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Extracts from an address delivered by L. A. C. Alles, Department for the Development of Marketing, Colombo, Ceylon, to the staff of the Division of Food Preservation and Transport, C.S.I.R.O., in June 1953.

Research in

TO APPRECIATE THE PROBLEMS FACING FOOD research in Ceylon, one should first learn something of the country and its peoples. In Ceylon, most of the land is not used to produce food directly but to grow crops which can be bartered for food. The population of Ceylon at the census of March 1953 was 8.09 millions and the rate of increase about 0.1 million per annum (which is *double* the rate at which the world population is increasing). The area of the island is 16½ million acres (about 1/120 of Australia) but 9½ million acres, taken up by roads, towns, villages, tanks, forest reserves, sanctuaries, and rocky land, are not available for agriculture. Of the remainder 3¼ million acres are now under cultivation, the land being divided among the main agricultural crops — coconut, rice, rubber, and tea — as in the following table. Therefore, about 3¾ million acres are left for future agricultural development.

The land surface of the island is divided into two large natural groups called the "wet zone" and the "dry zone". The wet zone (about 4 million acres) consists of the western, central, south-western, and southern regions; the remainder (12½ million acres) constitutes the dry zone. Each zone carries about half the total population. The dry zone is very poorly developed on account of the relatively scanty rainfall and most of the undeveloped arable land is situated within it. This land can be put to use only under artificial irrigation.

Tea plants 18 months old.

Ceylon's economy is mainly agricultural. The chief products (tea, rubber, and coconut) are exported. Nearly two-thirds of the total quantity of the staple food (rice) is imported, as well as clothing and other manufactured goods.

Acreage of Main Crops

Crop	Acreage
Coconut	1,070,942
Rice	901,500
Rubber	655,225
Tea	561,031

Research Aims

Food research in Ceylon is directed towards increasing the yield and improving the quality of rice to make the country self-supporting as regards her main food, and maintaining the yield and improving the quality of the three main commercial crops, tea, rubber, and coconut.

Tea

Tea brings in over 50 per cent. of the export income, in spite of the relatively small area of land devoted to its production. Research in tea is carried on by the Tea Research Institute, which is semi-government and is financed by a tax levied on the tea exported (approximately sixpence per 100 lb). The Tea Research Institute is situated at an elevation of

Food Technology in Ceylon

4500 feet above sea-level in the heart of the tea-growing district, and has a 400-acre estate, a fully-equipped factory and workshop, and research laboratories. An advisory service helps the tea planters with their problems, and accounts of the research work are published in the "Tea Quarterly". The work of the Tea Research Institute may be summarized as:

Maintenance of soil fertility and protection against erosion.

Protection of tea plants against diseases, pests, and weeds.

Improvements to the manufacturing process.

Mechanization.

Selection and propagation of high-yielding, high-quality types of tea.

In recent years the Institute has been engaged in controlling "blister blight", a disease which was threatening to destroy the tea industry. Extensive field work and laboratory studies, carried out over the last seven or eight years, resulted in the development of copper-containing fungicides which proved effective against the causative organism (*Exobasidium vexans*).

Field trials have been conducted to study the various factors affecting the efficacy of the treatment, for example:

Interval between applications of fungicide.

Interval between treatment and plucking time.

Protection of crops after pruning.

Methods of application, namely wet spraying, dry spraying, and dusting.

The effect of wind and rain on the activity of the fungicide.

From the consumer's point of view, the most important consideration is the copper content of the tea and its effect on flavour and on the consumer. Extensive laboratory analyses have shown that the copper content in the manufactured tea is about one-third of the quantity permitted by the United Kingdom Ministry of Food.

Coconut

Coconut is the next major food crop. About half is exported as oil, copra, desiccated coconut, and coir. A recent survey shows that the local consumption is about 140 nuts per head per annum. It is the main source of fat in the diet. The white kernel is grated and the oil, squeezed out from the gratings as an emulsion, is added to curries. It is reported that coconut fat is very easily digested and has a higher calorific value than most commonly consumed fats. Research on coconut, pertaining to its agricultural and semi-agricultural aspects, is carried out at the Coconut Research Institute, a levy-financed organization which has its own estate for

A coconut nursery.

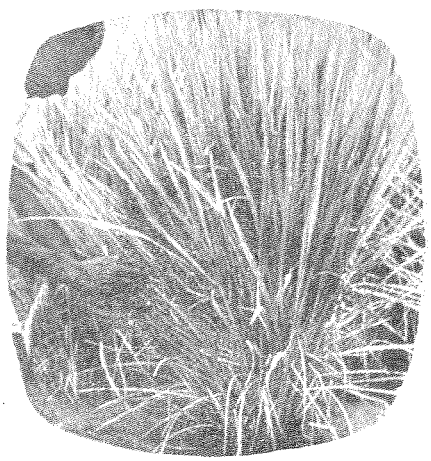
agricultural trials and its own central laboratories. Fertilizer research during the past few years has revealed the predominant role of potash in the coconut and the deleterious effect of excessive nitrogen. Trials are being conducted for studying magnesium deficiency, which has been shown to cause yellowing of leaves, and investigations are being made into the following problems:

Selection and breeding of high-yielding varieties.

Effect of different types of livestock on coconut estates.

Use of catch crops, such as pineapple, between planting and bearing.

Effect of various agricultural practices on the yield and quality of copra and coconut oil.



A hybrid rice plant.

Research on industrial products from coconut is in the hands of the Government Department of Industrial Research. Examples of these products are acetic acid (extensively used as a coagulant for rubber latex), coconut-shell charcoal, coir, and matting.

Rice

Highly important food research immediately applicable to the staple food, rice, is being carried out by the Department of Agriculture and the Government Medical Research Institute. The former is investigating paddy (unhusked rice) and the latter the nutritional value of rice. Important current projects on paddy cultivation are:

Intensification of breeding programmes.

Testing out of a large number of introduced and indigenous varieties of paddy.

Hybridization with the object of eliminating defects in Ceylon pure-line paddy.

Development of strains resistant to flood conditions and to brackish water.

Study of photo-periodism in rice.

Study of response to nitrogenous and phosphatic fertilizers.

Effect of a pre-sowing treatment, consisting of repeated soaking and drying, on the yield of the rice and its resistance to drought.

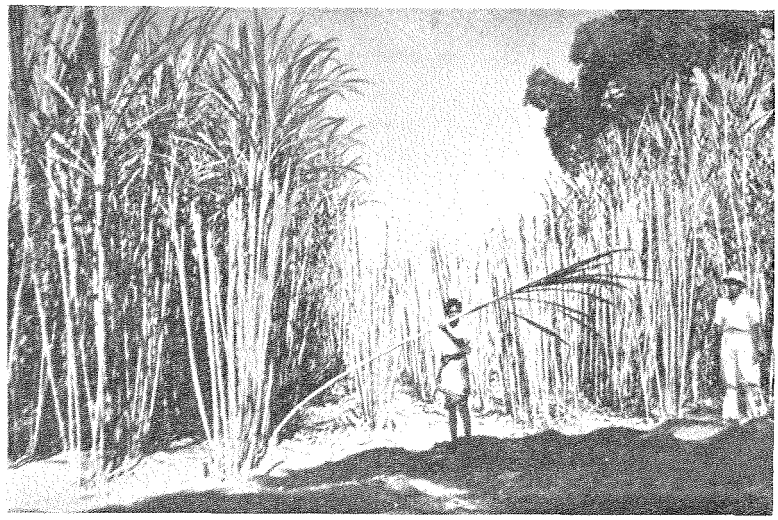
Summarizing the results of work done in Ceylon and elsewhere on the dietary value of rice, Baptist of the Ceylon Medical Research Institute concludes that, in general, the rice diet compares very favourably with other cereal diets in carbohydrate and protein content and in its biological value and essential amino-acid content. The vitamin content depends largely on the treatment of the paddy before husking. Parboiling, a traditional practice which consists of steeping the paddy in boiling water and subsequently drying, and the newer "rice conversion process",* introduced in the United States, conserve the vitamins to a large extent.

Fruits

Bananas, oranges, pineapples, mangoes, and papaws are the common fruits in Ceylon. Very little work has been done on their commercial production, and much remains to be done to improve the varieties and to control diseases and pests.

Orange and mango orchards have been established on several government farms in different parts of the island, but their production is a relatively small fraction of the total amount. Canning was begun on a very small scale by the Marketing Department, and a small quantity of pineapple and mango is preserved in this way. Although the production is small there has been a rapid growth. With a view to encouraging the growers to extend cultivation, the Marketing Department operates a "Guaranteed Price Scheme" by which the grower is assured of a fair price for his produce even at the peak of the season.

* See *Food Industr.* **19**: 763-8 (1947).



A nursery field of sugar cane.

It is hoped that this industry will develop rapidly, following increased production of fresh fruit and the establishment of a small cannery. It should contribute substantially to Ceylon's export income in the not distant future.

Some analyses of Ceylon fruits and vegetables have been made by the Medical Research Institute and the Department of Agriculture, but more extensive investigations are needed.

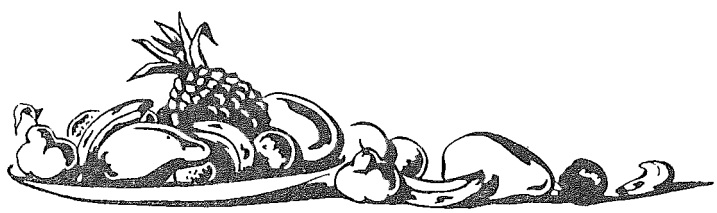
Sugar

Sugar, which is at present imported, is to be grown in Ceylon. This will greatly benefit the canning industry, for the high cost of cans and sugar is hindering its development. Sugar-cane plantations have been opened in some parts of the dry zone and in the Gal Oya Irrigation Area (NE. Ceylon), where a large irrigation reservoir was recently completed. A number of technologists from Ceylon have been studying sugar-cane cultivation and sugar manufacture in Queensland. Recently, it was reported that the yields from the new sugar-cane plantations in Ceylon were very high — greater than those in Queensland.

Plans for the Future

The Government of Ceylon proposes to establish a Food Research Institute. Dr. Z. I. Kertesz (Professor of Chemistry at the New York Agricultural Experimental Station, Cornell University) visited Ceylon under the auspices of the Food and Agriculture Organization to advise the Government on plans for this Institute.

Thanks to the assistance being given to Ceylon by other countries under various schemes, and to the efforts of its own Government, Ceylon expects soon to meet the basic needs of its people as it did in its proud past.



Headspace, Internal Capacity, and Fill of the Can

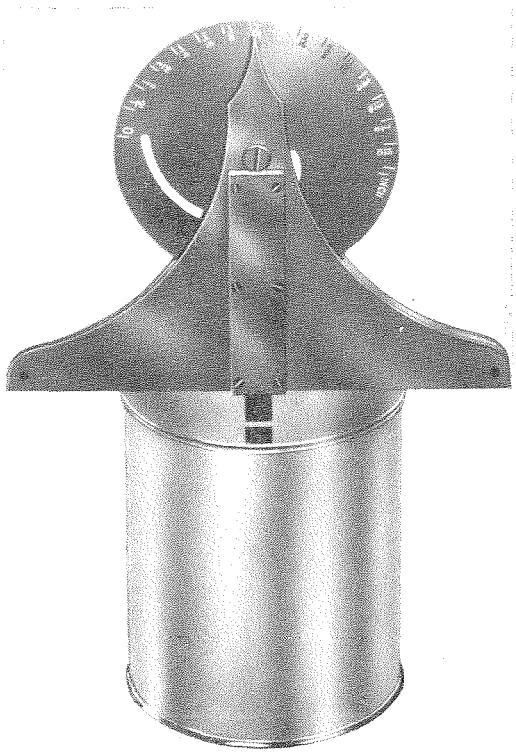
THE HEADSPACE IN A CAN IS THE FREE SPACE not occupied by the contents. A determination of the amount of headspace, measured either as headspace depth or as headspace volume, is usually made immediately a can is opened, following the measurement of the internal vacuum.

HEADSPACE DEPTH

In routine inspections of foods canned in liquid media, the headspace is measured in terms of *headspace depth*, which is defined by convention as the distance in sixteenths of an inch from a flat edge laid across the top of the open can to the level of the liquid in the can. The can should be opened with an opener which does not damage the double seam. The measurement is often made with an engineer's depth gauge having an extended cross-bar; the scale is lowered until it meets its reflection in the surface of the liquid in the can, and the depth is read. It is necessary to submerge completely any solid portions of the can contents, so that a smooth liquid surface is presented. For this purpose a thin, perforated, stainless steel disk, with a diameter slightly less than that of the can, is sometimes used, a correction being applied for the displacement of the disk.

Headspace depth is measured from the top of the double seam on the opened can, because this is a convenient reference level. But this level is approximately 3/16 in. above the average level of the can end. Therefore, the headspace depth so measured is sometimes recorded as *gross headspace depth*, and this depth, less 3/16 in., is recorded as *net headspace depth*.

A headspace depth gauge of special design, devised by workers at the Campden Research Station, is illustrated below. The graduated disk with the milled edge has an exponential slot which engages a pin on the flat rod. When the bevelled tip of the rod meets its reflection



Campden headspace gauge.

The fourth article in this series. Earlier articles appeared in the **Food Preservation Quarterly**, *Volume 13 (1953), pages 3-8 and 21-31, and Volume 14 (1954), pages 8-18.*

By J. F. Kefford

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in the liquid surface, the pointer indicates the headspace depth in sixteenths of an inch.

Another type of headspace tester, a stepped gauge, was developed by the Fishing Industry Research Institute in South Africa (Dreosti and le Roux 1951). A gauge of this type is illustrated at right. It consists of a bar which bears a series of prongs increasing in length from 2/16 in. to 10/16 in., in steps of 1/16 in. The bar is laid across the top of the opened can, and the headspace depth is given by the prong that just touches the liquid surface.

The gauge illustrated was made to measure gross headspace depths according to the conventional definition given above, but the original gauge described by Dreosti and le Roux (1951) was designed to measure the average depth of the surface of the contents below the underside of the lid. Measurements on a number of common sizes of fish cans showed that the average depth of the top of the lid below the double seam was 9/64 in. The thickness of the tinplate of the lid was taken as 1/64 in. and the zero prong on the gauge was made 10/64 in. long. Successive prongs increased in length in steps of 4/64 in. up to 42/64 in., representing average net headspace depths up to 32/64 in. Headspace depth measured with this gauge and multiplied by the internal cross-sectional area of the can then gave an approximate value for the headspace volume.

HEADSPACE VOLUME

Headspace depth is a convenient measurement for inspection and control purposes, but in research studies and in the examination of solid packs where the surface of the product is irregular, a determination of the volume of the headspace may be more useful.

South African F.I.R.I. stepped headspace gauge.

The use of the Campden manometer to determine headspace volume is described earlier in this series (Kefford 1954). It is important to remember that the internal vacuum in a can influences the headspace volume because of its effect on the concavity of the ends. Thus the headspace volume in a can increases when the vacuum is released, because the ends move outwards. For this reason, when headspace volume is determined with the Campden manometer the ends of the can should be clamped before puncturing.

Headspace determination in solid packs with the Campden manometer is frequently unsatisfactory because the headspace is not readily located and the puncture needle often becomes blocked. These difficulties are avoided in a method devised by Mitchell (1944), of this Laboratory, which makes use of Nicholson's hydrometer.

Nicholson's Hydrometer

The use of Nicholson's hydrometer to determine headspace volume is based on the principle of Archimedes: a body immersed in water shows a loss in weight equal to the weight of water displaced. Nicholson's hydrometer provides a convenient means of weighing a can and its contents in air and in water. From these weights, the internal capacity of the can and the volume of the contents can be calculated, and the difference between these two quantities is the headspace volume.

A large Nicholson's hydrometer can be constructed from materials readily available in a cannery laboratory. The body of a No. 10 can (603 × 700) fitted with two conical end-pieces makes a suitable float chamber. A copper tube soldered to one conical end-piece supports a 401 can end which serves as a platform for weights and for samples to be weighed in air. Two tinplate strips, soldered to the float chamber, carry a lower platform for samples to be weighed in water. For this lower platform it is convenient to use an open 4-oz can (211 × 111), which may be weighted with lead shot so that the hydrometer will float at a suitable level. The weight added to the lower platform may be varied according to the weight of the samples being examined. A hydrometer of the dimensions suggested will weigh cans up to approximately 2-lb size, but a larger float chamber is necessary to handle 6-lb cans.

The procedure for using Nicholson's hydrometer in the examination of canned solid packs, such as corned meats, meat loaves, processed cheese, puddings, etc., is as follows:

1. Float the hydrometer in a tank and add weights sufficient to submerge it to a mark on the stem.
   Let the weight required be . . . . A grams.
2. Place the unopened can on the upper platform and add weights to submerge the hydrometer to the mark.
   Let the additional weight required be B g. Then the weight of the filled can in air is . . . . . $A - B = C$ g.
3. Place the unopened can on the lower platform and add weights to the upper platform to submerge the hydrometer to the mark.
   Let the weight required be . . . . . D g. Then the weight of the filled can in water is . . . . . $A - D = E$ g, the loss of weight in water is . . . . . $C - E = F$ g. and the volume of the filled can is F ml.
4. Open the can and remove the contents as a block. Repeat steps 2 and 3 with the empty can (including both ends) and calculate its volume, i.e. the actual volume of the tinplate making up the can.
   Let the volume of the empty can be G ml. Now the internal capacity of the can is given by the volume of the filled can less the volume of the empty can, therefore the *internal capacity* is . . $F - G = H$ ml.
5. Repeat steps 2 and 3 with the block of contents and calculate its volume. If free liquid separates from the pack, measure the volume in a measuring cylinder.
   Let the total volume of the contents be . . . . . J ml. Then the *headspace volume* is . . . . . $H - J = K$ ml.
6. From the weight of the block of contents in air and its calculated volume, the *relative density* is obtained. This direct determination of the density of the block as canned is frequently useful, since bubbles or pockets may be present within loaf packs, particularly those not mixed under vacuum.

Solid packs which are less dense than water, for example, butter, margarine, tropical spreads, etc., are examined according to the same procedure but clips are fitted to prevent the block from floating off the lower platform.

Although the use of Nicholson's hydrometer to determine headspace and the density of the pack is restricted to "block" packs, the method is applicable to canned foods in general for the determination of internal capacity, i.e. the difference in volume between the filled, sealed can and the empty can. Adam

and Stanworth (1936-37) describe a flotation balance, designed to measure the internal capacity of cans by a similar procedure.

A typical application of Nicholson's hydrometer is in the selection of a size of can to contain a given weight of a product. It is necessary to avoid overfilling, with danger of subsequent springiness and distortion, and also to avoid an excessive headspace. In a specific case which was investigated, a high proportion of springy cans had been encountered in 12-oz processed cheese packs from certain manufacturers. In the absence of microbial spoilage, tests were made with Nicholson's hydrometer and the results are shown in the table below. It is apparent that the two canners encountering springy cans were using cans that were too small.

(x/16 in.). Remove the contents. Wash, dry, and weigh the can. Fill the can with water at room temperature to a headspace depth of 3/16 in., and weigh. Deduct the weight of the can to obtain the weight of water (A g). Then the approximate internal capacity of the can is A ml. Draw off water from the can until the headspace depth is x/16 in., and again weigh. Deduct the weight of the can to obtain the weight of water (B g). Then $A - B$ ml is the approximate headspace volume and $B/A \times 100$ is the percentage of the total capacity of the container occupied by the contents.

Some approximate relations between headspace depth, headspace volume, and internal capacity in No. 1 Tall and No. 2½ cans, sealed at 15 in. Hg vacuum, are set out in a table on page 30. Boyd and Bock (1952) give a

Examination of Canned Processed Cheese

Canner	Can Size	Condition	Capacity of Can (ml)	Density of Cheese	Volume of 12-oz Block (ml)	Headspace (ml)
A	401 × 115	Springy	321	1.045	325	Nil
B	401 × 114	Springy	310	1.094	311	Nil
C	401 × 201	Flat	331	1.077	316	15
D	401 × 201	Flat	335	1.094	311	14

Care is necessary in the interpretation of the results of examinations of springy cans of this type. The relevant capacity to be determined is the internal capacity of the normal flat can and not that of the distended can. It is important also to note that a significant reduction in internal capacity occurs when a can is sealed. The amount of this reduction is determined by the constructional dimensions of the can, for example, the radius of the flange. Thus the internal capacity of the sealed can should not be taken to be the same as the capacity of the can before sealing.

Approximate Internal Capacity

The South African Bureau of Standards (1951) describes a method, suitable for routine control purposes, for estimating the total volume capacity of a can, as follows:

Cut out the end without damaging the double seam. Measure the headspace depth

formula and tables by means of which the headspace volume can be calculated from the gross headspace depth, in cans having diameters from 202 to 404, at various levels of internal vacuum.

SIGNIFICANCE OF HEADSPACE LIMITS

In good canning practice, both maximum and minimum limits for headspace are observed for a number of reasons.

Control of the Fill of the Can

It is generally accepted as desirable that the consumer should receive a can that is reasonably full. Thus maximum limits for headspace depth have been incorporated in some specifications and standards for canned foods, as a control of the fill of the can. For instance, the United States standards for canned clingstone peaches (U.S. Department of Agriculture 1940) set out maximum head-

space depths for cans of various sizes, for example, 9.9 and 13.6 sixteenths of an inch in No. 2½ and No. 10 cans respectively. For most other canned fruits and vegetables, the United States Standards recommend that the fill of

Headspace Relations in Cans at 15 in. Hg Vacuum

Can Size	Gross Headspace Depth (in.)	Approximate Headspace Volume (ml)	Approximate Internal Capacity (ml)
No. 1 Tall	4/16	14	463
(301 × 411)	5/16	20	457
	6/16	27	450
	7/16	34	443
	8/16	41	436
No. 2½	4/16	37	820
(401 × 411)	5/16	47	810
	6/16	57	800
	7/16	68	789
	8/16	80	777
	9/16	92	765

the can should be not less than 90 per cent. of the total volume capacity of the can, which is another way of saying that the headspace volume should not be greater than 10 per cent. of the capacity of the can. South African Standards include a similar provision (South African Bureau of Standards 1951).

Control of Oxygen Content

Restriction of the amount of headspace is also desirable to reduce the volume of oxygen present in the can. Oxygen accelerates internal corrosion, affects quality adversely, and causes losses of labile nutrients. For example, the effect of headspace on ascorbic acid retention in No. 2½ cans of apple juice, fortified to an initial ascorbic acid content of 26.5 mg per 100 ml and stored six months at room temperature, is illustrated in the table in the next column. The excessive headspaces in sample B were caused by spillage in the closing machine.

Mushing of Contents

Excessive headspace provides opportunity for exaggerated movement of the contents of a can during handling and transport, which may cause mushiness in the product and turbidity in the liquid medium. Dreosti and le Roux (1951) found that the appearance and texture of canned pilchards were greatly influenced by the amount of headspace in the cans.

Hydrogen Reservoir

On the other hand, minimum limits for headspace are recommended for packs which are subject to hydrogen swelling (Adam and Dickinson 1944). The headspace provides a reservoir for hydrogen and so delays swelling. In a No. 2½ can with vacuum 15 in. Hg, 104 ml of hydrogen are required to cause swelling when the headspace is 8/16 in., but only 60 ml when the headspace is 4/16 in.

Steam-flow Vacuum

Headspace control is an important factor in the use of steam-flow closing machines. Within normal limits, the greater the headspace, the greater is the vacuum obtained by steam-flow closure (Peterson 1949).

Processing with Agitation

In the application of rolling or end-over-end agitation to the heating and cooling of canned foods, the amount of headspace influences the extent of turbulence and hence the rate of heat transfer. A minimum gross headspace of 6/16 in. has been recommended by Conley, Kapp, and Schuhmann (1951).

Ascorbic Acid in Canned Apple Juice

Canner	Vacuum (Mean) (in. Hg)	Headspace (Mean) (in.)	Ascorbic Acid Content (Mean) (mg %)
A	19	5/16	21.5
B	14	14/16	5.5

Overfilling

Finally, a reasonable minimum headspace is desirable in most canned foods as a safeguard against overfilling, which may cause springy cans.

In canning practice, therefore, a compromise is sought between upper and lower headspace limits. For instance, in No. 2½ cans, headspaces in the range 6/16-8/16 in. represent good practice; headspaces greater than 9/16 in. are excessive, and headspaces less than 5/16 in. are inadequate.

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ANSWERS TO INQUIRIES

UTILIZATION OF FISH WASTE

What methods for using fish waste would be suitable for Australian conditions?

Quite considerable capital expenditure is required to produce dry fish meal by the conventional methods. Essential equipment includes a factory building, a boiler for steam, a precooker, a screw press, a drum dryer, and bagging equipment. The relatively few fish-meal plants in Australia are run in conjunction with fish markets or fish processing plants, where large quantities of reject fish, fish waste, and offal are obtainable at practically no cost. In South Africa and other countries overseas, fish with high oil content, which are the best for making fish meal, are obtainable in large quantities for about £5 per ton or about one halfpenny per pound. Four tons of raw material yield about one ton of fish meal, which, therefore, contains £20 worth of raw material. To this must be added the costs of handling, preserving, transporting, and processing the raw material, and of selling the meal.

It is doubtful whether it is possible to produce fish meal profitably in Australia at ruling prices, particularly since Australian fish lack the high oil content of many overseas species, for example, pilchards, sardines, and herrings. Australian factories operating fish-meal plants do so to save the cost and trouble of waste disposal. Holding fish or fish offal prior to its manufacture into fish meal adds to costs, but it is practised on some trawlers overseas. The fish are gutted at sea, and the offal is stored separately in ice, provided it is not all required for the fish catches. Experiments have been carried out overseas on the incorporation in the offal of very small concentrations of

formalin and sodium nitrite (one-third oz of the latter in 100 lb of offal) where ice storage is not possible. It is difficult, however, to distribute these preservatives uniformly throughout the material. It has been shown that bacterial decomposition will reduce the protein content of the final fish meal.

In certain overseas countries an acid fish-scrap has been made from fish, fish offal, or fish waste simply by adding sulphuric or formic acid to the minced or ground raw material, which is kept in returnable metal containers lined with bitumen. The digested raw material is distributed in the drums and the product, after being neutralized with lime, is added to foods for poultry, pigs, and other livestock. The success of this method depends on access to cheap raw material which can be handled and processed close to the feeding areas, so that transport costs are kept as low as possible. It has been successful in certain closely settled agricultural areas in Denmark, which are close to the fishing ports, but whether it would prove successful in Australia remains to be seen. The protein content of such a product (not being dried) is, of course, only about one-fourth of that of fish meal.

PRESERVATION OF OYSTERS

What is the procedure for canning oysters?

The usual procedure overseas is as follows:

Washing.—The oysters are thoroughly washed to remove all dirt adhering to the shells.

Steaming.—Steaming opens the shells so that the meats can be easily removed by hand. Steaming is carried out for five minutes at 240°F. In addition, two or three minutes are required to raise the retort to 240°F, and one or two minutes to cool down.

Washing of Shucked Meats.—The shucked meats are washed in fresh water to remove any particles of grit or sand entrapped in the folds, after which they are removed by dip nets and transferred to screen-bottomed metal trays to drain.

Can Filling.—The cans are filled with meats and hot brine to the recommended weights, according to the size of cans. For 8-oz (301 × 209) cans the weights are: four ounces of steamed, washed, and drained oyster meats, and four ounces of hot one per cent. brine or hot strained oyster liquor.

Sealing of Cans.—The cans are sealed immediately after filling. The vacuum obtained depends on the temperature of the added liquid.

Processing.—The cans are placed in the retorts as soon as possible after sealing. Processing times and temperatures used are according to the size of the cans in the pack. Recommended times are: for 8-oz cans filled with hot liquid—20 minutes at 240°F; for 8-oz cans filled cold and sealed under mechanical vacuum—23 minutes at 240°F. In addition, two or three minutes are required to heat the retort to 240°F, and one or two minutes to cool down. This applies to both processes.

Cooling of Cans—The cans may be cooled quickly by the gradual release of steam pressure in the retorts and by a simultaneous, but gradual, intake of cold water and compressed air.

Oysters may be processed in glass jars, but these require more care in handling and transport to avoid breakages. Oyster meats may also be smoked and then canned in oil.

A REVIEW AND DISCUSSION OF

DRIP FORMATION IN MEAT AND FISH

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DRIP IS DEFINED AS THAT PORTION OF THE liquid phase or muscle juice which exudes during or after thawing from the cut surfaces of previously frozen muscles.

In nature and composition, drip closely resembles muscle juice which flows naturally from, or which is easily expressible from, the cut surfaces of unfrozen muscle. Drip may contain less dissolved solids after storage of the muscle at relatively high temperatures in the frozen condition. The chief protein (myogen) of drip may under some conditions differ from that of muscle juice owing to its partial denaturation as shown by aggregation of its particles.

Measurement of Drip

The methods used for the quantitative measurement of drip are natural flow and/or (i) absorption into absorbent paper of the liquid from sections of minced muscle, and (ii) exudation into a medium such as petroleum ether. Varying degrees of pressure have also been applied to the muscle during or after thawing. Similar measurements are frequently made on unfrozen muscle and the differences between these and those on the frozen muscle are expressed as "net" drip.

Factors Influencing Drip

With any selected method used, the factors which influence the extent of drip are:

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Time and Temperature of Holding the Muscle before Freezing.—With some, but not all, combinations of time and temperature, drip losses are lower than those from muscle frozen within a few hours of death.

Rate of Freezing.—This is especially in relation to the time taken for the muscle to pass through the "critical temperature zone" (—1° C to —5° C). In most cases where drip losses have been measured, the amounts are reduced with increasing speed of freezing, but occasional departures from this relationship are recorded.

Time and Temperature in the Frozen State.—Increased drip losses are recorded, especially in fish, with increasing periods of storage at the higher temperatures. Such increases appear to be associated with denaturation of the muscle proteins and an increase in size of ice crystals (in rapidly frozen muscle).

Rate of Thawing.—No definite conclusions can be drawn from the data relating to the influence of the rate of thawing on drip loss from meat, but the evidence shows that with quickly frozen fish, drip losses are increased at the slower rate of thawing which allowed relatively long periods of exposure in the critical zone (—1°C to —5°C).

Storage after Thawing.—The limited data do not allow any conclusions to be drawn regarding the influence of time and temperature of storage, subsequent to freezing and thawing, on subsequent drip losses.

Hydrogen Ion Concentration in the Muscle.—There is clear evidence that the amount of drip from thawed muscle (meat) progressively

decreases as its pH is increased from the acid range (5.3-5.5) to above 6.0, becoming almost negligible at about pH 6.4. This influence of pH is indicated in post-rigor muscles or in muscles in which the pH is artificially adjusted either by depletion of glycogen before death or by the addition of acid and/or alkaline substances to the muscle prior to freezing. Appreciable drip is, however, shown in some fish muscles at pH levels between 6.2 and 6.4.

Osmotic Pressure.—No measurements of osmotic pressure in muscle are recorded in relation to drip losses, but it is shown that in drip-susceptible muscle, drip could be reduced or eliminated by increasing the osmotic pressure in the muscle by the addition of approximately one per cent. of its weight of sodium chloride before freezing, or just before thawing.

Type of Muscle.—Drip varies with different muscles from the same meat carcass or from fish. Apart from the effect of pH, the percentages of fat, water, and connective tissue in the muscle, and the distribution of connective tissue influence the amount of drip.

Species.—There is some evidence that drip is greater from the coarse-textured fish species than from those of finer texture, even when pH values are similar.

Theories Advanced to Account for Drip

The three theories proposed to account for drip losses are: trauma, dehydration, and denaturation. The evidence put forward suggests that drip is due in part to structural changes brought about by the formation of ice and in part to the development of denaturation in the proteins which normally tend to hold the water of the muscle. Denaturation appears to be bound up with dehydration brought about by ice formation.

The histological evidence supporting claims of structural damage to the muscle fibres, particularly to the myofibrils and the sarcolemma, is conflicting and difficult to interpret. There appears to be good evidence, however, that fibre damage is much greater in quickly frozen muscle than under very slow freezing. In the former, ice crystal formation is largely confined to the interior of the muscle fibre. Longitudinal splitting of the fibre occurs and the sarcolemma is ruptured. Cell nuclei and protein material migrate into the interfibre spaces during the thawing of the quickly frozen muscle. A histological structure indistinguishable from that of unfrozen muscle is shown in frozen muscle the temperature of which has been reduced and subsequently raised through the zone of ice crystallization at a rate (thousands of degrees per second) sufficient to produce vitrified muscle, free from ice crystals. A slight deviation from this extremely rapid rate of temperature change results in distorted fibres showing clear evidence of structural damage.

Suggestions for Further Investigations

In this review the authors emphasize the conflicting opinions between different workers concerning the relative influence of different factors on the extent of drip. In some cases it appears that conclusions have been drawn without evidence from experiments statistically designed to take into account the many factors influencing drip losses and the inherent variability of the experimental material.

In outlining a scheme for further investigations, the authors propose the following:

- Standardization of methods for measurement of drip. The method of natural flow from muscle of standard dimensions, thawed for fixed periods at specified temperatures, appears satisfactory for following the changes likely to occur in frozen packaged meat or fish of limited thickness. Where meat is frozen and thawed in large pieces it would be appropriate to apply light pressures to the thawed meat. The adoption of artificial practices, such as the use of minced muscle, absorption of drip into solvents or absorbent materials, and centrifuging, may not give a true indication of naturally occurring drip, but may be useful in throwing light on the changes in water-holding capacity of the muscle.
- A reinvestigation of factors known to influence drip, in conjunction with (*a*) studies of the composition of drip, particularly of freezing and thawing in intact muscle (micro-

dissection and examination of the frozen inter-fibre material present in slowly frozen muscle may indicate whether substances other than pure water pass through the cell wall during freezing; a similar procedure may be possible in thawed muscle); (*b*) examination of frozen and thawed muscle by means of an electron microscope to obtain clearer pictures of changes in the muscle; (*c*) studies of methods for the detection of early stages of denaturation in muscle protein.

- A search for "new" factors influencing drip, for example, the state of "liberation" of water under various conditions of rigor development prior to freezing and during thaw-rigor. (The latter occurs during thawing of muscle frozen before normal post-mortem rigor has taken place.)
- Attempts to reduce drip by raising the pH and/or osmotic pressure within the muscle fibres by means of aqueous solutions of suitable substances introduced through the circulatory system of meat carcasses or pieces.

INVESTIGATIONS SINCE 1947*

Since 1947 further investigations on the problem of drip in meat and in fish have been carried out in various countries.

Up to the end of 1953 only a small proportion of these investigations was sufficiently advanced to warrant publication of the results in scientific journals. A number of papers have, however, appeared dealing with the physiology and biochemistry of muscle immediately preceding death and during the post-mortem period prior to freezing. The earlier investigations on meat were carried out by workers of the Low Temperature Research Station, Cambridge, and later by others from the New Zealand Department of Scientific and Industrial Research and from C.S.I.R.O. These three groups of workers are now cooperating in a broad scheme of investigations on meat freezing problems.

*This section was compiled by the authors after the publication of the earlier portion of this article in the Proceedings of the Eighth International Congress of Refrigeration.

Bendall and Marsh* have shown that the fundamental prerequisite for the appearance of drip on freezing is a low level of adenosine triphosphate (ATP) in the muscle. The disappearance of this substance brings about a release of water from the muscle protein (actomyosin) in unfrozen muscle, resulting in an exudation of muscle juice or "weep" from cut muscle surfaces, particularly when the pH is lower than 5.8. In muscle which has suffered structural damage during freezing, the muscle juice is more easily released in the form of "drip" in amounts dependent on the pH of the muscle. When the muscle is frozen before rigor has developed, there is a marked increase in rate of the disappearance of ATP during thawing, and an increased drip production which is relatively independent of pH.

The problem of drip in fish has been studied by workers of the Torry Research Station of the Department of Scientific and Industrial Research, Great Britain, and by others in the laboratories of the Fisheries Research Board of Canada, the Fish and Wild Life Service of the United States of America, the Ministry of Fisheries in Denmark, and in various institutions in other countries. Studies on the characterization of the proteins of fish muscle have been carried out at the Torry Research Station, the Atlantic Fisheries Experiment Station of Canada, and the University of Liége, Belgium. The "denaturation" of fish muscle proteins in frozen fish and its relationship to drip are also being studied in the first two laboratories and in one of the laboratories of the Fish and Wild Life Service of the United States. The ante- and post-mortem chemistry of fish muscle, with special reference to the glycolytic and contractile systems, especially as affected by freezing, is being studied at the Torry Research Station, Aberdeen.

A good deal of work has been done at the Low Temperature Research Station, Cambridge, on the problem of drip from frozen whale-meat.

*Proceedings of the Eighth International Congress of Refrigeration, London, 1951, pp. 351-4.

The following points have emerged from the investigations being conducted by the Australian, New Zealand, and United Kingdom team of research workers:

- Reliable methods have been devised for the measurement of drip, from both large and small cuts of beef.
- Drip losses from beef muscles, taken from quarters frozen at comparatively rapid rates in a cold air blast, have been found to be only slightly less than those from quarters frozen slowly in accordance with commercial practice.
- It has been found that in any one muscle there is a definite decrease in drip with increase in fat content. It has been postulated that this is due to the fact that the water and muscle-juice contents (which provide a source of drip) decrease as the fat content of the muscle increases.
- It has been confirmed that drip is almost negligible when the muscle pH is 6.3 or higher, and that wide variations in drip are found within the normal range 5.3-5.8.
- There is clear evidence that the differences in muscle pH (in the normal range of 5.3-5.8), in fat content, and in rates of freezing, are insufficient to account for all the variations in drip observed in different muscles from the one carcass and in similar muscles from different carcasses.
- Attempts have been made to confirm the observations made on whale-meat and rabbit muscle at the Low Temperature Research Station, Cambridge. Investigators there had found that muscle frozen pre-rigor drips considerably more than muscle frozen post-rigor. The findings have been confirmed with small pieces of beef muscle and, to some extent, with very light grade carcasses. The latter could be frozen (in cold air blast) before rigor had developed to any extent, but beef quarters of commercial size could not be frozen before the onset of rigor.
- Studies are being made of the effects on drip loss of certain biochemical modifications of the muscle prior to slaughter. The aim is to reduce the severity of the post-mortem changes which may render the meat more susceptible to damage by freezing and to the formation of drip.
- A technique, based on conductivity measurement, is being developed to follow the development of rigor *in situ* and during chilling and freezing.

The chief points so far demonstrated in the drip investigations on fish are:

- Investigations at the Torry Research Station have confirmed that fish muscle frozen rapidly drips less than when frozen slowly.
- Investigations in Denmark have confirmed that the addition of salt (sodium chloride) to fish muscle prior to freezing or just before thawing (in order to raise the osmotic pressure of the muscle) reduces drip.
- At the Torry Research Station drip has been measured by determining the quantity of fluid expressed from thawed fish under pressure. These measurements indicate that the quantity of fluid increases rapidly during the first few months of cold storage at 14° and at —4°F, and thereafter remains fairly constant. It reaches a higher level at the higher temperature.
- In Denmark it has been confirmed that coarse-textured fish muscles drip more than those of finer texture.
- Investigators at the United States Fish and Wild Life Service, Boston, have compared the amount of drip from fillets prepared from the same fish by two different methods. In the first method the fish was rapidly frozen in brine, thawed, then refrozen in fillet form. In the second method the fish was iced and the fillets were prepared and then frozen.

Drip from the first lot was not significantly greater than from the second.

The influence of pH on the susceptibility of fish muscle to drip has not been studied, probably because the level of pH in most fish species is usually between 6.2 and 6.4.

As yet, no clear-cut relationship has been established between the susceptibility of fish muscle to drip and the degree of its denaturation during frozen storage.

NEWS from the Division of Food Preservation and Transport

WORK OF THE ORGANIC CHEMISTRY SECTION

The Organic Chemistry Section, which is housed at the Divisional Headquarters at Homebush, has a staff of three research officers and three technical assistants.

The Section was set up to study, primarily, chemical reactions in processed foodstuffs. The reactions selected for the first series of investigations were those which produce brown colours in dehydrated fruit and vegetables during storage. Browning occurs in many processed foodstuffs, and it is likely that several different types of chemical reaction are involved. In certain cases flavour changes accompany these reactions. In dehydrated foods browning is undesirable, but it is also responsible for the characteristic flavour of coffee, the crust of fresh bread, and roasted nuts and cereals.

Dehydrated fruit was chosen for the initial studies because browning can be readily induced in it. But, since any dehydrated fruit is a very complicated mixture of chemical compounds, it was realized that progress would be more rapid if a study could also be made of model systems containing only a few substances. It was known that sugars, amino acids, and certain carboxylic acids could all be involved in browning reactions. However, owing to inadequate knowledge not only of the browning reaction, but also of the chemical composition of the raw fruits, it was impossible to say which would be the most important model systems for study. It was, therefore, decided to concentrate initially on detecting and identifying the sugars, amino acids, and water-soluble carboxylic acids present in various fruits in the fresh state. Modern chromatographic methods have been used in this work. Apparatus has been installed and techniques developed for the following: paper chromatography for all three of the above types of compounds, chromatography on cellulose and charcoal columns for sugars, and displacement chromatography on ion-exchange columns for both types of acids. Information which has already been obtained about major and minor constituents of fruits has proved interesting in fields besides the main one under investigation.

To permit studies to be made on the browning of dried fruit in the presence and absence of sulphur dioxide (which acts as an inhibitor), freeze-dried purées of blanched fruit have been prepared with the help of the Physics Section at Homebush. Unlike other dried fruit, the freeze-dried purées will keep without sulphur dioxide.

PERSONAL

Dr. H. L. WEBSTER returned to Sydney on March 19, 1954, after an absence of two years and seven months. After taking an honours degree in science at the University of Sydney and spending six months in the Division of Food Preservation and Transport at Homebush, Dr. Webster went overseas on a traineeship financed by the Australian Meat Board.

He entered the University of Cambridge and carried out research at the Low Temperature Research Station, Cambridge. This research, on post-mortem changes in muscle tissue, earned him his Ph.D. degree. Dr. Webster is now a Research Officer at the Brisbane Branch Laboratory of the Division, where he is a member of a team of investigators engaged on fundamental aspects of meat research. Dr. Webster will devote himself to the biochemical and physiological aspects of the research.

Mr. J. H. SCHELTEMA, a graduate of the Agricultural University, Wageningen, Holland, has accepted a temporary post as Research Officer in the Division. Mr. Scheltema is assisting with investigations into the freezing of fruit and vegetables during the absence overseas of Mr. I. J. Tinsley.

Dr. R. N. ROBERTSON, who is in charge of investigations within the Division on plant physiology and the storage of fruit and vegetables, has been elected a Corresponding Member of the American Society of Plant Physiologists. This is an honorary title shared by only 22 plant physiologists.

PUBLICATIONS BY STAFF

WATER RELATIONS OF SALMONELLAE AT 30°C. *J. H. B. Christian and W. J. Scott. Aust. J. Biol. Sci.* **6** *(4): 565-73 (1953).*

Sixteen strains of salmonellae have been grown in various media of known water activity (a_w) at 30°C. The reactions of 15 motile strains were very similar, whereas the single non-motile strain grew more slowly and over a smaller range of a_w's.

For the motile strains aerobic growth occurred in liquid media at a_w's between 0.999 and 0.945. In foods the lower limit for growth was slightly less. Anaerobic rates of growth were only slightly less than the aerobic rate at all a_w's. A large percentage of the cells could form colonies on agar media with a_w's as low as 0.96.

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COMPRESSION OF DEHYDRATED MUTTON SLICES. *A. R. Prater. Aust J. Appl. Sci.* **4** *(4): 603-11 (1953).*

Studies on the compression of dehydrated mutton slices were undertaken to improve the pack by decreasing its volume and by limiting damage during transport. The loose packing density of dehydrated mutton slices (0.2 g/ml) was increased more than threefold by compression. The effects of various compression techniques on the texture of blocks were studied, and a procedure described for the production of firm, compact blocks with good slice size after reconstitution.

In the most satisfactory treatment the meat was precooked, chilled, and sliced approximately 0.10-0.15 in. thick. It was dried at an initial temperature of 155°F, falling to 135°F, then covered with fat at a temperature of 158°F, kept at that temperature for about 15 minutes and, after drainage, pressed in dies at the same temperature, using a pressure of 252 lb/sq. in. and a dwell of 3-5 minutes. Cooling of the blocks in a draught of air at 32°F was carried out to set the fat.

THE DEFINITION AND PREDICTION OF THE OPTIMAL HARVEST TIME OF PEA CANNING CROPS. *L. J. Lynch and R. S. Mitchell. C.S.I.R.O. Bull. No. 273 (1953).*

The maturometer, an instrument used for objective measurement of maturity of peas in the field, designed by L. J. Lynch and R. S. Mitchell of the Division of Food Preservation and Transport, was described in C.S.I.R.O. Bulletin No. 254 (1950), copies of which are available on request.

Crops of canning peas were studied in Tasmania and New South Wales during two successive seasons.

Detailed measurements were made of changes in yield, maturity, and size of peas and in vine weights, and the relation between yield and maturometer values was determined for each size grade at different stages in the development of the crop. Total yield increased with time over the sampling period, but the yield of first-quality peas passed through a maximum when the maturometer value of ungraded peas (maturometer index) was 250 lb.

The rate of change of maturometer index with time was about 20 lb/day, and predictions of the optimal harvest time were made on this basis. Such predictions were reliable to within 1 day when crops were sampled up to 4 days before the harvest time, when the maturometer index was approximately 170 lb.

When yield and maturometer index were determined for small plots of known area within a commercial crop, a relation was found between these factors which permitted useful prediction to be made of crop yield at the optimal harvest time.

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COOL STORAGE OF PEARS. *E. G. Hall and M. T. Sykes (Fruit Officer, Research, of the N.S.W. Department of Agriculture, formerly stationed at C.S.I.R.O., Homebush). N.S.W. Dep. Agric., Div. of Horticulture (1953).*

This pamphlet explains how to store pears successfully. The recommendations deal with the correct stage for picking, storage without delay, rates of cooling, maintenance of a uniform temperature of 29-30°F during the cool storage period, and removal of the fruit at or before the first sign of over-storage.

WATER RELATIONS OF STAPHYLOCOCCUS AUREUS AT 30°C. *W. J. Scott. Aust. J. Biol. Sci. 6 (4): 549-64 (1953).*

Fourteen food-poisoning strains of *Staphylococcus aureus* have been grown in various media of known water activity at 30°C. (Methods used for controlling the availability of water are given in some detail.) Aerobic growth was observed at water activities between 0.999 and 0.86. The rate of growth and the yield of cells were both reduced substantially when the water activity was less than *c.* 0.94. The lower limits for growth in dried meat, dried milk, and dried soup were similar to those in liquid media. Aerobic growth proceeded at slightly lower water activities than anaerobic growth. All cells were capable of forming colonies on agar media with water activities as low as 0.92. The 14 strains proved to be a homogeneous group with similar water requirements.

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BIOELECTRIC EXPERIMENTS AND THE PROPERTIES OF PLANT PROTOPLASM. *A. B. Hope and R. N. Robertson. Aust. J. Sci. 15: 197-203 (1953).*

This paper reviews the various interpretations of the results of bioelectrical experiments and examines their validity.

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SALT UPTAKE BY ROOT TISSUE CYTOPLASM: THE RELATION BETWEEN UPTAKE AND EXTERNAL CONCENTRATION. *By A. B. Hope. Aust. J. Biol. Sci. 6: 396-409 (1953).*

A study of the relation between apparent free space and the external salt concentration.

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THE EXPORT OF BEEF FROM AUSTRALIA. *J. R. Vickery. J. Aust. Inst. Agric. Sci. 19 (4): 222-8 (1953).*

This article describes the changes in the export trade in beef brought about by the war, reviews the prospects for export of chilled beef and frozen packaged cuts, and advocates scientific research to improve frozen beef as at least 60 per cent. of exports are likely to be in the form of frozen quarters even if exports of chilled beef are established again.

PHYSIOLOGY OF GROWTH IN APPLE FRUITS. V. SOLUBLE NITROGEN CONSTITUENTS. *H. S. McKee and Gerda E. Urbach. Aust. J. Biol. Sci. 6: 369-78 (1953).*

This paper reports a qualitative study of the ninhydrin-reacting substances of the Granny Smith apple during its development on the tree. These substances were extracted from the fruit with alcohol, adsorbed on "Zeo-Karb" 215, eluted with ammonia, and identified by paper chromatography. Similar studies were made with leaves and branches. The technique used detected only large changes in concentration. The paper includes a table of amino acids detected at various stages of development of the apple. Among them are two unidentified substances of which the chromatographic behaviour is described. The ninhydrin-reacting compounds present show little variation during development but glutamine, conspicuous in very young and in over-mature apples, disappears at intermediate stages. An increase in the soluble nitrogenous compounds in over-mature apples left on the tree is confirmed qualitatively.

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CHEMISTRY OF BITTERNESS IN ORANGE JUICE. 4. LIMONEXIC ACID. *B. V. Chandler and J. F. Kefford. Aust. J. Sci. 16: 28-9 (1953).*

The name limonexic acid is proposed for a naturally-occurring bitter principle, $C_{25}H_{30}O_{10}$, m.p. 315-316°C, isolated from the seeds and peel of immature Washington Navel oranges, also produced by oxidation of limonin or limonilic acid. The note discusses the structure of the molecule.

Copies of the papers mentioned above are available from the Librarian, Division of Food Preservation and Transport, Private Bag, P.O., Homebush, N.S.W. (Telephone: UM 8431, UM 6782.)

FOOD SCIENCE ABSTRACTS

AN INVESTIGATION ON CONTROL OF MOULD FUNGI ON CORK INSERTS OF CROWN TOPS. *R. M. Brien and W. D. Reid. N.Z. J. Sci. Tech. B* **33**: *393-7 (1952).*

Species of *Penicillium* and *Aspergillus*, and to a lesser extent *Rhizopus nigricans, Cladosporium herbarum,* and *Trichoderma viride* have been responsible for mould growth on composition, gelatin-bonded, cork disks which are inserted in crown tops used for bottled foods or beverages. The ability of the following chemicals applied as dusts to control these moulds was tested: salicylanilide (50 per cent. micronized), "Shirlan W.S." (98 per cent. sodium salicylanilide), "Cetavlon" (80 per cent. cetyl trimethyl ammonium bromide), "Thiram" (tetramethyl-thiuram disulphide, 50 per cent. seed dust and 50 per cent. micronized), "Spergon" (97 per cent. tetrachloro-*p*-benzoquinone), yellow cuprocide (90 per cent. cuprous oxide), copper oxychloride (50 per cent.), and copper carbonate. When applied in amounts of one per cent. dust by weight, micronized "Thiram" and "Spergon" gave complete control; micronized salicylanilide, "Thiram" seed dust, "Cetavlon", and yellow cuprocide greatly decreased the amount of infection; the remaining chemicals were relatively ineffective. All except salicylanilide and "Thiram" proved unsuitable for commercial use. "Thiram" was the more effective, and results of laboratory tests with this substance were confirmed in factory tests; it had no deleterious effect on rabbits and guinea-pigs. To prevent growth of mould on cork disks inserted in crown tops, dusting with 50 per cent. micronized "Thiram" in amounts of 0.25 per cent. is recommended.

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RELATION OF NITROGEN, POTASSIUM, AND MAGNESIUM FERTILIZATION TO SOME FRUIT QUALITIES OF VALENCIA ORANGE. *W. Reuther and P. F. Smith. Proc. Amer. Soc. Hort. Sci.* **59**: *1-12 (1952).*

Heavy applications of nitrogenous fertilizers to Valencia orange trees on acid sandy soil caused a substantial increase in yield of fruit, a slight decrease in size of fruit, a slight decrease in the total soluble solids of the juice and in vitamin C content, and a slight increase of total acids. De-greening of the rind and maturity were delayed. Heavy applications of potassium tended to produce a high proportion of late-maturing, poorly-coloured fruit with thick, coarse-textured rind and a low content of soluble solids. Small amounts of potassium fertilizers gave a high proportion of early-maturing, well-coloured, small fruit with thin, smooth-textured rind, a high content of soluble solids, and low acid content. Amounts of magnesium in fertilizers did not appreciably affect the yield or quality of the fruit.

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A RAPID METHOD FOR THE DETERMINATION OF OIL IN POTATO CHIPS. *K. T. Williams and E. A. McComb. Potato Chipper* **10** *(9): 5-6 (1951). (Abstr. in J. Amer. Oil Chem. Soc.* **28**: *279 (1951).)*

Coarsely-ground potato chips are extracted three times with hot carbon tetrachloride in a sintered glass crucible. The chips are then finely ground and again extracted three times with carbon tetrachloride. The oil is recovered from the extract and weighed. The accuracy is ± 0.5 per cent. An analysis can be completed in 25 minutes.

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BLANCHING BEETS AND CARROTS. *J. Urschel. Food Packer* **33** *(9): 42, 60 (1952).*

To obtain a canned product of good quality, beetroots and carrots should be blanched before they are cut. If the skins are first loosened by high-pressure steam this process should be followed immediately by a hot-water blanch. For most efficient blanching, the beetroots and carrots should be graded into at least two different sizes, and these blanched separately. The paper briefly describes methods of removing chips from diced carrot and beet, and end-slices from sliced beet.
