, places more emphasis on the quality of the product than previously, especially in the old-style concentrates, and the secret of their success lies in the avoidance of off-flavour development by the newer concentration techniques. So successful are these products that they now dominate the world's largest lemon industry, that of the U.S.A., and Americans now consume 10 lb of lemons per head per year in this form, representing about one-third of the crop, whereas previously fresh fruit had been the industry's biggest seller. In fact, Florida, whose fruit cannot compete with that of California on the fresh market because of its poor appearance, has recently developed a lemon industry of its own to provide raw material for these frozen concentrates.

In contrast to the lemon juice produced previously by vacuum pan evaporation, when the juice was largely a by-product from the preparation of lemon oil and citric acid, the high-quality frozen lemon juice concentrates and lemonade concentrates demand careful quality control not only of the extraction and concentration processes but also of the raw material. For instance, a green-fruit off-flavour can be objectionable in juice products prepared from immature fruit or from fruit which has not undergone the process of controlled storage known as 'curing'; fruit that has been overstored, on the other hand, will give juice with a very flat character. Before extraction the fruit must be sorted, washed, sprayed with weak chlorine solution, brushed with detergent, and finally rinsed. Stainless steel or plastic equipment must be used throughout the plant where there is direct contact with juice; otherwise metal contamination will cause discoloration and rapid loss of vitamin C.

Lemon Juice Beverages

Because of its strong flavour and high acidity lemon juice is normally consumed in diluted form, and in Australia most of our lemon juice output finds its way into cordials, squashes, or ready-to-drink beverages. These products are prepared in three stages; rarely do lemon processors market all three, usually supplying products in the first or second stage to the final bottlers and packers. This flexibility in operations is accompanied by a wide variety of products, and the subject of lemon juice beverages will be discussed here in general terms only. The first step is the flavour base, usually prepared by blending juice or concentrate, compounded lemon oil, and colouring matter with water; to prevent separation, the oils must be emulsified and adjusted in density by the use of permitted additives.

From the flavour base, the cordial or beverage base is prepared by mixing it with syrup solution containing a preservative, which may be sulphur dioxide, benzoic acid, sorbic acid, or a mixture of these. Because at this stage the ratio of sugar, acid, and pectin approaches that which results in gel formation, problems of gelling can occur here with products of high pectin content such as are obtained if the lemons used are too immature or if the extracted juice has been allowed to stand too long before separation of rag and pulp.

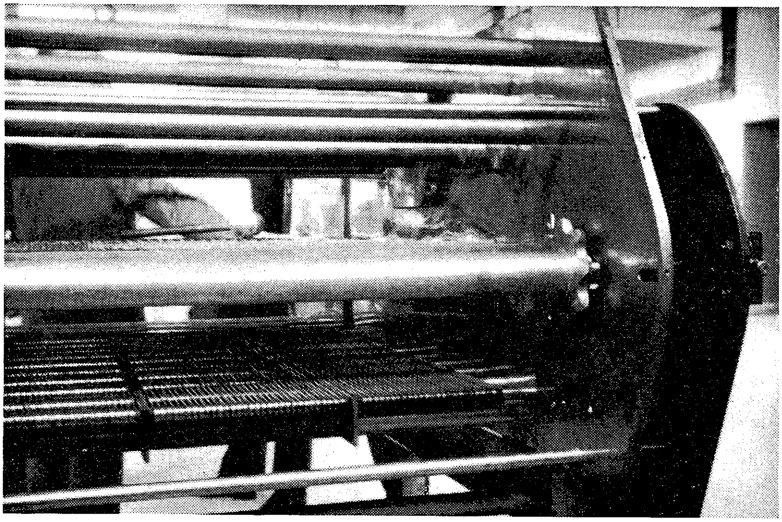
The ultimate stage in the process is dilution of the beverage base with carbonated water in the preparation of ready-to-drink bottled or canned products; these may be either cloudy, or clear like the Australian-style lemonade which may incorporate a de-pectinized, clarified lemon juice concentrate specially produced for this purpose.

An overseas development which has yet to make its full impact on the Australian citrus industry is the comminuted citrus drink which uses finely ground citrus peels to provide most of the flavour and colour of the product. Using comminuted orange peel, for example, with some orange juice, sugar, citric acid, and water, it is possible to make an orange drink indistinguishable to consumers and even to most food analysts from orange juice but containing only about 30% orange juice. Because lemon juice is rarely drunk undiluted, the comminuted product does not provide as much competition for pure lemon juice as it does for pure orange juice. Thus, comminuted lemon products find their principal use in the preparation of lemon drinks and lemon cordials, which consequently do not require the incorporation of flavourings and colourings from other sources; most of the lemon beverage bases prepared in the Mediterranean area make use of this principle. If the Australian industry follows overseas trends, such comminuted products will become increasingly important for our citrus processors, bringing with them problems for certain sections of the industry as well as the opportunity for optimum utilization of the crop in the production of attractive and nutritious citrus drinks.

A few lemon beverage products of fairly regional importance in Britain deserve mention here. Particularly popular is lemon barley water which uses a hot infusion of barley flour to smooth out the acidity of lemon juice and presents a drink with a pleasant bland flavour containing about 3% lemon juice. Another product is pure clarified lemon juice, often fortified with vitamin C, preservatized with sulphur dioxide and sold in bottles; it is most frequently consumed hot as a domestic medicine by sufferers from colds and mild fevers or cold as part of a diet programme by weight-watchers. It is remarkable that lemon juice with its low sugar content and high vitamin C content is not more widely used in such diets; a mixture of lemon and orange juice could easily replace grapefruit juice in any dieting programme at a considerable reduction in cost.

Lemon Oil Production

In most countries lemon juice and its derived beverages are the most economically important of the processed lemon products, but in Italy the dominant product is still lemon oil. Italy is traditionally the home of fine-quality oils, though less attention is paid to the quality of the juices which sometimes fetch only about 5 cents per gallon on the export market. Recent improvements in processing techniques, however, are changing this situation, and lemon juice is currently increasing its contribution to the economy of the Italian industry. Lemon oil, of course, will always remain a most useful and important flavouring material, ranking in this respect with orange oil. Orange oil, however, because of its much greater availability, does not command such a good price as lemon oil, profits from which can recover the cost of the



Vibrating spiked platforms on which oil is removed from whole citrus fruits in the Fratelli Indelicato Automatic Citrus Oil Extractor MK/2. The machine shown is undergoing construction: the two levels of platforms visible will form one continuous self-returning belt, and the pipes above them will carry the water sprays to wash away the released oil.

necessary plant within a few seasons. The U.S.A. has an annual production of about 1·5 million lb of lemon oil, Italy about 0·75 million lb, and Australia about 20,000 lb. About 60% of the world's lemon oil production goes into soft drinks and beverages, about 20% into bakery products, about 15% into confectionery, and about 5% into cosmetics, perfumes, and pharmaceuticals.

Oil Extraction in the FMC Juice Extractor

As mentioned earlier, lemon oil is obtained in several different ways depending on the method used to extract the juice. In the FMC extractor, the oil is obtained by spraying water on the outside of the fruit as it is being squashed. The very nature of the extraction process and its extreme rapidity mean that maximum oil recovery is not possible, but the manufacturer of the machine puts the recovery figure at 70% of the total oil in the fruit. This yield would be equivalent to about 8–10 lb of oil per ton of lemons; in practice, a figure of 4–9 lb per ton would be more realistic.

Oil Extraction from the Reamed Fruit

Where reaming types of juice extractors are used, the methods of oil recovery fall into two categories according to whether the oil or the juice is extracted first. In one of the earliest methods of oil extraction, the lemon cups with the juice reamed out were gently pressed by hand into a sponge to absorb the oil which was recovered by squeezing the sponges from time to time. This hand-sponge method is slow, tedious, and expensive but it yields a high-quality oil which commands a premium price on the market. The method nowadays, however, finds its main application in cottage industries in Italy and Spain.

Modern procedures for recovering oil from reamed lemon halves make use of machines which bend, turn, and gently press the cups while a spray of water rinses the expressed oil from the skins. If operated correctly to allow very little contact between oil and albedo, these machines give a high yield of a good-quality product, and the process is widely used, particularly in Italy where several machines incorporating this principle are available from local manufacturers. The method, called *sfumatrice* in Italy, has one drawback in that it is most suitable for peels of a certain maturity only; such peels, however, yield very high-quality oils which are in great demand from perfumery houses. Other peels are too soft for the process to be efficient, and in Italy they are subjected to a liming treatment to harden them, so increasing the amount of oil expressed and preventing its re-adsorption by the albedo. The peels are held in a bath of 0·25% lime for five minutes and allowed to stand overnight before passing into the extraction machine.

Oil Extraction from the Intact Fruit

Because the liming process as a stage in oil recovery involves time, space, and labour and results in a peel which is unsuitable for any further processing except as cattle feed, there have always been advocates of the third main method of oil recovery which involves rupturing the oil sacs on the whole fruit before it passes into the juice extractor. This method, called *pelatrice* in Italy, had its origin in one of the most primitive methods of oil extraction in which the fruit was rolled by hand around a funnel on the walls of which were set fine spikes; the spikes pierced the oil cells and the released oil drained down to the bottom of the funnel.

In the mechanical version of the *pelatrice* method the gentle pressure required to rupture the oil cells on contact with a spiking or abrasive surface is supplied by centrifugal force or by the momentum of a moving belt, and the oil is rinsed away by water sprays. In most such equipment, the abrasive action is excessive, in some cases resembling that of a potato peeler, and the oil has too much opportunity to pick up undesirable constituents, such as the green pigments from the peel, and to undergo enzyme-catalysed oxidations. The new Indelicato machine from Italy, however, has an action so gentle that close inspection of the treated fruit is necessary to distinguish it from fresh fruit and the oil is of very good quality, with higher concentrations of citral (the characteristic lemon aroma constituent), better colour, and better odour than most oils. The fruit is gently jostled along a vibrating platform in which are set innumerable small spikes; the speed of forward movement and the amount of vibration can be varied according to the maturity of the fruit to give the optimum oil yield.

Although the Indelicato process is less effective for lemons, because of their irregular shape, than it is for oranges, the yields claimed by the manufacturers of 8–12 lb of oil per ton of fruit are higher than the claims made for any other oil extractor. Moreover, the fruit can be used just like fresh fruit for juice extraction and for any form of by-product recovery, even high-quality candied peel; indeed, it is claimed that juice obtained from such fruit is superior because excessive oil levels are avoided. Certainly the method lends itself readily to automatic operations, unlike the process of recovering oil from the reamed halves.

Processing Extracted Oils

Since all modern methods of oil extraction involve the use of water sprays, several centrifugation steps are necessary to recover the oil from the emulsion of water, oil, and fine peel particles, obtained after the heavier particles have been removed in settling tanks. The aqueous phase from centrifugation is usually recirculated as spray water since the loss of water-soluble oil constituents can thus be minimized, but the wash waters must be renewed each day to prevent the build-up of undesirably high levels of enzymes. The final centrifugation leaves an oil of 99·9% purity but to obtain a high-quality product it is stored at low temperatures to precipitate waxy materials which would otherwise appear as sediments or clouds in beverages or perfumes prepared from the oils. Accelerated precipitation of these waxes has been achieved in the U.S.A. by dilution with alcohol, removal of the precipitated waxes, and vacuum distillation of the alcohol. In a process used in Italy, pectinase is added to the oil to hydrolyse the pectin which assists in holding the waxes in solution in the oil; the pectinase must subsequently be inhibited if the oil is destined for a product in which pectinase activity would be harmful.

Further oil can be recovered from peels after they have been through the above processes. The peel is passed through a screw press and the resultant peel juice is distilled to give a water–oil emulsion which is centrifuged to obtain the oil. The wash waters from the principal oil extraction process are also treated in this way but the product obtained from these two sources is only of fair quality and does not store well. It must be marketed separately from oils obtained in other ways and in Italy, for instance, the government regulates against its exportation. A product of even lower quality can be obtained by direct refining and centrifuging of the pressed peel juice.

The best-quality oil products and the ones in greatest demand by perfumers are the so-called 'concentrated' or 'terpene-less' lemon oils which are obtained by vacuum distillation or solvent extraction of the normal oil. These operations remove the terpenes which, although they are the oil's principal constituents, contribute little to its aroma or flavour. The processes of vacuum distillation or solvent extraction are more in the province of industrial chemistry than food technology, and the preparation of these products is mainly carried out by essential oil manufacturers from oils supplied by the lemon processors.

Candied Lemon Peel

The only remaining lemon produce processed in any quantity in Australia is candied peel, most frequently prepared from brined peel, in which form the lemon cups can be stored indefinitely until the candying operation. The peels should be reasonably thick, evenly and brightly coloured, without visible skin defects, undamaged by the juice extraction operation, and freed of all rag or pulp by hand or machine. The Brown citrus shaver, for instance, will take all types of peel from the Brown citrus extractor and shave the skin to any desired thickness; a thick shave merely removes the rag remaining in the reamed-out cups, making them ready for candying. Peels which have been through the FMC juice extractor or the *sfumatrice* oil extraction process do not give the best-quality product.

For brining, the clean cups are washed, placed in barrels, and covered with 10% salt solution; the concentration of the brine is maintained by salt addition until curing is complete as judged by an even transparency throughout the peel. Over-mature or very spongy peels can give a mealy or mushy product, and frequently lime is added as a firming agent at the rate of 0·5 oz per gallon of brine. When cured, the peel is covered with fresh 15% brine, usually containing 500–600 p.p.m. sulphur dioxide.

For candying, processors can use either fresh peel or brined peel which has been freed of salt by soaking in hot or cold water. Because washing removes from the brined peel the citric acid which is a natural inhibitor of discoloration by small amounts of iron, metal contamination during these operations should be avoided or the wash waters should contain about 0·2% citric acid; otherwise the peel will develop a dull grey appearance. Once the peel is ready for candying, the oil cells are ruptured by gentle brushing or rubbing, and the peel is cooked until tender and until it reaches the desired flavour level, with changes of water when necessary. The tender peel is drained, pressed dry, and cut to the required size before candying.

There are a number of variations to the actual candying process from an operation taking several days in which the peel is steeped in a sucrose–glucose syrup of increasing concentration until a level of 76% sugar is reached to one taking 30–40 minutes in which the peel is cooked with the sugar syrup under intermittent vacuum. The sucrose–glucose mixture, which is usually obtained by the use of commercial invert-sugar or prepared in the plant by mild acid hydrolysis of sucrose (cane sugar), produces a better product in the candying operation than sucrose alone. Once candied, the peel is drained dry and marketed either semi-moist for use in bakery and other products, or dusted with powdered sugar for sale as a confection; in either case storage in moisture-proof packages is necessary.

Lemon Waste Products

Lemon processors in this country are fortunate that the preparation of candied peel absorbs so much of the waste products from their juice operations. This form of utilization makes the disposal of lemon wastes far less a problem here than the disposal of the much larger amount of orange processing wastes, and certainly nowhere near the problem faced by overseas processors whose lemon juice production results in far more peel than can be disposed of in candied peel and other similar products. Australian lemon processors are doubly fortunate in this regard since the principal outlets for lemon wastes overseas, the production of citrus pectin on the one hand and dried pulp and molasses for cattle feed on the other, both require the installation of expensive plants.

With the expected increase in the amount of citrus (including lemons) processed in Australia, there are likely to be more problems in the disposal of our citrus processing wastes which currently find limited use as fertilizer and fodder for orchards and dairy farms adjacent to the processing plant, the rest being dumped in areas specially set aside by local government authorities. Indeed, the growing resistance to environmental pollution may lead Australian processors, voluntarily or otherwise, to consider disposing of their wastes by conversion into marketable products in regional plants even though the operations themselves may not be economically profitable.

Unfortunately, the two main outlets for waste disposal overseas are less economically attractive in Australia. Although lemon peel is rich in pectin, pectin recovery is not an economic proposition for this country because of the high initial cost of the plant and the present and apparently permanent world surplus of pectin. Likewise, the conversion of citrus wastes into dried cattle fodder, although widely practised in Florida, California, and most other citrus areas, also requires high capital outlay and in addition faces stiff competition from the more cheaply produced by-products of wheat processing. Of the two, the cattle feed operation has greater potential because our large dairy and beef herds frequently present feeding problems, and centrally located cattle feed plants utilizing all the wastes from that area may become a feature of our processing operations in the future. It is, after all, economic for Florida to market cattle feed products in the north-eastern New England States against competition from wheat waste products from Iowa.

Besides pectin and stock feeds (pulp and molasses), there are a number of other products manufactured by overseas lemon processors ranging from lemon marmalade and powdered lemon drink base, obtained from lemons alone, to seed oils, juice sacs, citrus wines, and other products obtained from pooled citrus processing wastes. In the present stage of the development of the Australian industry, however, it should consider consolidating its operations in terms of lemon juice and juice products such as frozen concentrated lemonade, lemon cordials and squashes with particular attention to the economics of comminuted drinks, lemon oil in varying quality grades, lemon peel in various forms including lemon marmalade, and alternative methods for disposal of its waste products. Further information on the production of these commodities may be obtained by consulting the following literature.

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Banana Drink

A New Canned Product

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Bananas have an attractive flavour but so far have not been used commercially as a base for beverages. This article gives details of the methods for preparing banana purée and banana drinks and the characteristics of the canned products.

Much work has been done on methods for processing bananas; they have been dehydrated to produce banana figs, powder, flakes, and flour (Anon. 1960; Singhagajen and McBean 1968) and canned as slices and purée (Anon. 1960; Board and Seale 1954; Guyer and Erickson 1954; Watson 1960). Northcutt and Gemmill (1957) described an aseptic processing procedure which makes feasible the production of a heat-processed purée which retains the characteristic colour and flavour of the fresh fruit. The aseptically canned banana pulp is used mainly for baby food products and for flavouring ice cream. Dupaigne and Dalnic (1965, 1969) have suggested clarification of banana pulp by pectolytic enzymes to produce a banana drink.

Fresh bananas are available throughout the year in most parts of the world, and hence processed banana products intended to substitute for fresh bananas are not widely used. However, an attractive banana drink which is difficult to prepare on a domestic scale and which does not compete on the market with the fresh product should have consumer appeal and provide an outlet for surplus production.

Board and Seale (1954) suggest that for processing at boiling water temperatures the natural pH of bananas, 4·6–5·4, should be reduced for canning to pH 4·2–4·3. This may be achieved by canning banana with acidic fruits as in 'tropical fruit salad', or by the addition of edible organic acids. A method for the adjustment of the pH and canning of banana purée is given by Guyer and Erickson (1954).

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Because banana tissue is particularly susceptible to oxidative enzymic browning, disintegration of banana tissue should be carried out in the absence of oxygen at a temperature that inactivates enzymes, and as bananas contain an interstitial gas space of about 13–16% (Forti 1954; Czyhrinciw 1969) vacuum steam blanching is an ideal process. Vacuum steam blanching has previously been described for apples (Casimir 1967).

A suitable process for the production of canned banana purée and drinks would thus involve:

- Acidification to reduce the pH to 4·2–4·3 and permit processing as an acid food.
- Rapid heating in the absence of oxygen, accompanied by tissue disintegration and enzymic inactivation.
- Separation of fibre and other undesirable rough fractions by screening.
- Filling hot for purée, or diluting, centrifuging and sweetening, filling, and spin cooking and cooling for drink.

The first two steps are conveniently carried out in one operation in a vacuum tumble blancher (VTB) and the third step in a screening centrifuge or screw press. The flow sheet illustrates the production sequence for purée and drink.

Equipment and Analytical Determinations

Vacuum Tumble Blancher (VTB).—A Pfaudler conical dryer-blender (Model No. 24-45CD-SB) having a total capacity of 4 ft^3.

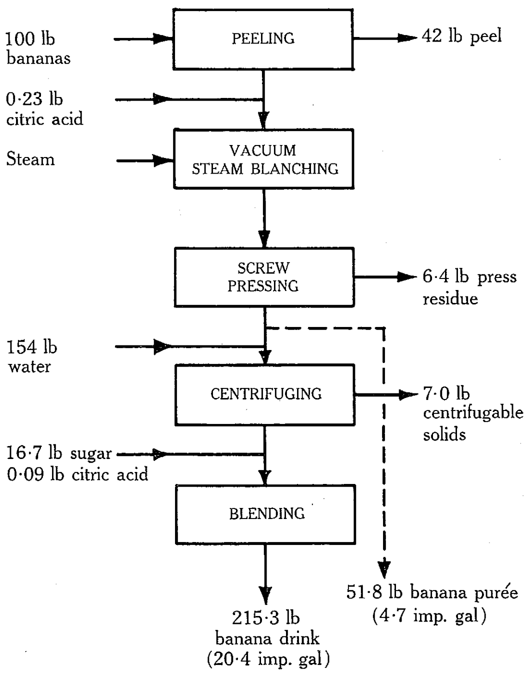
Screw Press.—Brown screw press (Covina, California) Model 3600 fitted with a 101926 screen 5 in. diam. and 11 in. long having 700 0·02 circular openings/in^2, i.e. 22% open area.

Centrifuge.—De Laval Model 1300 fitted with wing distributor.

Specific Gravity.—Determined using the specific gravity bottle procedure of Casimir, Mitchell, and Moyer (1967).

Soluble Solids.—Determined using a Carl Zeiss Abbé refractometer Model A.

Total Solids.—Determined by drying the material to constant weight at 70°C in a vacuum oven operated at 28 inHg vacuum.



Flow sheet illustrating production sequence for banana purée and drink.

Experimental

Raw Material

Cavendish bananas purchased from the Sydney markets were ripened until the cut flesh had a translucent appearance and had developed the full banana flavour. Less mature samples when canned gave a product that tended to be astringent.

The bananas were hand peeled giving a yield of 58%. Peeling yields depend upon a number of factors, including fruit size and maturity, and have been found to vary from 57 to 67%.

Acidification and Vacuum Steam Blanching

The peeled and trimmed bananas together with 0·4% by weight of citric acid were placed in the VTB which was then closed and revolved at 6 r.p.m. The vessel was evacuated using a two-stage steam ejector to 28 inHg vacuum in 55–60 sec and the chamber was isolated from the vacuum system. The vacuum was then broken by admitting steam until a positive steam pressure of 2 lb/in^2 gauge was reached. This took about 30 sec and the steam pressure was maintained at this level for approximately 7 min to heat the banana 'purée' to 200°F.

Screw Pressing

The pulp was discharged from the VTB at 200°F into the preheated screw press with the screw running at 380 r.p.m. and 25 lb/in^2 gauge air pressure on the solids discharge cone.

Canning of Purée

The purée discharged from the screw press at 185°F was filled directly into plain cans without leaving a headspace; the cans were then closed and inverted.

Preparation of Banana Drink

The purée as discharged from the screw press was diluted in the ratio of 1:3 with water, and the pH adjusted to 4·2–4·3 by the addition of further citric acid. The diluted purée was centrifuged at a rate of 20 gal/hr and the opalescent liquid obtained adjusted to 12–15°B by the addition of sugar to produce the banana drink.

The drink was then filled in 16-oz (301 × 411) plain cans leaving a headspace of $\frac{5}{16}$ in., vacuum closed, spin cooked at 150 r.p.m. for 2 min, and spin cooled under water sprays for the same time.

Results and Discussion

Analytical Determinations

Analytical determinations made at various stages throughout the process are set out in Table 1.

Colour Addition and Taste Panel Evaluation

The banana drink as prepared above has an attractive opalescent appearance but it was considered that addition of artificial yellow colour might enhance the acceptability of the product.

To ascertain the influence of added colour three samples of drink, one coloured with 3·6 p.p.m. of Sunset Yellow (Index No. 15985), another coloured using 4·0 p.p.m. of riboflavin-5′-phosphate sodium, and the third without added colour were presented to a taste panel. The 29 tasters scored the samples on a hedonic scale for the degree of liking at two sessions. At the first session yellow-orange lighting was used to make the colour of samples indistinguishable to ascertain whether the added colouring influenced flavour, and at the second session natural daylight was used which permitted the tasters to observe the colour differences. The average panel score placed the drink in the 'like moderately' category (7 on a 9-point scale) and there was no significant preference for the coloured drink at either session.

The Sunset Yellow is decolorized in plain cans and the riboflavin-5′-phosphate sodium is light-sensitive. Hence, if colour modification is required Sunset Yellow should be used for drinks to be packed in lacquered cans or bottles and riboflavin-5′-phosphate used when the product is to be packed in plain cans.

Storage Stability of Banana Drink

Canned banana drink in plain electrolytic tinplate cans has maintained quality for 18 months at ambient temperatures. Artificially coloured drinks have also maintained quality provided the colouring material used is compatible with the container. Iwamoto *et al.* (1970) reported abnormal de-tinning in canned banana drink due to the presence of naturally occurring nitrate in the bananas used, but no problem has been encountered with Australian raw material in these trials.

Costing

The approximate cost of manufacture of a 16-oz 301×411 unlabelled can of banana drink is made up as follows: can, 4 cents, sugar and citric acid, 0·8 cent, banana, 1·0 cent (based on 2·0 cents/lb for fresh bananas), and permits the product to be produced at less than 10 cents/can if 4·0 cents/can is allowed for processing and overhead costs.

Table 1

Characteristics of the Product at Various Stages

	°Brix	% Acid (as anhyd. malic)	pH	Specific Gravity	Brix/Acid Ratio	Total Solids (%)
Raw peeled banana	20·5	0·37	5·4	1·027	55·4	24·24
Blanched pulp	21·5	0·61	4·3	1·099	35·2	23·52
Screw press residue	—	0·60	—	1·117	—	32·40
Purée	21·5	0·63	4·3	1·097	34·3	22·71
Drinks	13·0	0·21	4·0	1·054	61·9	13·52
B1300 Centrifugal solids	—	0·27	—	1·064	—	17·80

Banana Drink Blends

Banana blends well with other tropical fruits such as passionfruit and pineapple. An attractive drink was made from a blend of 30% banana drink, 5% passionfruit juice, and 65% pineapple juice.

Carbonated Banana Drinks

The banana drinks when carbonated to 2·5 volumes produced an attractive and refreshing drink which maintained its attractive opalescent cloud during storage. When bottled carbonated blends are required it is necessary to use pasteurized juices in which enzymes have been inactivated in order to produce products with a stable cloud.

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News from the Division

Plant Physiology Unit

The Plant Physiology Unit of the Division of Food Research, which was established in 1952 and until now has been located at the University of Sydney, moved to Macquarie University last December.

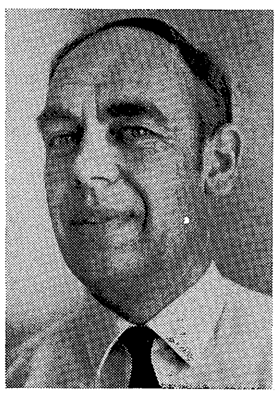
The move brings the Plant Physiology Unit closer to the Headquarters of the Division at Ryde.

The Unit will continue to be led by Dr R. M. Smillie; staff will consist of six research scientists and supporting staff. University staff working in association with the Unit will comprise Professor F. V. Mercer, a former joint leader of the Unit, Professor F. L. Milthorpe, three senior lecturers, and two lecturers.

New Appointments

Dr G. R. Germaine joined the Microbiology Section at Ryde on December 4, 1970 as a Research Scientist, Post-Doctoral Fellow to study the chemical composition and structure of bacterial spores in relation to their resistance to radiation and other agents. He graduated M.S. from the University of Minnesota in 1966 and Ph.D. from the same university in 1968. Since then he has been a research microbiologist with the North Star Research and Development Institute, Minneapolis, Minnesota.

On December 14, 1970 Mr P. L. Thomas was appointed Liaison Officer to the Meat Research Laboratory at Cannon Hill. Mr Thomas obtained his B.Sc. at the University of London in 1952 and since 1967 has been Officer-in-Charge of the Monsanto Animal Research Unit at Petrie, Queensland. His duties will be to assist the Officer-in-Charge, Dr W. J. Scott, in technical and scientific aspects of the Meat Research Laboratory's programmes and to maintain liaison with other CSIRO, University, and Government departments. Mr Thomas will also share responsibility for the processing of manuscripts for publication.



Mr P. L. Thomas.

Mr K. G. Newton, an Experimental Officer at the Meat Research Laboratory since January 4, 1971, will participate in investigations of the microbiology of meat and meat products, with special emphasis on new processes and products. Mr Newton completed his B.Sc. (Hons.) at the University of Queensland in 1966.

Visiting Workers

Mr K. S. Jayaraman, Colombo Plan Fellow from India, received practical training in food technology at Ryde, under the supervision of Mr D. J. Casimir, over an extended period terminating in January 1971. Mr Jayaraman obtained the Diploma of Food Technology from the University of New South Wales before returning to India.

After spending three years in the Division's Fruit Storage Section at Ryde, Mr Wasim Farooqi, Colombo Plan Fellow from Pakistan, returned to his home country. During his stay in Australia he completed the requirements for the M.Sc. degree from Macquarie University.

Among other visitors to the Food Research Laboratory since the beginning of 1971 was Mr S. Hardisty, Horticultural Adviser of the Western Australian Department of Agriculture, who had discussions with members of the Division on the physiology, storage, and processing of apples.

Professor W. L. Dunkley, Professor of Food Science and Technology at the University of California, Davis, who was attached to the Dairy Research Laboratory for two months early in the year, also visited Ryde to discuss reverse osmosis and ultrafiltration of whey.

Mr A. R. Neill, of the Biochemical Laboratory, Animal Research Institute, Queensland Department of Primary Industries, had discussions with members of the Animal Products and Physical Biochemistry Sections at the Food Research Laboratory.

General

Mr R. Atkins, Divisional Engineer, visited New Zealand for three weeks in March, to study controlled-atmosphere and cool stores used for fruit and vegetables.

The Division was represented at the Pome Fruit Handling Conference, held at Orange on February 17–19, by Messrs Atkins, Hall, Scott, and Riley.

Mr M. V. Tracey, Chief of Division, and Mr J. Czulak, Acting Officer-in-Charge, Dairy Research Laboratory, participated in the National Agricultural Outlook Conference, Canberra, in February.

Mr M. V. Tracey (Chief), Dr J. H. B. Christian (Associate Chief), Mr P. W. Board, Dr A. Howard, Dr June Olley, and Mr E. G. Davis, of the Division of Food Research, have been admitted as Fellows of the Australian Institute of Food Science and Technology.

The 7th International Conference on Plant Growth Substances, Canberra, December 6–12, 1970, was attended by Dr C. J. Brady, Dr W. B. McGlasson, Mr P. O'Connell, and Dr R. M. Smillie of the Plant Physiology Unit and Mr R. B. H. Wills of the Fruit Storage Section.

The Division organized a 'Meeting of Investigators' at Ryde on February 9, 1971, under the general direction of the Committee on Fruit and Vegetable Storage Investigations in New South Wales.

Mr R. R. B. Russell received the Ph.D. degree from the University of Melbourne and Mr R. K. Tume the Ph.D. degree from the University of Adelaide. Both are on the staff of the Meat Research Laboratory, Cannon Hill.

Macquarie University approved the award of the Ph.D. degree to Mr R. B. H. Wills, an Experimental Officer in the Fruit Storage Section, for his thesis 'The relation between low-temperature breakdown and volatiles of apples'.

Mr M. L. Rooney, an Experimental Officer in the Food Technology Section at Ryde, was awarded the degree of M.Sc. by the University of New South Wales.

Dr J. R. Vickery, retired Chief of the Division of Food Preservation, was invited to present the ninth annual Institute of Food Technologists Tanner Lecture at Chicago, on April 12, 1971, on 'The next 50 years of food developments'.

Readers will have received a copy of the brochure announcing the course on 'Instrumental Techniques', to be held at Ryde on July 19–23, 1971. Details are available from the Division's Technical Secretary.

Retirement

Dr George Kaess, Principal Research Scientist, retired from the Meat Research Laboratory on January 6, 1971, ending 22 years' association with the Division. Dr Kaess graduated in Mechanical Engineering in Munich and received his doctorate at Karlsruhe in Germany. He joined the Division to work with Mr A. Howard at the original meat research laboratory in Brisbane's Cannon Hill abattoir in 1949. A shy and always courteous man, Dr Kaess became a naturalized Australian in 1957.

A passion for detail and mechanical exactitude characterized George Kaess's experiments, which covered a wide range of investigations into the preservation of meat by refrigeration and by treatment with ozone and with ultraviolet rays. He had a rare ability to develop methods of obtaining measured results where others had produced only general observations. Some 35 papers testify to the contribution made during his many years of valuable service.

Dr Kaess is planning a tour to Europe in 1971. He takes with him the best wishes of his former colleagues for good health and happiness.

Selected Publications of the Division

From the Dairy Research Laboratory

Copies of these papers are available from the Librarian, CSIRO Division of Food Research, Dairy Research Laboratory, Box 20, P.O., Highett, Vic. 3190. (Telephone 95 0333.)

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From the Food Research Laboratory

Copies of most of these papers are available from the Librarian, CSIRO Division of Food Research, Food Research Laboratory, Box 52, P.O., North Ryde, N.S.W. 2113. (Telephone 888 1333.)

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From the Meat Research Laboratory

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