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The Laboratory Examination of Canned Foods*

II. Routine Microbiological Examinations

By

W. J. Scott†

Introduction

Frequently microbiological examinations of canned foods are made in conjunction with other assessments of quality and of conformity with specifications. At other times the microbiological examination may be the only one required. In the former case the cans selected for the microbiological examination should be additional to those required for other purposes.

The aim of the following notes is to serve as a guide to those charged with the responsibility of making routine examinations of canned foods, to ensure, as far as possible, their freedom from microbial spoilage. It is assumed, therefore, that the products are submitted for examination a few days or weeks after manufacture. The remarks apply only to those foods for which preservation is dependent on a successful heat process.

Sampling

(*a*) *Size of Sample*

The sample should be large enough to give a reasonable chance of detecting abnormalities in the large population of cans from which it is drawn. The sample should be small enough to enable the laboratory to cope with a regular and frequent flow of samples covering a variety of products and a number of manufacturers. The dual nature of these requirements calls for a compromise. It is considered that a sample of nine cans may be acceptable. Of these, three may be examined without incubation, and three should be incubated at each of two temperatures for the detection of mesophilic and thermophilic spoilage. For products such as citrus juice, canned plums, etc., in which thermophilic spoilage has not been recorded, there is little point in providing cans for thermophilic incubation and the sample may be reduced to six.

The sample should be representative of a known population of cans, the identity of which should be preserved at least until the report of the examination is available. It will generally be advantageous to have only one code mark represented in each sample. If these conditions are observed any action requiring further sampling and/or the isolation of the lots concerned will be simplified.

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* For the first article of this series, *vide* The Food Preservation Quarterly, 1953, Volume 13, p. 3.

† C.S.I.R.O., Division of Food Preservation and Transport, Homebush, N.S.W.

(b) *Frequency of Sampling*

The frequency with which samples should be taken for examination obviously depends on many factors such as the product, the quantity manufactured, the manufacturer, and the resources of the laboratory making the examination. It should ensure that, as far as possible, all products receive adequate attention. The schedule adopted may, of course, be varied from time to time to meet changing circumstances.

(c) *History of Samples, and Recording*

All samples should be accompanied by a brief statement giving the origin, manufacturer, product, date of manufacture, and details of the heat process. Some of this information may be available from the code marks, but it is not always indicated. Knowledge of the heat process is often important in assessing the bacteriological results.

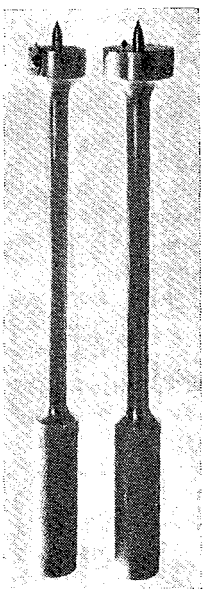

Fig. 1.
Can Opening Instruments
(¼ normal size.)

It is recommended that all cans be permanently marked when received so that each sample and each can may later be identified with certainty. Serial lot numbers, together with numbers for each can within a sample, have proved convenient in this laboratory.

Examination

(a) *Preliminary External Examination*

It is of value to note all code marks on each can as these may be important in decisions regarding the large stocks from which the samples were drawn. The preliminary external examination should also note any signs of leakage and the condition of the can as judged by absence of swelling. From time to time some cans will swell during incubation, and it is often important to be sure that the swelling did not develop earlier. Unless the external condition of the can is noted before incubation it may not be possible to be certain when the swelling occurred.

Incubation.—The purpose of incubation is to provide temperatures favourable for the growth of any living organisms which may be present in the product. Owing to the great variation in temperature requirements of different types of spoilage organisms, it is obviously not feasible to provide ideal temperatures for all types. An acceptable compromise may be to use two temperatures :

(1) 86° F. (30° C.) for most spoilage organisms, and
(2) 122° F. (50° C.) for thermophilic organisms.

The lower temperature is suitable for a great variety of organisms but may be somewhat high for certain yeasts which cause spoilage in acid products.

The duration of incubation should be sufficient for most spoilage organisms to have an opportunity for growth. In some products, for example some cured meats, periods as long as several months may be necessary for all potential spoilage organisms to develop. Such examples

are rare, and it is not feasible to provide for all such possibilities in routine procedures. In general it appears that incubation for one week will permit the detection of almost as much spoilage as incubation for two weeks and, for reasons of convenience, for reducing the time required to obtain results, and for economy in size of incubator requirements, it is probably permissible to choose the shorter period. When experience indicates that it is desirable, incubation for longer periods could be instituted for particular products. Where longer periods are adopted it is convenient to make the periods multiples of seven days.

Accordingly it is recommended that, of the nine cans in a sample, three be held for seven days at each of the following temperatures :

(1) Room temperature.

(2) 86° F.

(3) 122° F.

Cans which are found swelled during the seven-day incubation period may be removed from the incubator and, if necessary, opened immediately. If there is no likelihood of the can bursting it is preferable to open all cans together at the end of the incubation period, as this provides the easiest way for the analyst to compare cans within a sample.

(*b*) *Second External Examination*

Before the cans are opened it is advisable to make another external examination, noting any swelling that may have occurred during incubation. Cans incubated at high temperatures frequently develop some convexity of the can ends due to expansion of the product. It is important, therefore, that the second examination be made when all cans are again at room temperature. As it may take some hours for cans to cool from 122° F. to the temperature of the laboratory it may be found convenient for them to cool overnight.

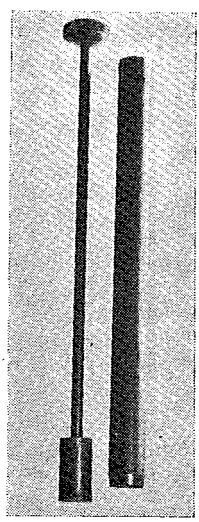

Fig. 2. Sampling Device for Removing Cores from Large Cans of Solid Packs. (¼ normal size.)

(*c*) *Internal Examination*

As far as possible all nine cans in each lot should be examined together.

(i) *Vacuum Determination.*—Although the determination of vacuum in the cans creates certain difficulties when careful sterility tests are to be carried out, it is probably advantageous to make regular determinations of vacuum on all flat cans being examined for freedom from spoilage. All cans should be at the same temperature for comparisons to be valid. As the main purpose is a comparison between cans the ordinary Bourdon type gauge will be sufficiently accurate. Readings for each can should be recorded.

(ii) *Opening Instruments.*—Instruments which do not affect the integrity of the double seams are desirable in case it is desired to make tests for leaks or measurements of the dimensions of seams. Instruments which remove a circular disc of 1–1½ in. diameter are convenient. Openers

of the type shown in Figure 1 have been satisfactory. Cans are preferably opened at the can-maker's end, which usually carries no embossed markings.

Swelled cans should be opened with aseptic precautions. The end to be opened is first sterilized by swabbing with a disinfectant such as mercuric chloride (0·2 per cent. solution) to which a small amount of detergent may be added to aid the wetting of the can. The opening instrument is sterilized in a flame immediately before use, and after removing the disc of metal the opening is immediately covered with a petri dish. Samples of liquid or solid can then be withdrawn with sterile equipment in case cultural tests are needed to establish the identity of spoilage organisms.

(iii) *pH Determination.*—This is an important measurement which it is desirable to take on the contents of all cans. It is recommended that measurements be made with the glass electrode. For products containing liquid, measurements are made on a sample of liquor. Solid products are conveniently reduced to a semi-fluid consistency by mixing with a known proportion of distilled water. Usually an equal weight of water is sufficient. Most types of spoilage lead to a change in pH, lowering of pH being much commoner than raising. In the absence of bacterial growth, incubation at 122° F. commonly leads to a fall of a few tenths of a pH unit. The analyst should be furnished with a table setting out the range of pH values which are normally encountered in unspoiled products.

(iv) *Odour.*—Any abnormal odours associated with the contents of a can should be noted.

(v) *Appearance of Contents.*—Any abnormalities in colour of the product, in general appearance, or in turbidity of the liquid portion should be noted. Turbid brines in vegetable packs are often an indication of bacterial growth.

(vi) *Microscopic Examination.*—Direct microscopic examination of the contents is probably the most important of the various measures for detecting spoilage in canned products. Usually this is done by examining stained smears with a 2 mm. oil-immersion objective with a total magnification of about 1000 diameters. Examination of unstained samples of can liquor is often valuable and may, by revealing motile organisms, prove that organisms in the product are living. The microscopic examination of canned foods is often rendered difficult by large amounts of organic matter which take up the stain and which may tend to obscure bacteria. Another difficulty is that many films are easily washed away during staining. Both these difficulties can be reduced considerably by using thin smears which can be made quite readily by placing a drop of liquid on a clean slide and spreading the film with the aid of another slide, as in the method customarily used for making blood smears. Such smears should be allowed to dry and then fixed by heating in a flame. Smears from meat products may contain a proportion of fat but, provided thin films are made, defatting with solvent is not necessary. Some authorities have proposed that slides be stained according to the procedure for gram staining. It is felt that this procedure confers no substantial benefits as many of the gram-positive spoilage organisms rapidly become gram-negative after growing for a few days.

The use of a simple stain which stains bacteria intensely has proved satisfactory in this laboratory, and it is recommended that Ziehl's carbol fuchsin* be used for routine purposes. Staining for 10 to 30 seconds is adequate with this stain. Others may be equally satisfactory, but it would probably be wise to adopt one stain as a standard until comparative tests show that substitution of another formula would be advantageous.

It is of the greatest importance that the methods used for cleaning slides should be absolutely dependable for removing all traces of the previous preparation. In this laboratory slides are first treated with solvent to remove immersion oil, they are then boiled in water and alkaline detergent and, after rinsing, heated for three to four hours in a mixture of hot concentrated chromic and sulphuric acids. They are rinsed thoroughly in tap water, then in distilled water, and stored in ethanol. Other methods may be equally satisfactory but it is important to make sure that the procedures used are effective. Where the results of the microscopic examination are of critical importance new slides should be used.

While the interpretation of the microscopic picture is a matter of experience, there is usually not much difficulty in detecting products which are frankly spoiled. Often spoiled products will reveal 20 to 100 organisms per microscopic field when stained preparations are examined. Even higher numbers are sometimes encountered. The greatest numbers are usually associated with small organisms and these are almost always non-sporing types. As sporing bacteria are relatively large, the numbers present in under-sterilized spoiled cans are generally less than when the same product is spoiled as a result of can leakage. In some normal products the slides are virtually free from bacteria, and dozens of fields may be searched without finding more than one or two organisms. In other products the normal condition is, for various reasons, associated with greater numbers of bacteria, and the analyst needs to become familiar with the range associated with various unspoiled products. An approximate indication of the results obtained with a number of products in this laboratory is given in Table 1. The results are intended only as a rough guide, but they do show that some products are much more variable in bacterial content than others.

As the commonest cause of spoilage is contamination after processing (through imperfect can seams), the analyst should endeavour to determine whether the microscopic evidence furnishes proof of post-processing contamination. If the product is non-acid and is spoiled by large numbers of cocci or other heat-labile types which can be recognized microscopically, the conclusion of post-processing contamination can safely be drawn. This conclusion can be established beyond all doubt if it can be shown that living non-sporing organisms are present in the product. This may be done by cultural tests or sometimes by the examination of unstained samples of food as mentioned previously. Non-acid foods spoiled as a result of under-sterilization will show bacterial rods, although they are often irregular and variable in morphology. Even though the organisms may produce spores readily in culture, it is the exception, rather than the rule, to find the organisms sporing in the can. Cultures made from cans spoiled as a result of under-sterilization should reveal a pure culture of a sporing organism.

* *Vide* Society of American Bacteriologists' Manual of Methods for Pure Culture Study of Bacteria, Leaflet IV, Staining Methods, October 1951, p. 5.

(vii) *Cultural Tests.*—In most routine examinations these should not be needed to determine whether or not the sample is unspoiled. If, however, one or more cans in the sample are spoiled or suspected of being spoiled, and the cause of spoilage is not otherwise established, cultural tests should be made. The first aim must always be to determine whether the organisms are sporing or non-sporing types. It is important also to inoculate solid media directly with food from the can so that some

TABLE I

Microscopic Examination of Unspoiled Canned Foods

Product	Normal Product Shows on Each Microscopic Field (×1000)		
	None or Few Organisms	A Few Organisms on Most Fields	More than 3 to 4 Organisms in Most Fields
Tomatoes	+	+	
Tomato juice	+	+	+
Citrus juice	+	+	
Carrots	+		
Parsnips	+		
Beetroot	+		
Cabbage	+	+	
Potatoes, diced	+		
Potatoes, whole	+	+	
Baked beans		+	+
Meat and cereal		+	
Meat and vegetable		+	
Meat		+	
Fish	+	+	
Soups	+	+	+

information on the numbers of living organisms will be obtained. Spoiled products commonly yield more than 10^7 or 10^8 organisms per gram and a rough indication of the numbers found is important in assessing the results. Some thermophiles, however, die rapidly and only small numbers of these may be found viable in spoiled cans.

For the simplest type of cultural test it is recommended that three petri dishes be inoculated with approximately 10^{-1}, 10^{-3} and 10^{-5} g. of the spoiled product, that is, one plate with each amount of inoculum. The plates should be poured with brain-heart-infusion agar. At the same time three deep tubes of the same medium should be inoculated at the same three levels. All should be incubated together either at 86° F. or 122° F., or at both temperatures, depending on the conditions under which the spoilage occurred. Examination of these cultures should indicate the approximate numbers of viable organisms present, whether there are several types or only one type, and whether the organisms are sporing or non-sporing, aerobic or anaerobic. Brain-heart-infusion agar is proposed as one suitable for growing a wide variety of aerobic and anaerobic organisms. It is more expensive and somewhat more difficult to prepare than beef-extract—peptone agar, but it has the

merit of being able to support the growth of a much wider range of organisms than the simpler medium.

The following are the ingredients required to make one litre of medium*:

Calf brains	200 g.
Beef heart	250 g.
Gelatin	10 g.
Peptone	10 g.
Dextrose	2 g.
Sodium chloride	5 g.
Disodium hydrogen phosphate	2·5 g.
Agar	10–15 g.

While the " Difco " brand dehydrated medium is satisfactory after solidifying with agar, it is very expensive in Australia: fortunately a suitable medium can be made easily from local ingredients. Brains from other animals may be substituted for calf brains. A standard method of preparing the medium should be used so that its performance will not vary greatly from time to time. " Difco " proteose-peptone is ordinarily used in the above formula, but perfectly satisfactory media could doubtless be prepared from other peptones. The brand selected should be specified in the detailed methods for making the medium.

The above cultural procedures are reduced to a minimum for simplicity. They should, however, furnish some evidence about the nature of the organisms present in the great majority of products. All microbiologists will, however, appreciate the limitations of a single medium and other media will be required in special cases. Some of the lactobacilli which may grow in acid products cannot always be grown successfully on brain-heart-infusion agar. Some anaerobic organisms also grow better on other media, and the above medium is by no means ideal for yeasts although most yeasts do grow on it quite well. Other media may well be introduced for certain products as the need is established.

In making cultural tests it is important that the analyst be able to employ aseptic technique with confidence. It is good experience for analysts to prove the adequacy of their technique by making cultures from cans which are known to be sterile. Careful attention to the proper sterilization of all equipment used in sampling is, of course, essential. As equipment may from time to time become contaminated with unusually heat-resistant spores, adequate sterilizing schedules should be drawn up and rigorously observed. The analyst will be aided materially by experience in growing the different types of micro-organisms encountered in canned foods. Finally the analyst should remember that not all swelled cans are the result of microbial activity.

(*d*) *Examination of Container*

The examination of cans for leaks should not be necessary for routine microbiological examination. There may, however, be occasions when tests for leaks, or measurements of can seams will be useful in confirming

* The recipe is: heat the minced heart and brain in water with peptone and gelatin for 20 minutes. Strain through gauze, discard the meat, and filter the liquid through cotton wool or paper pulp. Dissolve other ingredients, except agar. Adjust the pH to 7·6, and steam for 10 minutes. Check the pH, adjust the volume, and filter again if necessary. Dissolve the agar, bring the pH to approximately 7·4, and sterilize.

bacteriological evidence of leakage. Any methods for assessing the quality of the can as a container are, of course, not under consideration in this statement.

Interpretation of Results

The routine examination of small samples should enable one of three conclusions to be drawn regarding the sample:

(i) The sample is microbiologically satisfactory.

(ii) The sample includes cans which are of doubtful microbiological quality.

(iii) The sample includes cans which are spoiled.

Samples should be satisfactory if they come up to the following standards:

(*a*) All cans remain flat.

(*b*) No low-vacuum cans are detected.

(*c*) Microscopic examination shows that the product in all cans does not carry abnormally high numbers of micro-organisms.

(*d*) The product in all cans is free from abnormalities in odour or appearance.

(*e*) The pH in all cans is uniformly typical of the unspoiled product.

A good deal of emphasis should be placed on uniformity between cans in a sample. Lack of uniformity is a reasonable ground for suspecting either the product or the reliability of the analyst's determinations.

Samples which fail to meet the above standards should be considered doubtful or not acceptable, and further samples should be drawn from the same stocks. It is recommended that repeat samples should contain not less than 24 cans. The type of examination to which the repeat sample is subjected may depend on the type of defect found or suspected in the first sample.

Samples which develop thermophilic spoilage as a result of spores surviving the heat treatment may or may not be acceptable. Products may be acceptable if they have received a heat process which is adequate from a public health aspect, and if conditions of distribution will not lead to development of the thermophilic organisms concerned. Under other conditions of distribution the presence of surviving thermophilic spores may be a basis for rejection. The analyst should report the presence of thermophilic spoilage in the sample giving the number of cans incubated at 122° F. and the number which spoiled within the period designated. Further action, if any, can then be decided by the parties concerned.

Spoilage due to leaky cans should be reported as a fraction of the cans examined.

Spoilage due to under-sterilization, if it develops at 86° F., is a matter for the greatest concern when the product is capable of supporting the growth of *Clostridium botulinum*. Any such spoilage should be reported with the comment that the question of accepting such stocks should await detailed investigation of the cause of the under-sterilization. Stocks in which such under-sterilized cans have been detected should not be approved for consumption until satisfactory evidence shows that the cans had received a heat process adequate to prevent the risk of botulism.

LABORATORY EXAMINATION OF CANNED FOODS

Specimen Report Form No. 2

Bacteriological Report

Product : Manufacturer : Sample No :

No. of Cans ; Can Size : Codes : Date Received :

Process : Equivalent Lethal Value :

Previous History :

Can No.	Special Code	Condition as Received	Incubation		Condition at Opening	Contents			Organisms Cultivated	Seams
			°F.	Days		Abnormalities	pH	Microscopic Examination		

Remarks on Bacteriological Condition :

Conclusion :

Reported by : Checked by : Date :

Form of Report

There are advantages in using a standard form for recording and reporting the results. This aids the analyst in so far as it helps to ensure that some of the relevant observations are not overlooked. It also assists in interpretation, as it facilitates inspection of the results on which the conclusions are based. The standard report form which has been used in this laboratory is shown on page 29.

Table 2

The Relation between the Observed Spoilage in Samples of Various Sizes and the Probable Limits of the True Level of Spoilage in Large Populations of Cans

Number of Cans in Sample	Number of Spoiled Cans in Sample	95% Confidence Limits for True Percentage Spoiled in a Large Population
6	0	0·0 –45·9
12	0	0·0 –26·5
24	0	0·0 –14·3
60	0	0·0 – 6·0
120	0	0·0 – 3·0
240	0	0·0 – 1·5
600	0	0·0 – 0·6
6	1	0·4 –64·1
12	1	0·2 –38·5
24	1	0·1 –21·1
60	1	0·04– 9·6
120	1	0·01– 4·6
240	1	0·00– 2·3
600	1	0·00– 0·9
6	1	0·4 –64·1
12	2	2·1 –48·3
24	4	4·7 –37·4
60	10	9·3 –28·0
120	20	11·1 –24·3
240	40	12·5 –21·9
600	100	13·9 –19·9

Limitations of Small Samples

Until now we have been concerned only with the results obtained in examining samples of canned foods. These results are of value only in so far as they are used to form opinions about the condition of the large populations from which the samples were drawn. To possess maximum usefulness the sample must be a truly random one, representative of the large population. Even when samples are collected without bias there is still a very real limit to the validity of the conclusions which can be drawn about the large population. For instance, if a sample of 24 cans consists entirely of unspoiled cans it does not follow that all cans in the large population are also unspoiled. Table 2 shows that there is one chance in 20 that the large population includes at least 14·3 per cent. of spoiled cans. On 95 occasions out of 100, however, the spoilage should be between 0·0 and 14·3 per cent. Thus there are very considerable limits to the conclusions which can safely be drawn from the examination

of small samples. It is equally true that the examination of samples sufficiently large to permit fairly exact conclusions is not practicable with present methods of examination.

General Considerations

The methods outlined above should be regarded as minimum requirements if the microbiological examinations are to have a reasonable chance of detecting spoilage in the samples examined. More complete methods could have been proposed. Other methods which are even simpler may be equally effective. There is, however, need for some compromise. The methods used should be standardized as much as possible, but at the same time they should not be so perfunctory that the chances of detecting abnormalities are considerably reduced. On the other hand exhaustive cultural tests add greatly to the resources of material and manpower required. As these are both limited, any extension of cultural tests will reduce the number of cans examined. Reduction in the number of cans examined is an equally undesirable alternative.

The methods proposed should not be regarded as having any considerable measure of permanence. They will need to be revised from time to time in the light of experience acquired. New methods of processing, new products, new varieties of crop plants, and even new spoilage organisms are all factors which change the status of a microbiological problem. Methods of examination should be adapted to meet the changing circumstances.

Acknowledgment

The figures in Table 2 were calculated by Mr. G. G. Coote, of the Section of Mathematical Statistics, C.S.I.R.O.

Use of Methyl Bromide in U.S.A.

Methyl bromide has been added to the list of tested and accepted products permitted to be used for fumigation of meat packing plants by the United States Department of Agriculture. Tests carried out by Dow Chemical Company, working in co-operation with the Meat Inspection Division Bureau of Animal Industry, U.S.D.A., have shown that methyl bromide can maintain excellent insect and rodent control in meat packing plants and curing houses without contamination of meat or noticeable effect on odour or taste; moreover, there is no danger of any toxic residue. Such pests as rodents, cockroaches, ham beetles, ham mites, and other vermin are readily controlled.

The gas is said to be toxic to all vermin found in food factories, but to leave meat products quite unaffected. It is stated to be simple and economical in use, and to leave behind no toxic residues. Traces of the gas may be easily expelled by forced ventilation.

—*From "Food Processing", September,* 1952.

The Artificial Colouring of Foodstuffs

By

D. W. GROVER*

" Their tables were stor'd full, to glad the sight
And not so much to feed on as delight."

—Shakespeare, " Pericles ", Act I, Sc. 4.

INTRODUCTION

We have ever leaned heavily upon our sense of sight to assist in the selection of food. Vision is not only more precise and detailed than smell or taste : it is also less easily confused. The association of colours with good or unpleasant foods is obvious, but by no means simple. Vegetables should be green, for this is the colour of freshness ; other foods should not be green, for this is the colour of decay. Bright yellows and reds mean sweetness and maturity in fruit, but danger in insects and reptiles (which have no doubt formed part of our diet during most of our million years of evolution). So we can imagine that through the ages men have come to rely upon colour to distinguish between the good and the bad, the pleasant and the unpleasant ; and to expect certain colours to be found with certain kinds of food. So great has this reliance become that it is extremely difficult to identify flavours of foods deliberately given the wrong colours.

An attractive colour often means more to us than the appetizing flavour it is supposed to imply :

" The appeal of bright colours, symmetry and size is irresistible. The sawdust apple of the Middle West is wonderfully red and round ; the Californian orange may have no flavour and a hide like a crocodile's— but it is a golden lamp ; and the roundness, redness and goldenness are what the buyer first perceives on entering the shop."

—Aldous Huxley, " Beyond the Mexique Bay ", 1934.

I have set out below three well known facts which are the premises of the discussions in this paper ; they and their implications must underlie the necessary legal control of the colouring of food :

(1) The acceptance of food is greatly influenced by colour.

(2) The colour of foods can readily be changed by the addition of dyes.

(3) Dyes may not be demonstrably harmless and some are demonstrably harmful.

By the use of dyes nutritious and wholesome foods lacking the right colours can be made attractive ; and second-rate and uninteresting produce can be given a spurious appeal. The purchaser may be prejudiced by these changes and by the possibly harmful effects of the dyes themselves.

* Food School, Department of Technical Education, East Sydney, N.S.W.

In order to protect the purchaser and consumer against such evils, all civilized countries have laws and regulations to control the use of colour in foods. The remainder of this paper will be concerned with a discussion of the principles which should underlie such regulations. Before embarking on this somewhat controversial task, I should state that the views expressed are entirely personal.

Classification of Foods

It is convenient here, as in other branches of food technology, to draw a distinction between processed and manufactured foods. While there cannot be any rigid separation of these classes, processed foods in general bear a close resemblance to the natural produce from which they are made. Examples are canned fruits, vegetables and meat, also frozen and dried foods. Manufactured foods, for example baked products, confectionery, and ice-cream bear no such resemblance. While the use of dyes in processed foods is usually viewed with suspicion, less objection is taken to the colouring of manufactured foods. This is evident in most food laws and regulations, for example, New South Wales Regulation No. 3, which does not require the declaration of added colour in a wide variety of manufactured foods.

A distinction is similarly drawn between staple and minor foodstuffs. The colouring of bread and the blueing of sugar are viewed with concern, whereas the use of dyes in cakes, icing and confectionery is taken as a matter of course.

The Right Use of Colours

So far we have accepted the fact that the use of colours can be a commercial asset to food manufacturers, and we have seen how it can sometimes be prejudicial to the purchaser and consumer. Can colouring ever be of positive value to the consumer ? To establish that it can, it is necessary to acknowledge the truth that both society and the individual are economically limited. In many cases added colour can be shown to assist in ensuring more effective utilization of food resources. Instead of discussing this in abstract terms, it is more interesting to consider a number of specific cases—not in order to make definite recommendations, but rather to indicate the complexity of the problems involved.

(i) *Bread.*—Bread is a staple food and the quantities eaten probably depend fundamentally much more upon palatability than upon colour. However, public preference now requires that white bread should be very white, and wholemeal and brown breads sufficiently brown. The bleaching of flour for white bread is not part of my story and has, in any case, received ample attention in recent years. The brownness of bread is worthy of some thought. It is possible to imitate the colour of wholemeal bread by the addition of caramel. Uncontrolled freedom to do so would prejudice the consumer, and regulations are enforced to prevent this. In Australia these take the form of a minimum content of whole-wheat flour in such breads. The general regulation prohibiting the addition of colour, including caramel, appears to apply to bread, although it is not usually enforced.

(ii) *Tomato Products.*—The characteristic red colour of tomatoes can be imitated by dyestuffs, enabling products deficient in tomato content, or made from unripe fruit, to look like high-grade products. The use of dyes for this purpose is similar in effect to the use of caramel

in bread deficient in wheat-meal. Here there is less traditional justification for the practice, and synthetic rather than "natural" colour is used. In Australia tomatoes of fair quality are sufficiently plentiful to make the use of dyes unnecessary. The position would be different if supplies were insufficient, and the choice were between not enough good tomato sauce and plenty of an inferior artificially coloured article.

Of the various States of the Commonwealth, only New South Wales prohibits the addition of colour to tomato sauce and related products. The other States require declaration of artificial colouring.

(iii) *Jam.*—Throughout the world, great quantities of jam are artificially coloured. The reasons for this are twofold: (*a*) in some countries there is a chronic shortage of jam fruit, and (*b*) the colour of some jam fruits suffers during processing. The first is particularly true in the United Kingdom, where the Government (and most manufacturers) consider it better to produce sufficient jam with a low fruit content (but requiring added colour) than a small amount of first class fruity jam. As the populace there is obliged to consume large amounts of bread and margarine, the argument is soundly based. The loss of colour during processing is aggravated by the economic necessity to preserve a large part of the fresh fruit crop in order to prolong the jam-making season. In the United Kingdom, where preservation of fruit pulp with sulphur dioxide is common practice, dyes are added to all kinds of jam. In Australia, except in Tasmania, declared addition is permitted in the following kinds: raspberry, plum, and strawberry.

(iv) *Table Margarine.*—Because table margarine is a substitute for butter, manufacturers have attempted to reproduce, as far as possible, all the desirable characteristics of butter—texture, taste, nutritive value, and colour. How far they have succeeded on the first two counts is debatable. It must, however, be conceded that the article produced is sufficiently attractive to have become the most important fatty spread in European and many other countries. The nutritive value can also be made equal to that of summer butter.

There remains the question of colour, concerning which the arguments are economic and political. So long as there is plenty of butter at a price within the means of all, there may be good reasons for discouraging the distribution of a cheaper substitute. These reasons have been very strong in Australia when the dairy industry has had difficulty in finding markets for all its produce.

Nutritionists now take another view of the question. With butter expensive, there is a risk that insufficient of this fat, with its concomitant vitamins, will be used by poorer families. This may be particularly true where butter is most needed—where there are several children. Moreover, butter manufacture is wasteful of the nutritive value of milk. These facts lend support to efforts of margarine manufacturers to produce a reasonably cheap table fat, with the correct texture, nutritive value, and colour. Of the Australian States, only Victoria permits the addition of colour to margarine.

Examples of this kind could be multiplied, but sufficient has been stated to indicate the complexity of the problem, and the need to consider the national economy in any review of the laws relating to colour in food.

Permitted and Prohibited Colours

In addition to regulating the foods to which colour may be added, food authorities also regulate the nature of the dyes which may be used in foods. I do not propose to discuss the individual dyestuffs, but will confine my comments to three aspects :

(1) Is a permitted list or a prohibited list preferable ?

(2) Should a permitted list be long or short ?

(3) How may new colours be added to the permitted list ?

The British Essence Manufacturers' Association has prepared a list of 70 different synthetic colours regularly used in the food industry. These have been listed by W. J. Puregger (1952), Federal President of the Council of Australian Food Technology Associations, in accordance with their acceptability in the Australian States, United Kingdom, United States of America, and New Zealand.

Permitted or Prohibited Lists ?

The United Kingdom Colour Regulations at present differ from those of most countries in having a list of prohibited colours instead of a list of permitted colours. The Food Manufacturers' Federation there favours this state of affairs, arguing that it gives food manufacturers greater freedom, which is helpful in competition overseas. For 50 years the people of the United Kingdom have carried on under this regime, whereas in the United States of America only the colours on a permitted list are used. Nevertheless no differences in the incidence of such maladies as cancer (the most dangerous possible effect of undesirable dyes) can be ascribed to this difference.

Logically the prohibited list is weak. A new dye, not on the prohibited list, could be employed in food. Only if the dye could be proved to be harmful could the manufacturer be penalized for such action. In practice, the risk is not very great. Food manufacturers use only dyes of food grade, in order to be sure that they meet the required standard of purity, especially as regards traces of arsenic and lead. The few manufacturers of food grade dyes would not market a new dyestuff unless tests of its suitability had been made.

The permitted lists suffer from the defect of relative immutability, and consequent discouragement of research. They do, however, at least in principle, give more positive protection to the consumer. That this greater protection is more illusory than real is illustrated by suspicions that have been cast upon certain colours on the United States permitted list, which colours are also permitted in most States of Australia. It has recently been reported that Light Green S.F. (Yellowish), also identified as F.D. & C.* Green No. 2, and in Rowe's Colour Index as No. 670, has caused sarcoma at the site of injection into rats. Two other F.D. & C. colours, namely F.D. & C. Blue No. 1 and F.D. & C. Green No. 3, are so closely allied in molecular structure to Light Green S.F. (Yellowish) that suspicion must also be cast upon them. But it cannot be assumed that parallel effects will follow oral administration to man.

* The initial letters of the United States Food, Drug and Cosmetics Act, 1938.

(i) *Length of Permitted Lists.*—The permitted lists of the Australian States allow the following number of dyes to be used :

New South Wales	38
Queensland	27
South Australia	32
Tasmania	38
Victoria	39
Western Australia	32

The United States of America permits the use of 17 dyes, while in the United Kingdom (which promulgates a prohibited list) no less than 90 dyes are in use. Altogether over 130 different dyestuffs are known to be employed for colouring food. The ideal list, according to the present state of knowledge, would no doubt fall very far short of 130, or even 90, but would probably exceed the 17 on the United States list. While a short list has administrative advantages it must not be forgotten that with a long permitted list of dyes it becomes easier to develop suitable colours for particular foods. Thus technical considerations make necessary a wide selection of dyes, as distinct from colours. Temperature, pH, traces of metals, sulphur dioxide, oxidation-reduction conditions, and light, all cause fading of some dyes, so that it becomes impossible to meet all requirements from a limited permitted list.

(ii) *Changes to Permitted Lists.*—There are two views of the circumstances which justify the addition of a colour to the permitted list. One requires that the colour be proved both harmless and essential ; the other, usually adopted by the manufacturer, requires only that the dye be harmless. This makes a vast difference, because it is usually very difficult for a user to prove that a new colour is essential, particularly before a council which is not very interested in any competitive advantage it may give.

It seems logical to apply only two conditions to the use of colour in a food :

(i) Is it proper to colour the food artificially ?

(ii) Is the proposed colour harmless ?

I have already discussed the obstacles to finding a satisfactory solution to the former question. It is easy to take up a dogmatic attitude either in favour of or against the addition of colour to a particular product. The correct decision requires a measure of statesmanship. Recently in New South Wales fish canners asked for permission to add colour to the local salmon pack. It was claimed that only by so doing could a full public acceptance be obtained for a valuable and nutritious indigenous food. Against this it was argued that by giving both the name and the colour of Pacific Coast Salmon to Australian salmon—which bears no relation to that aristocrat of fishes—the buying public would be deceived.

What is the true answer in this case ? Who knows ? We do know, however, only too well, that one decision has been taken in Victoria and another in New South Wales.

Our opinion as to the harmlessness or otherwise of a dyestuff is, or should be, scientifically based. Dyestuffs may be harmful owing to their intrinsic molecular structure, or owing to intermediates which are not completely removed during manufacture. Aniline, β-naphthol, and β-naphthylamine are toxic intermediates used in dye manufacture, the presence of which (either from incomplete purification or from

partial hydrolysis) could render a dyestuff unacceptable. As these or similar poisonous chemicals enter into the manufacture of all dyestuffs, manufacturers should be told the safe limits of contamination, as they are for the heavy metals.

Assessment of the long term toxicity of chemicals added to food is a formidable task. The task becomes greatly magnified when the chemical is suspected of carcinogenic properties. It takes twenty to thirty years for β-naphthylamine to produce observable effects on man, by which time, of course, irreversible damage has been done. However, rats may be used as test animals, and in this way information is being slowly accumulated. Interpretation of this information in terms of human feeding must always involve an element of doubt. As a result of investigation of its carcinogenic properties, Butter Yellow, an oil-soluble azo-dye, was removed from the United States list in 1936, and experiments are tending to discredit other F.D. & C. dyestuffs.

The Delaney Reports (1951, 1952) do not give any definite guidance, being content to sound a note of warning. In the United Kingdom the Ministry of Food has taken extensive evidence and its report is looked forward to with great interest. Also in the United Kingdom the use of chemicals in food has been the subject of a most informative conference held by the Society of Chemical Industry—Food, Agriculture, and Fine Chemicals Groups (1952). In Australia the Commonwealth Public Health Committee on Food Additives is busy collecting evidence and making recommendations on all aspects of the addition of chemicals in food. This activity is symptomatic of the intense interest in all parts of the world—an interest which should result in a sounder understanding of this complex subject.

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Society of Chemical Industry. Joint Conference of the Food, Agriculture, and Fine Chemicals Groups (1952).—Problems arising from the use of chemicals in food. *Chem. and Ind.* 1952: 72, 114, 178, 238, 259, 342, 345, 384, 456, 484, 487. *Also issued in book form,* 1953.

Food Science Abstracts

The abstracts printed below have been selected from "Food Science Abstracts", and are reproduced with the kind permission of the Controller of Her Majesty's Stationery Office, London.

(1) The Value of Temperatures Close to Freezing on the Storage of Fish. C. H. Castell and W. A. MacCallum. *J. Fish. Res. Bd. Can.*, 1950, **8**: 111–116.

Fillets of cod and haddock, in waxed paper or in waxed cardboard boxes, were stored at 31·5, 33 and 37° F. (−0·3, 0·55 and 3° C.), and in a few tests at 45 and 77° F. (7 and 25° C.). The periods elapsing before the trimethylamine content of the fillets reached the value associated with definite signs of spoilage were, respectively, 11–12 days, 6–8 days, 5–6 days, 2–3 days, and 22–30 hours. Lowering the storage temperature by 5·5° F. from 37 to 31·5° F. (3 to −0·3° C.) thus prolonged the keeping time of the fillets by about as many days as lowering the temperature by 40° F.—from 77 to 37° F. (25 to 3° C.). With fillets of poorer quality which could be kept only for two days at 37° F. (3° C.), and with whole gutted cod fish, the keeping time could also be doubled by decreasing the storage temperature from 37 to 31·5° F. (3 to −0·3° C.).

(2) The Condensation of Water on Refrigerated Surfaces. J. K. Hardy, K. C. Hales and G. Mann. *Dep. sci. industr. Res. Lond., Food Investig. spec. Rep.* No. 54, 1951, 34 pp.

The problem of calculating the rate at which water vapour from a stream of air will condense on a surface has been analyzed previously (see *Rep. Food Investig. Bd. Lond.*, 1937, p. 253), and is briefly summarized in Part I of this report. It is shown that a simple relationship exists between the coefficient of heat transfer from air to a dry surface and the coefficient of mass transfer, when there is condensation on the surface from the air stream. The validity of the analysis was tested by experiments on a single wetted plate and on banks of refrigerated pipes, and the results form the subject of Parts II and III of this report. A range of conditions was covered. In the case of the bank of pipes, measurements of the rate of heat transfer and of resistance to air flow were made with the surface of the pipes dry. This provided the basic data required to analyse the performance when the pipes were wet. Measurements of the rate of condensation of water vapour and of transfer of heat were made in conditions such that the surfaces of the pipes were wet with water. Finally, a general study was made of the frosting of the bank of pipes. The method of analysis, although directed particularly towards the specific problem of the condensation of water in the refrigeration of air, is of wider application, and has been used in solving the problem of protecting aircraft against ice by heating exposed surfaces, and in predicting the rates of evaporation and the temperature in a system with the two components, alcohol and water. It can be used generally in problems involving the transport of matter by diffusion in a stream of gas, and has the merit that measurements of the transfer of heat can provide the basic data. An appendix gives calculations showing the rate of flow of air through a frosted cooler. It also shows how to use the results given in the report to calculate the conditions under which a cooler of given design will be operating 120 hours after starting with clean pipes.

Answers to Inquiries

Discoloration of Peeled Apples and Potatoes

Question : What treatment would you recommend to prevent discoloration of peeled and packaged apples and potatoes ?

Answer : By far the simplest and least expensive method consists in dipping the material in a weak solution of sodium or potassium metabisulphite (0·01–0·05 per cent. by weight) for a few seconds. This method has been used at the Food Preservation Laboratory, Homebush, to prevent potatoes discoloring before drying. Under these circumstances the dipped material has been held only about 24 hours, but this period could undoubtedly be extended. However, trials are advised to establish the best procedure for particular conditions. The metabisulphite solution used for dipping is likely to cause corrosion of iron, so it should be kept in a stainless steel container. As the potato or apple would be cooked ultimately, all or most of the metabisulphite would probably be destroyed in the cooking process.

Useful information will be found in " Pre-peeled Potatoes for Commercial Use ", by R. L. Olsen and R. H. Treadway, issued by the United States Department of Agriculture, Bureau of Agricultural and Industrial Chemistry (No. AIC-246), 1949.

Effect of Sodium Hypochlorite on Tinned Equipment

Question : Does sodium hypochlorite cause rusting of tinned equipment ?

Answer : W. Semple, Dairy Supervisor of the Victorian Department of Agriculture, gave this advice in the October 1952 issue of the Department's Journal : " The development of rust spots on new and re-tinned dairy utensils after using for a few weeks has caused many dairy farmers to question the quality of the tinning. From observations over a period, it has been found that rapid deterioration in the condition of tinning may take place when *cold* sodium hypochlorite solution is used freely as a final sterilizing agent after washing. The consequent slow drying of the cold surfaces of the utensils prolongs the corrosive action of the sodium hypochlorite, adversely affecting the tinning.

To protect the tinning on utensils, they should be washed *immediately* after use in tepid water, followed by the removal of milk fats with a detergent, and finally sterilized with boiling water or steam. The hot utensils will soon dry when placed on a chain wire or piping rack. (Wooden racks retain moisture, and cause rust to develop when utensils come in contact with the wood.)

As the surfaces of utensils can be re-contaminated between milkings, they can be sterilized with sodium hypochlorite solution *immediately before* use, with less damaging effect on the tinning. If sodium hypochlorite solution is not used for sterilizing purposes, and utensils are showing rust spots, washing and sterilizing methods should be checked. Utensils left in a wet condition soon develop rust spots."

News from the Division of Food Preservation

Organization of Research in the Division

The Division of Food Preservation and Transport carries out research on the preservation of all classes of foods except dairy products, dried vine fruits, and cereals. The two former are investigated by other parts of the Commonwealth Scientific and Industrial Research Organization, and research into cereals is mostly in the hands of the State Departments of Agriculture. Investigations on bread are, however, undertaken by the Bread Research Institute, Sydney, New South Wales, an industrial research association which is subsidized by C.S.I.R.O. As its name indicates, the Division of Food Preservation and Transport also undertakes research into the transport of food.

The Division of Food Preservation and Transport has a dual function. On the one hand it aims to discover new principles in the field of food science, that is, to engage in "pure" research. On the other hand it seeks to add to our knowledge of food technology; this is the "applied" side of its activities. A third but subsidiary function should perhaps be mentioned: it is to convey the results of investigations to the food industry. This is done through various publications issued by the Organization, and through lectures, broadcasts and personal contacts.

The twofold nature of the Division's activities is reflected in the titles of the Sections to which its research projects are allocated (Table 1).

Table 1

Sections within the Division of Food Preservation and Transport

Title of Section	Chief Type of Research, and Location	
	Basic	Applied
Physics and Transport	Homebush, N.S.W.	Homebush, N.S.W.
Fruit Storage*	Plant physiology at Sydney and Melbourne Universities.	Technology of fruit storage at Homebush and Gosford, N.S.W.
Biochemistry	Homebush, N.S.W.	——
Organic Chemistry	Homebush, N.S.W.	——
Physical Chemistry	Sydney University.	——
Microbiology	Homebush, N.S.W.	——
Canning and Fruit Products	——	Homebush, N.S.W., and Hobart, Tas.
Freezing of Fruit and Vegetables.*	——	Homebush, N.S.W.
Dried Foods	——	Homebush, N.S.W.
Meat Preservation	Brisbane, Q'ld.	Brisbane, Q'ld., and Auburn, N.S.W.
Fish Preservation	——	Homebush and Eden, N.S.W., and Hobart, Tas.
Egg Preservation	——	Homebush, N.S.W.

* Research in these fields is in co-operation with the New South Wales Department of Agriculture.

It should not be thought that the line of demarcation between the Sections is as fixed as their arrangement in Table 1 suggests. All Sections have their independent tasks, but at the same time their activities interpenetrate both horizontally and vertically. For example, the biochemical group (a " pure " section) has investigated the " applied " problem of the destruction of ascorbic acid in canned fruits and vegetables. On the other hand an active group of organic chemists within the Canning and Fruit Products Section is endeavouring to elucidate the structure of limonin, the bitter principle in oranges. In the same way research in plant physiology goes hand in hand with investigations into the technology of fruit and vegetable storage. Vertical overlapping is also common. The microbiologists are called upon to assist the canners, and the physicists to advise many of their fellow workers on such matters as the measurement and control of temperature and humidity. On occasions such advice can be given only after research, for fresh situations may call for modified or new instruments, or novel techniques.

Future issues of the FOOD PRESERVATION QUARTERLY will contain accounts of research in progress in the various Sections.

PERSONAL

Mr. L. J. Lynch, the Officer-in-Charge of the Canning and Fruit Products Section at Homebush, left Australia on March 19th, 1953, to take up a Research Professorship for six months at the New York Agricultural Experiment Station, Geneva, New York. The invitation to take up the position is a tribute to the work done by Mr. Lynch and his colleagues in developing techniques for predicting the maturity and yield of crops of peas by the Maturometer. The work has excited considerable interest in North America, and Mr. Lynch will test the application of the techniques to pea crops in U.S.A.

After completing his work in North America, Mr. Lynch will visit Europe to discuss research work on canning and to inspect modern canneries.

Mr. R. S. Mitchell, Senior Research Officer of the Canning and Fruit Products Section at Homebush, left Sydney by air on June 17 to assist Mr. Lynch with the investigations on pea crops which will be carried out at Geneva.

PUBLICATIONS BY STAFF

(1) Quantitative and Two-dimensional Paper Chromatography of Organic Acids. By B. T. Overell (1952).—*Aust. J. Sci.*, **15**: 28.

(2) A Toxin in Culture Filtrates of *Sclerotinia sclerotiorum*. By B. T. Overell (1952).—*Aust. J. Sci.* **14**: 197.

Sclerotinia sclerotiorum is a fungus which may cause rots in a wide variety of plant tissues. Such parasites are believed to kill cells of the invaded tissue in advance of their growth by giving out a toxin which diffuses through the host. The fungus was grown on a liquid medium and at various intervals the liquor was filtered free of the fungus through sintered glass and its effects on discs of carrot estimated.

The toxicity of the filtrates was determined by estimating leakage from washed carrot discs, as loss of fresh weight or increase of glucose and organic acids in the surrounding medium. Up to the fourteenth day no toxin could be demonstrated in cultures, but as the culture degenerated its filtrate caused pronounced leakage from the carrot discs. It is

suggested that oxalic acid is the main, if not the only, heat-stable toxin produced in the filtrates by the fungus.

(3) Volatile Products of Apples. III. Identification of Aldehydes and Ketones. By F. E. Huelin (1952).—*Aust. J. Sci. Res.* B **5**: 328.

A systematic study of the volatile substances produced by apples is being made in relation to the problem of superficial scald, a functional disorder of cold-stored fruit. In Part I of the series, methods for identification of the acids and alcohols are described, and Part II deals with the production of volatile esters by Granny Smith apples. Abstracts of these papers were given in the FOOD PRESERVATION QUARTERLY, 1952, Volume 12. Part III describes how the volatile aldehydes and ketones produced by whole Granny Smith apples at 30° C. were identified by paper chromatography and spectral absorption of the dinitrophenylhydrazones, and by conversion of the aldehydes to hydroxamic acids. Acetaldehyde was found to be the major constituent, with smaller amounts of propionaldehyde and acetone.

(4) Effects of Skin Coatings on the Behaviour of Apples in Storage. I. Physiological and General Investigations. By S. A. Trout, E. G. Hall and S. M. Sykes (1953).—*Aust. J. Agric. Res.*, **4**: 57–81.

The term " skin coating ", as used here, refers to a very thin film of wax, oil, or other material artificially applied to the surface of the apple as an addition to, or a replacement for, the natural protective waxy coating.

The effects of skin coatings on the physiological behaviour of apples have been investigated, and a mechanism for the effects has been suggested. Using mainly the variety Granny Smith, the composition of the internal atmosphere, respiration rate, and changes associated with ripening have been studied in both uncoated and coated apples. The effects were found to depend greatly on temperature, thickness and type of coating, and variety and condition of the fruits.

Coating increased the resistance of the skin to gaseous diffusion and thus greatly reduced the internal oxygen concentration, increased the internal carbon dioxide concentration, reduced the respiration rate, and retarded ripening changes by varying degrees. The most spectacular effect on ripening was a marked retardation of normal yellowing of the skin, which is mainly controlled by internal oxygen supply.

Copies of the papers summarized above may be obtained from The Librarian, C.S.I.R.O., Food Preservation Laboratory, Private Mail Bag, Homebush, New South Wales. Telephone UM 8431.

Book Review

Second International Congress on Canned Foods, Paris, October, 1951. Texts of Papers Presented, Summary of Discussions, and Resolutions. (Permanent International Committee on Canned Foods: 25, Rue du General Foy, Paris. 315 pp.)

In 1937 there was held in Paris the First International Congress on Canned Foods. This congress set up a continuing body, the Permanent International Committee on Canned Foods, generally referred to as C.I.P.C., from the initials of its French title—Comité Internationale

Permanent de la Conserve. The activities of C.I.P.C. embrace " everything that can help in promoting scientific, technical and practical knowledge useful to the canned food industry, and everything likely, directly or indirectly, to lead to an increased consumption of canned foods ". Representation on C.I.P.C. is open to " associations or bodies of a private or official character, organized and qualified to represent the canning or allied industries ". At present the active membership appears to be confined to about 10 European countries and Great Britain. American delegates have participated actively in the congresses, but the National Canners' Association has not sought representation in the international organization ; neither has the Australian canning industry.

A second international congress was planned for 1940 ; but war intervened, and it was 1951 before it was possible to organize the second congress, the proceedings of which are recorded in the volume under review. A third congress is projected in 1956.

The Second Congress opened with a session on " Preserved Food and Nutrition ", which comprised a group of papers summarizing present knowledge on the nutritive value of canned foods, and also an account of French work on the comparative digestibility of some canned and fresh foods. A subsequent session discussed the cost and availability of canned foods compared with home-cooked foods. The results of detailed surveys conducted in Belgium, Denmark, Sweden, France and the U.S.A. point to the conclusion that canned foods compare favourably with fresh foods in cost and nutritive value, and more than favourably in convenience of preparation and year-round availability.

Two sessions were devoted to discussions of technical developments in the canning industry throughout the world in the period since the First Congress (1937). Four " product " surveys cover canned fish (M. Jul, F.A.O.), canned meats (J. P. K. van de Steur, Unilever), canned vegetables (J. Durocher and G. Roskis, Institut National de la Conserve), and canned fruits (W. B. Adam, Campden Research Station). These are important summaries—readable, thorough, and well-documented. Advances in canning technology in the period 1937–51 were of two kinds : some were fundamental to the canning process, for example aseptic canning, the attempted use of antibiotics, and the beginnings of non-thermal electronic sterilization ; but most were engineering innovations leading to greater efficiency and higher speeds of production, for example steam-flow closing and continuous pressure-cooking. A most interesting development in continuous pressure-cooking is the Carvallo cooker, which brings to successful commercial application the principle of introducing and removing cans through barometric waterlocks, without the use of pressure valves. Carvallo cookers are stated to be in regular use in France for processing vegetables and fish at 250° F. at rates up to 150 cans per minute.

The product summaries are followed by a series of " geographical " surveys which describe the progress of the canning industry in the period 1937–51 in 14 countries : Algeria, Australia, Belgium, Britain, Denmark, France, Israel, Morocco, Portugal, South Africa, Spain, Sweden, Tunisia and United States. Most of the surveys tell a similar story—the wartime expansion in the canning industry followed by a period of stabilization ; the gradual acquisition of modern, continuous equipment, mainly of American construction or design ; the discovery of the need for quality standards and the setting-up of inspection organizations ; the lack of trained technologists. There is much useful technical information on

specialized canning industries, for example : fish canning in France, Morocco and Portugal ; citrus products in Israel ; and passion fruit in South Africa.

In canning technology, the can is an inseparable part of the preservation process. It was appropriate therefore for this Congress to review developments in tinplate technology and can fabrication over the period 1937–51. This period saw two major revolutions in tinplate manufacture : displacement of hot-rolling by continuous cold reduction in the production of steel base-plate so that now 85 per cent. of tinplate base is cold-rolled ; and the spectacular success of electrolytic tinning which now provides more than 50 per cent. of total tinplate production. Both of these developments contributed to a progressive reduction in the thickness of the tin coatings on tinplate. In 1937, 69,000 tons of tin were required to coat 4,200,000 tons of tinplate ; but in 1950, 5,750,000 tons of plate were coated with only 61,500 tons of tin. The effects on can performance of these changes in practice are ably discussed by Hedges (Tin Research Institute), Lueck and Brighton (American Can Co.) and Jakobsen (Platmanufactur, Sweden). Looking to the future, the experts predict that the significant advances in the next ten years will be these : continuously-annealed base-plate having both ductility and stiffness, unlacquered electro-tinplate with 1 lb. of tin per base box in general use on food cans, and differentially-coated electro-tinplate with a lighter coating on the outside of the can.

Noteworthy among the developments in can-making in the period reviewed are several which were forced on the industry by wartime shortages, but which proved to be substantial improvements on earlier techniques. Thus low-tin solders make stronger side seams than orthodox solders ; synthetic resins in lacquers give better protection than natural resins ; and sealing compounds based on synthetic rubber " are so far superior . . . that there is little chance of ever returning to the use of natural rubber ".

Although appearing late on the programme, it is the " Scientific Section " which supplies the hors d'oeuvres to this feast of technical information. Such delicacies as pâté de foie gras, spice-salted herring tidbits, anchovies and hams are discussed in the session on deliberately non-sterile canned foods. Some valuable original observations are recorded here on the bacteriological and enzymic processes in the salt-curing of fish. Studies on the processing of foie gras indicate that " safe " heat processes affect its quality adversely, so that it normally receives only a pasteurizing process. It should be regarded as a semi-sterile preserve to be plainly labelled " Keep under Refrigeration ". Also in this category are canned hams, for which there is set out a comprehensive scheme of bacteriological analysis.

In conclusion, it is not extravagant to say that this volume presents a stimulating panorama of modern canning technology, which should be made accessible to all canning technologists. It is to be regretted that the binding is very flimsy and the small-type lithoprint rather fatiguing to read ; but the quality of the text will amply make up for a little eyestrain.

J. F. KEFFORD.