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Preliminary Report on the Possible Use of Aluminium Cans for Fruit and Vegetables*

By

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For a number of years past aluminium cans have been used fairly widely—chiefly in Scandinavia and Switzerland—for fish, milk, meat and vegetables, and investigations have been undertaken in those countries, and also in Germany during the late war, to ascertain the suitability of this metal as a container for foods. In considering the various aspects of the case for the use of aluminium in place of tinplate for food cans it is convenient to separate these into two groups, (*a*) the technological considerations of the type of aluminium used and its treatment during fabrication of the cans, and (*b*) the scientific aspects, including chemical and physical problems involved in processing and storage of the filled cans. The subjects contained in the first of these two groups have been the subject of investigation by Aluminium Laboratories Ltd., Banbury, England,‡ and the present article is concerned only with those falling within the second group. Details of the economic aspects of supply, including prices and availability, though of supreme importance, are outside the scope of the present survey.

Chemical Aspects

(*a*) *Internal Corrosion.* One of the chief factors influencing the corrosion of aluminium is the pH of the medium in contact with the metal. Aluminium is rather rapidly corroded under distinctly acid or alkaline conditions, but is reasonably resistant to attack over a range of pH values close to the neutral point. Corrosion is generally very slight between pH 6·2 and 7·2 and additional protection may be obtained within this range, and a measure of protection extended down to at least as far as pH 5·5 if an oxide film is produced on the metal by the process known as anodizing. Still further protection may be obtained by lacquering. Although pH is perhaps the overriding factor in the corrosion by fruit and vegetable products specific accelerators and inhibitors may operate significantly at any pH. There appear to be slight accelerators of corrosion in most fruits, except cherries, which contain inhibitors. On theoretical grounds the soluble red and purple colouring matters of fruit might be expected to form one such group of accelerators, but it is doubtful whether they have a significant effect in practice. Oxalic acid

* Presented on the occasion of Canners' Day, May 3, 1951, organized by the Fruit and Vegetable Preservation Research Station of the University of Bristol, Campden, Glos., England.

† Fruit and Vegetable Preservation Research Station, University of Bristol.

‡ A paper entitled "Considerations in the Manufacture and Surface Finishing of Aluminium Cans for Fruit and Vegetables" was presented at the above Canners' Day by D. W. Taylor of Aluminium Laboratories Ltd., Banbury.

and oxalates, which are present in rhubarb and spinach, are strong accelerators of corrosion of aluminium; the common hydroxy-organic acids—tartaric, citric and malic—appear to be milder accelerators. Chlorides, such as common salt, have a strong corrosive action, particularly in the presence of acid, and may cause pitting of the metal. Sugar seems to be a mild inhibitor.

The rate of production of hydrogen may be no greater in aluminium than in tinplate cans, and may well be less, but the relationship between the volume of hydrogen produced and the amount of metal dissolved is very different in the two cases. In lacquered tinplate cans it is mainly iron that is attacked and, in dissolving, it releases only about one-third of the volume of hydrogen that would have been produced by the dissolution of an equal weight of aluminium. In plain cans it is the tin that tends to dissolve, with production of still less hydrogen and, in certain circumstances, tin may dissolve without formation of any hydrogen at all. When aluminium corrodes the high proportion of hydrogen formed to metal dissolved has one advantage, however, in ensuring that cans which are not hydrogen swells can have very little metallic contamination of their contents.

Plain tinplate corrodes by the action of the electro-chemical couple set up between the tin coating and the steel base-plate, the tin being anodic and dissolving. If an aluminium end is spun on to a tinplate body, or *vice versa*, the aluminium is the anode and tends to be attacked severely, resulting in rapid production of hydrogen swells or of pinholes.

(*b*) *External Corrosion.* Aluminium does not rust like tinplate, but severe external corrosion of cans may occur if they are stored in a damp condition, particularly if they are in contact with another metal, for example, if they are placed on galvanized iron shelves. Surface discoloration may take place during processing, but this may be avoided by the use of a small quantity of sodium silicate in the processing water; alternatively an external lacquer coating may be used.

Physical and Mechanical Aspects

(*a*) *Physical Characteristics of Aluminium Cans.* The drawbacks arising from some of the chemical causes referred to above may eventually be eliminated by the introduction of improved methods of treating the metal or lacquering the cans. Some of the physical disabilities of aluminium may be more difficult to overcome. It has very different properties from those of mild steel from which tinplate is made. It is more easily bent and drawn than mild steel, which is by no means an advantage in the fabrication of the cans, while the soft nature of the metal, its low elastic modulus, and its relatively small range of elasticity make the cans easily dented or distorted. It requires little pressure stress to produce permanent straining or distortion of cans made of this metal. Aluminium has also a much higher coefficient of linear expansion than mild steel so that an A2½ can is about 0·006 in. taller at 160° F. than at room temperature—an important feature when it comes to the setting of a seaming machine. On the other hand aluminium has only about one-third of the density of steel, and this materially reduces the gross weight of any size of can.

(*b*) *Strain Pressures and Distortion of Aluminium Cans.* Two of the main disadvantages of aluminium cans are the low pressure at which the ends flip outwards and the low pressure at which they become permanently distorted. These critical pressures could be raised considerably by using metal of heavier substance, or by varying the treatment in the Keller press, but there seems to be little chance of effecting a significant improvement by altering the composition of the metal. With standard expansion rings, 401 ends of 0·012 thickness of 3S aluminium* show flipping pressures of about 1½ lb. per sq. in. compared with about 4½ lb. for tinplate cans. This low flipping pressure is important when considering the development of hydrogen swells, the aluminium cans becoming unmarketable at much lower pressures of hydrogen. Aluminium cans also " peak " (become permanently distorted by forcing out of the metal of the counter-sink into a sharp peak) much more easily than tinplate cans, the figures being 12½ lb. for aluminium and about 26 lb. for tinplate. To counteract this defect it is necessary *in all cases* to pressure cool aluminium cans which have been processed under pressure, and in most cases (except in squat or flat cans) to process under a " super-pressure " of air and steam. This can be done by retorting the cans in water with an air bell above the retort to control the amount of super-pressure. This device has been used successfully in Norway and might be worth while installing in canneries where aluminium cans have to be used regularly.

(*c*) *Mechanical Problems of Seaming.* All aluminium cans are drawn (or possibly extruded) and have no side seam ; a side seam, at any rate, would be too weak to hold. Its absence is, of course, an advantage when it comes to seaming, but there are a number of disadvantages in the aluminium can to set against it. No attempt will be made here to deal with the setting and maintenance of seams of aluminium cans other than to note that it is customary to use A10 second operation rolls, to have a balance of can and cover hook rather different from that on standard tinplate cans, to keep a closer watch and more frequent check on the seams, and to make sure that the original setting is done with hot cans and hot seaming rolls.

Experimental Data

Experiments at Campden Research Station, initiated in 1950 and still in progress, appear to confirm the fact that aluminium cans are satisfactory containers for vegetables. But for fruits, promising results were obtained only with lacquered cans which had received the " Alocrom " treatment, a process which deposits a phosphate-chromate-fluoride film on the metal to improve lacquer adhesion.

Most of the experimental data available comes from Norway, Denmark and Germany. In the tests on vegetables, using plain cans of untreated aluminium, storage periods of two to three years at normal temperatures have been recorded for peas and asparagus, but carrots, butter beans and French beans have lasted only four to seven months. Anodizing of the plate raised the storage life of these last three by about six months, but did not even then give satisfactory results ; plain anodized cans proved very satisfactory, however, for peas, asparagus and vegetable macedoine and reasonably satisfactory for spinach and leeks. Lacquered cans, with or without anodizing, gave satisfactory results (two to three years' storage) with butter beans, dwarf and runner beans, carrots, parsnips, peas and spinach.

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* An aluminium alloy containing 1·25 per cent. manganese.

In the tests on fruits the results have been generally unsatisfactory though a storage life of two years has been recorded for apple pulp and cherries in tests made in Germany during the late war.

Relative Merits of Aluminium and Tinplate Cans

(1) The deciding factors are, in most cases, the economic ones of prices and availability, and these vary from time to time. The general tendency favours tinplate at the moment.

(2) Aluminium has an advantage over tinplate in not producing a dark sulphur stain with vegetables such as peas, and turnips. The outside of aluminium cans tends to stain during processing unless sodium silicate is added to the processing water, or the cans are lacquered externally. This staining can also take place when the cans are processed in steam, but does not occur if the metal is anodized.

(3) For vegetables lacquered aluminium cans (preferably anodized) appear to give no more trouble from hydrogen swells than lacquered tinplate cans.

(4) Until better methods of protecting aluminium against corrosion are found it is improbable that cans made of this metal will be suitable for acid products, such as fruits.

(5) Aluminium cans are lighter than tinplate cans, but they are more easily dented and peak more readily during processing or cooling.

(6) Traces of aluminium in the contents of the cans are non-toxic and are seldom detectable as a metallic flavour. Tin is also non-toxic in the quantities normally present in canned foods.

(7) There is little difference in the colour and flavour of the products from the two types of cans, though it is possible that the darkening or blue discoloration of some fruits stored for long periods in tinplate may be more unsightly than the bleaching which may occur in aluminium cans.

The experimental work on aluminium cans is still in its early stages and some of the faults—particularly those connected with the physical characteristics of the cans—are very evident. Nevertheless progress in eliminating these drawbacks and effecting a general improvement in these cans may well be made and it is still too early to prophesy whether aluminium cans will compete on their own merits with tinplate cans in the United Kingdom. Even if this goal is reached the final decision as to the use of aluminium cans will rest on questions of price and availability.

Notes on the Influence of Nitrite on the Quality of Canned Cured Meats

By

W. A. Empey

Introduction

In present-day meat canning practices in the manufacture of " cured " products such as corned meat, camp pie and meat loaf, the curing substances such as salt, nitrite and nitrate are very often mixed with small pieces of raw or lightly cooked uncured meat and any other ingredients just prior to canning. Under these conditions the reactions leading to the development of the characteristic " cured " meat colour, odour and flavour take place in the can during the cooking process. In these characteristics, such canned cured meat products closely resemble those produced by using meat which has previously been treated by conventional curing procedures and which does not receive a further addition of curing materials before canning.

On occasions, when examined by the Division of Food Preservation, various commercially canned cured meat products such as meat loaf, ham paste and bacon have been found with one or more of the following abnormalities in colour, odour, flavour, texture and gas production :

Colour : the colour of freshly exposed surfaces, instead of being a normal bright reddish pink was either dull or greyish and in extreme cases reddish brown.

Odour : off-odours in the contents of freshly opened cans were variously described by different observers as being pungent, " metallic " or resembling nitrogen peroxide, in contrast to the agreeable " cured " meat odour of the contents of normal cans.

Flavour : descriptive terms used by different tasters to describe off-flavours were similar to those used to define off-odours.

Texture : in a few instances the texture of the meat loaf was coarser than normal, sometimes showing a " honeycomb " structure on freshly cut surfaces.

Gas production : evidence of gas production in abnormal cans was shown by the presence of " springy " can ends and of low vacua in cans which would normally have slightly concave ends and relatively high vacua.

Most of the cans which showed one or more of these abnormalities were meat-loaf type packs and in some instances it was possible to obtain from the manufacturers the details of their composition, preparation and processing. It was sometimes observed by the manufacturers that a whole batch of 100 pounds or more of the mixed raw materials—meat, wheaten flour (or wheaten flour preparation), water plus salt, nitrite, and/or nitrate would produce abnormal cans, whereas other batches of supposedly similar composition which were processed and pressure-cooked at the same time showed no abnormal cans. Less frequently, only a few cans out of a batch were found to be affected. The trouble occurred also in batches of meat loaf containing all these ingredients with the exception of nitrate.

Under the usual methods for the production of this type of product the meat (in small pieces) and other ingredients were mixed in batches of about 100 pounds weight in various types of mechanically operated mixers, filled into cans and pressure cooked, either after a preliminary heat exhaust or following vacuum-closing without heat exhaust. The cooking times and temperatures varied in different factories but the processes were judged, in each case, to be roughly equivalent to recommended safe processes by National Canners' Association standards.

Other canned products affected had been prepared from various meats cured by conventional procedures, usually involving a preliminary "pumping" or arterial injection of the meat with a solution containing salt, nitrite, and/or nitrate.

The present paper describes investigations, aimed at the elucidation of this problem, carried out at Homebush in 1943.

Experimental

The first step taken was to analyse the contents of normal and abnormal cans of meat loaf produced from different batches of raw material in the same factory and to check the analyses against the composition of the original mixture as shown by the manufacturer's formula. With the exception of concentrations of nitrite which were, in almost all cases, considerably lower than those calculated from the formula, the composition of the canned product agreed closely with that of the various mixtures. The finding of relatively low concentrations of nitrite was not unexpected since it had previously been observed at Homebush that this substance was largely destroyed by pressure-cooking of cured meats during the usual canning processes. However, a comparison between the contents of normal and abnormal cans, showed that nitrite concentrations in the contents were usually higher in the abnormal than in the normal .

In preliminary laboratory experiments in which the effect of various levels of nitrite was tested in prepared canned meat loaf it was shown that all the abnormalities found in commercial packs could be reproduced, and that the development of these abnormalities was independent of the presence of salt, nitrate, flour, and added water in the mixture.

In a series of experiments it was decided, therefore, to make a closer study of the effects on the cans and their contents of variations in the initial concentration of nitrite without altering the ratio of other ingredients of a meat loaf which had the following composition :

Minced lean raw beef	82 per cent.
White wheaten flour	7 per cent.
Water	9 per cent.
Salt	2 per cent.
Sodium nitrite	0-0·4 per cent.

The salt and nitrite were dissolved in the water and thoroughly mixed, in small lots, with the meat and flour. The mixture was then distributed in 16 ounce lots in one pound squat cans (401×211) which were then heat-exhausted or vacuum-closed prior to their final retorting for two hours at 240° F. The processed cans were rapidly cooled in water and their contents reduced to room temperature within approximately four hours of removal from the retort. Examinations of the cans and their contents were carried out on the following day or at varying times up to two months after processing. The following results were obtained by means of physical and chemical examinations of cans and their contents, and by tasting tests carried out by a panel of five or more tasters selected from members of the laboratory staff.

Vacua in Cans. With increasing initial concentrations of nitrite in the mixture the final vacua in cans progressively decreased, although this effect was not significant below sodium nitrite concentrations of approximately 120 p.p.m. (Table 1)

TABLE 1

Influence of Concentration of Sodium Nitrite on Vacua in Canned Meat Loaf

Sodium Nitrite (Parts per Million)	Vacuum (Inches of Mercury)	
	Heat Exhausted	Vacuum Closed
Nil	10	18
115	9	17
450	7	13
1200	0·5	3
4000	+30	+20

Colour of Product. On visual examination the typical desirable reddish-pink colour of cooked cured meat was judged to be fully developed at approximately 25 p.p.m. of sodium nitrite and to remain relatively unchanged until the concentrations reached about 150 p.p.m. With further increase in concentration of nitrite the colour changed through dull reddish-pink to shades of grey and reddish-brown. At nitrite levels of 3000 to 4000 p.p.m. brown fumes developed in the headspace of cans on exposure to air.

As reported by Callow (1936), excessive concentrations of nitrite may cause discoloration of tank pickles and of the surfaces of bacon on exposure to air.

Texture. Abnormalities in texture of the meat loaf could not be detected until sodium nitrite concentrations exceeded 1000 p.p.m.; beyond this level increasing "coarseness" was apparently brought about by the production of gases in the meat loaf. In some cases sufficient gas production had occurred to produce a honeycomb appearance and in extreme cases where sodium nitrite levels of 4000 p.p.m. had been reached there was a significant reduction in density of the meat loaf from 1·07 with low levels of nitrite to 1·02 at the highest level.

Odour. Most observers agreed that a typical and desirable "cured" meat odour was not developed below sodium nitrite concentrations of about 50 p.p.m. At levels in excess of 150 p.p.m. there was increasing development of off-odours resembling nitrogen peroxide. Such off-odours, however, tended to become less pronounced during subsequent storage of unopened cans at atmospheric temperatures and to be replaced by less clearly defined and less unpleasant off-odours.

Flavour. It was generally considered by the tasters that the most desirable " cured " meat flavour was developed when the initial concentrations of sodium nitrite were between 50 and 100 p.p.m. At levels below 50 the flavour was thought to be insufficiently pronounced and at concentrations greater than 150, off-flavours suggestive of nitrogen peroxide were developed. These off-flavours tended to disappear and to be replaced by less clearly defined off-flavours during storage of the unopened cans for one to two months at atmospheric temperatures.

On mixing canned meat loaf of high (400 p.p.m.) and low (30 p.p.m.) initial contents of sodium nitrite, so that the mixture corresponded with one having initially about 100 p.p.m. of sodium nitrite, tasters were unable to detect, in this mixture, the strong off-flavours previously found on tasting the high level nitrite canned material.

Headspace Gases. The distribution of the gases, nitrogen, oxygen, carbon dioxide, combustible fractions, and nitric oxide, found on analyses of the headspaces of a series of cans prepared from the same mixture containing different levels of nitrite, is shown in the following table.

TABLE 2

The Influence of Nitrite on the Composition of Headspace Gases in Canned Meat Loaf

Sodium Nitrite (Parts per Million)		Can Vacua (Inches of Mercury)	Headspace Gases (per Cent.)				
Initial	After Processing		Nitrogen	Oxygen	Carbon Dioxide	Combustibles	Nitric Oxide
4000	500	+20	84	1	2	Nil	13
4000	500	+20	97	Nil	3	,,	Nil
1200	60	Nil	88	7	5	,,	,,
450	25	7	81	16	3	,,	,,
115	11	9·5	79	19	2	,,	,,
Nil	Nil	10	79	19	2	,,	,,

When headspace volumes and pressures (positive or negative) were taken into account together with the percentages of the various gases present in the headspaces, it was apparent that nitrogen had been produced in the cans with initial sodium nitrite contents of 450 p.p.m. and that the amounts of the gas increased progressively with increasing concentrations of nitrite in the meat loaf. It was estimated that the approximate volumes of nitrogen evolved were : 2 mls. in the can with an initial sodium nitrite concentration of 450 p.p.m., 11 mls. in the can with 1200 p.p.m., and 194 and 224 mls. respectively in the two cans which had 4000 p.p.m. In addition, 30 mls. of nitric oxide were found in the first of the latter two cans. The absence of nitric oxide in the second can may have been due to the fact that the examination was carried out about 30 days after processing.

An indication of one possible source of nitrogen was obtained by heating an aqueous solution of one per cent. glycine, one of the known amino-acids of meat, together with sodium nitrite at a concentration of 4000 p.p.m. When 460 mls. of this solution were substituted for meat loaf in a 1 lb. can a considerable amount of nitrogen was evolved.

Disappearance of Nitrite during Processing. Analyses of a number of experimental canned meat loaf packs containing initial concentrations of sodium nitrite from 10 p.p.m. up to 4000 p.p.m. showed that the destruction of nitrite during processing ranged from 100 per cent. at the lowest level down to 80 per cent. at the highest concentration. For any concentration of nitrite there was some variability in the extent of its loss from different batches prepared at different times. For example, the percentage losses occurring in five different lots of meat loaf containing initial sodium nitrite concentrations at 400 p.p.m. were 92, 94, 96, 98, and 99 respectively.

Discussion

The data presented in this paper do not allow the construction of accurate balance sheets to fully account for the disappearance of nitrite during processing of canned cured meat loaf. Only in the cases of colour fixation and of gas production has it been possible to arrive at reasonably accurate estimates of the amount of nitrite used up.

Brooks and others (1940) estimated that 30 parts by weight of sodium nitrite would be sufficient to convert the whole of the blood and muscle pigments (haemoglobin and myoglobin) of approximately one million parts by weight of shin beef muscle into nitroso-haemoglobin and/or nitroso-myoglobin to bring about the full development of the specific colour of cured meat. From this estimate it could be calculated that a mixed meat loaf containing 82 per cent. of beef having a similar concentration of pigment to that of shin beef would require approximately 25 p.p.m. of sodium nitrite to effect colour fixation.

It was considered that the nitrogen developed in some cans may have been derived from a reaction between nitrite and amino-groups in the meat tissue and it was calculated that one gram of sodium nitrite would produce about 325 mls. of nitrogen as the results of such reactions. From an examination of the experimental results it was indicated that the nitrogen formed in canned meat loaf containing initial concentrations of 400 p.p.m. sodium nitrite would account for only about 10 p.p.m. of this substance. At the higher initial levels of 1000 p.p.m. and 4000 p.p.m. sodium nitrite the corresponding figures for conversion into nitrogen were about 70 p.p.m. and 1500 p.p.m. respectively.

Insufficient data were obtained to enable reliable estimates of the amounts of sodium nitrite used up in the production of nitric oxide, but from the limited observations made it would appear that only relatively small amounts of nitrite were concerned in this reaction. Brooks and others (1940), who investigated the action of heat on the nitrite in small samples of minced bacon and in minced pork containing concentrations of sodium nitrite ranging from 8 p.p.m. to 589 p.p.m., reported that the destruction of nitrite during heating for 60 minutes at 100° C. (212° F.) ranged between 40 per cent. and 80 per cent. These workers found that both nitrogen and nitric oxide were evolved during heating of the samples but they did not quote figures for the quantities of gases produced. They considered that nitric oxide was formed by the thermal decomposition of sodium nitrite ($3HNO_2 \rightarrow HNO_3 + 2NO + H_2O$) and suggested that the formation of nitrogen was due to a reaction between nitrite and amino-groups in the tissue. More recently an investigation by Morris (1952) showed that " swells " in canned cured tongues in agar jelly, accompanied by the formation of gases including oxides of nitrogen, had been caused by the use of excessive amounts of nitrite in the pickle used for curing the tongues before canning. Morris quoted Thompson

(1948), whose reference to the production of oxides of nitrogen in canned cured meats was obtained from the results of the present writer's investigations in 1943.

Apart from colour fixation and gas production there is evidence of less clearly defined reactions between the nitrite and constituents of the meat tissues with production of substances imparting characteristic flavours to the canned meat loaf. From experimental observations on bacon and ham Brooks and others (1940) concluded that " while it is not yet possible to be certain, the evidence available points to the conclusion that the characteristic flavour of bacon and ham (as opposed to salt pork) is due to a product of a reaction of nitrite with constituents of the tissue, either during curing or during cooking ". In experiments by these workers samples of minced lean pork, plus salt and sodium nitrite to give a range of concentrations of 0, 10, 50 and 100 p.p.m. of the latter substance, were cooked immediately and tasted. It was found " that samples containing sodium nitrite were preferred, but there was no clear-cut preference for one particular concentration ".

In canned meat loaf containing different initial concentrations of sodium nitrite, and prepared and processed by the methods described in this paper, all tasters in assessing " cured " meat flavour showed a clear-cut preference for the samples produced from mixtures containing between 50 and 100 p.p.m. of sodium nitrite which would be equivalent to between 60 and 120 p.p.m. in the meat component of the mixture. Below this optimum level the intensity of " cured " flavour was too low, whereas at the higher levels unpleasant off-flavours were developed.

It was not possible accurately to define the order and the rates of the various chemical reactions between nitrite and the meat tissues of meat loaf during canning, but the development of " cured " flavour appeared to follow the formation of " cured " colour and to precede those reactions involving the development of off-flavours and the production of gases. It is quite possible, however, that all the reactions involving nitrite may have proceeded simultaneously, but at different rates. It has also been demonstrated that reactions resulting in changes in the odour and flavour of canned meat loaf proceed slowly for some time after canning. A clearer understanding of the nature of the changes taking place in canned cured meat loaf must await a knowledge of the chemical reactions taking place between nitrite and the various fractions of meat, and particularly those which are concerned in the production of substances with specific and distinctive flavours.

Conclusions and Recommendations

On the basis of these studies it has been concluded that the optimum concentration of sodium nitrite to be included in the mixed ingredients for the production of a canned cured meat loaf containing approximately 82 per cent. of previously uncured beef is between 50 and 100 p.p.m. of the mixture. At lower levels of nitrite the " cured " colour and/or flavour may be insufficiently developed, while at higher levels the odour, colour and flavour of the product may be adversely affected and the cans may develop low vacua or positive pressures due to gas production in the can contents.

There appears to be no valid reason why these conclusions could not be applied to any other type of canned cured meat product containing similar proportions of previously uncured meat. Previously cured meats when used for canning present a separate problem because measurements of their nitrite content at the completion of curing cannot be used to arrive at an estimate of the actual amounts of nitrite taken up during curing or as an indication of the suitability of the meat for canning. As shown by Brooks and others (1940), the nitrite content of bacon cured in tank-pickle was considerably less than the amount taken up by the meat from the pickle. Apart from the nitrite used up in colour fixation these authors suggest that some of the nitrite may have been used up in reactions with constituents of the meat tissue during curing and maturation. Under present day meat curing practices where the whole of the nitrite is very often introduced into the meat during an initial " pumping " or arterial injection, the amounts of nitrite used could readily be calculated, but when nitrate is also used there may be some additional nitrite produced by bacterial reduction of portion of the nitrate during the subsequent holding period prior to canning.

It is not known whether the inclusion of excessive quantities of nitrite in meat such as ham, which usually receives relatively mild pasteurization processes in the can, would bring about all the unfavourable changes noted in canned meat loaf and other products receiving recommended safe processes by National Canners' Association standards.

In the application of nitrite to meats which are to be canned, it is recommended that:

(1) The concentrations of nitrite, expressed as sodium nitrite, should be between 60 p.p.m. and 105 p.p.m. (the upper limit permissible under the Pure Foods Acts of the Australian States), or between 74 p.p.m. and 133 p.p.m. when potassium nitrite is used to replace the sodium salt. Under these conditions the approximate quantities of nitrite required for each 100 lb. of lean beef are : sodium nitrite, 1/10th oz. to 1/6th oz., or potassium nitrite, 1/9th oz. to 1/5th oz.

(2) The required amount of nitrite should be dissolved in sufficient water to enable its uniform distribution through the meat. In meat loaf and meat paste mixtures containing cereal the amount of added water is usually sufficient to permit effective mixing with the aid of mechanical mixers. In the case of pre-cooked pieces of meat to be prepared as canned cured products without the addition of cereal and without appreciable amounts of water, even distribution of nitrite could be facilitated by dissolving it in a comparatively small volume of water and spraying the solution amongst the pieces of meat while they are being stirred or agitated.

(3) The amounts of nitrite taken up by meat cured by conventional methods before canning should be restricted to concentrations between 60 p.p.m. and 100 p.p.m. (of sodium nitrite) of the estimated weight of lean muscle tissue, excluding fat and bone. For example, if it is desired to introduce the required quantity of nitrite into hams by pumping or by arterial injection involving the addition of 7 per cent. by weight of a brining solution, it is calculated that this could be done by using a solution containing from 1/10th ounce to 1/6th ounce of sodium nitrite per gallon for treating hams estimated to contain a total content of 25 per cent. of fat plus bone.

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Factors Affecting the Colour of Potato Crisps

By

D. McBean

Difficulty has often been experienced, especially in late winter and early spring, in the production of potato crisps or chips with a satisfactory pale golden-brown colour. Many batches of stored tubers produce chips which are dark brown and unacceptable.

Much information is available on this subject particularly from the Boyce Thompson Institute, where Denny and Thornton (1940, 1941, 1942, 1943) have studied the problem in detail. They showed that there was a direct correlation between the tendency of crisps to darken during cooking and the amount of reducing sugar present in the tubers. Crisps of satisfactory colour could not be produced when the reducing sugar content of potatoes was greater than 0·4 per cent. (fresh weight basis). Although the colour problem could be overcome to some extent by varying the temperature of the fat and length of cooking time, these adjustments usually affected the texture adversely. Crisps prepared from potatoes with high reducing sugar were not fully cooked when their colour was satisfactory ; if the cooking time was extended, the product was too dark to be acceptable.

The extent of darkening was not affected by the amount of non-reducing sugar (sucrose) present in the potatoes.

It has been shown in many laboratories that the low temperature storage of potatoes results in increases in reducing sugar. Small differences in temperature cause large variations in reducing sugar content. In the laboratory of the Division of Food Preservation, Brownell potatoes having 0·28 per cent. reducing sugar on entering storage contained 0·49 and 1·06 per cent. after storage for 30 and 80 days respectively at 41° F. After the same periods at 46·4° F., the reducing sugar contents were 0·29 and 0·32 per cent. respectively. After 80 days at 34° F. the reducing sugar content was as high as 2·25 per cent. From Denny and Thornton's observations, the tubers stored at 34° F. and 41° F. would have been unsuitable for chip manufacture when they came from storage.

Many temperature ranges have been suggested for the storage of potatoes, all between 38° and 50° F. The detailed work of Denny and Thornton and corroborative data from the C.S.I.R.O. laboratory at Homebush suggest the narrow range of 44·5° to 46·5° F. Within this range most varieties of potatoes can be stored for 3-4 months, after which the reducing sugar content would not exceed 0·4 per cent. and sprouting would not be excessive.

If potatoes for crisp manufacture have been held at a temperature below 45° F., which may occur in bulk storage in the southern part of Australia, the accumulated reducing sugar may be removed by placing the tubers at a temperature of 70-75° F. The Brownell potatoes which were stored at 34° F. were desugared at 75° F., and after 3 weeks the reducing sugar content had fallen to 0·4 per cent. Sprouting was apparent after 2 weeks and was slight after 3 weeks. As most potatoes stored in Australia would have reducing sugar contents well below 2·25 per cent., 2 weeks at the elevated temperature should be sufficient to make them suitable for chip manufacture.

The varieties of potatoes used by Denny and Thornton had characteristic increases in reducing sugar content during low temperature storage. They were able to divide the varieties into three groups—low, medium and high reducing sugar producers. Of the better known varieties grown in Australia, on which data were available, Bismarcks fell in the low group, while Brownell, Factor, Sebago and Katahdin fell in the medium range.

Soil conditions and locality showed no important effect on the amount of reducing sugar developed during storage.

The increase in reducing sugar during the low temperature storage of potatoes can be inhibited by suitable concentrations of carbon dioxide in the storage atmosphere. However, this method of control has no marked advantages over the methods outlined above.

References

Denny, F. E., and Thornton, Norwood C. (1940).—Factors for colour in the production of potato chips. Contr. Boyce Thompson Inst. 11 : 291-303.

Denny, F. E., and Thornton, Norwood C. (1941).—Potato varieties : sugar-forming characteristics of tubers in cold storage and suitability for production of potato chips. Contr. Boyce Thompson Inst. 12 : 217-252.

Denny, F. E., and Thornton, Norwood C. (1942).—The third year's results of storage of potato tubers in relation to sugar content and colour of potato chips. Contr. Boyce Thompson Inst. 12 : 405-430.

Denny, F. E., and Thornton, Norwood C. (1943).—The effect of low concentrations of carbon dioxide upon the sugar content of potato tubers in cold stores. Contr. Boyce Thompson Inst. 13 : 73-78.

Answers to Inquiries

NOXIOUS GASES FROM FORK LIFT TRUCKS

Question : What hazards attach to the use in cool stores of fork lift trucks propelled by petrol motors ?

Answer : The exhaust fumes from a petrol motor often contain 9 or 10 per cent. of carbon monoxide, and the figures may rise to 13 per cent. As human beings can tolerate only 50 parts per million of this highly toxic but colourless and odourless gas, the generation of it in an unventilated room or in a confined space is most hazardous. For this reason electric lift trucks are strongly recommended for use in cool stores.

The exhaust fumes may also affect the fruit. Small amounts of ethylene and other unsaturated hydrocarbons tend to ripen apples (and other fruit). It is just possible also that the carbon monoxide will stimulate ripening, though no visible adverse effects are noted with percentages of carbon monoxide less than seven.

It should be added that filters of activated carbon cannot be relied upon to effectively remove either the carbon monoxide or ethylene, notwithstanding claims which are sometimes made.

Food Technology Diploma Course

Reference has already been made in the FOOD PRESERVATION QUARTERLY (Volume 10, page 55) to the two-year Diploma Course in Food Technology at Hawkesbury Agricultural College.

The Principal advises that entries for the first stage of the course should be sent to the Hawkesbury Agricultural College, Richmond, N.S.W., as soon as possible. Full particulars and application forms are obtainable from the College.

Bursaries and scholarships are available as below :

(1) N.S.W. State Government Bursaries—apply to the Principal, Hawkesbury College.

(2) Commonwealth Scholarships—apply to the University Branch Office of the N.S.W. Department of Education, Sydney University.

(3) Matthews Thompson Scholarship—apply to the Principal, Hawkesbury College.

Applications for these should be made at once.

Translations and Bibliographies

The following translations have been prepared by C.S.I.R.O. Copies may be obtained from the Secretary, C.S.I.R.O., 314 Albert Street, East Melbourne, C.2, Victoria. A charge may be made for photocopying.

No. of Translation	Author	Title	Periodical
1429	Chizhov, G.	New data on the origin and growth of ice crystals in water and foodstuffs.	Kholodil'naya Tekhnika. (1950), pp. 61-66.
1476	Kegel, K.	Possibilities of dielectric high-frequency drying in the timber and paper industries.	Das Papier (1950), 4 (21-22) : 405-410.
1486	Schelhorn, M. von.	Investigations into the deterioration of foodstuffs with low water content through osmophilic micro-organisms.	Zeitschrift für Lebensmitteluntersuchung und -forschung (1950),91 (2) : 117-124 ; 91 (3) : 338-342.
1535	Burcik, E.	Relationships between hydration and growth of bacteria and yeasts.	Archiv für Mikrobiologie (1951), 15 (2) : 234-5 (Summary).
1540	Bellon, L.	Fishing and utilization of the sardine of the coastal waters of Malaga (*Sardina pilchardus* Walb.).	Conseil Permanent International pour l'Exploration de la Mer. Rapports et Procès-Verbaux des Réunions. Rapport Atlantique, Copenhague (July 1950), 126 : 3-8.
1555	Ballman, H., and Deuel, D.	Review of the chemistry and physics of pectic substances and discussion of the more recent publications, 1937-46.	Chimia. (1947), 1 (2) : 27-33 ; 1 (3) : 51-56.

News from the Division of Food Preservation and Transport

BRANCH LABORATORIES

The Division of Food Preservation and Transport, which commenced its organizational existence as the section of Food Preservation in 1932 at the Brisbane Abattoir, Queensland, now has work in progress at seven locations in Australia.

The Headquarters of the Division are at the Homebush Abattoir, Sydney, New South Wales, and branch laboratories are located as follows :

Meat Investigations Laboratory, Brisbane Abattoir, Queensland.

Citrus Wastage Research Laboratory, West Gosford (50 miles north of Sydney, New South Wales), operated in conjunction with the New South Wales Department of Agriculture.

Plant Physiology Unit, Botany Department, University of Sydney, operated in conjunction with the University.

Physico-chemical Laboratory, Biochemistry Department, University of Sydney.

Meat Dehydration Laboratory, Auburn, New South Wales.

In addition a Fish Processing laboratory will shortly open at Eden, a fishing port in the South Coast district of New South Wales. Work recently commenced also at the C.S.I.R.O. Tasmanian Regional Laboratory, Hobart, Tasmania. This forms the subject of a note below.

Laboratories at Stowell, Hobart

Plans were prepared as long ago as 1945 for the establishment of laboratories in Tasmania for preservation and processing investigations on fruit, vegetables and fish. Owing to difficulties in obtaining accommodation and trained staff, it was not possible to implement these plans until late in 1951, and then only on a reduced scale.

Suitably equipped laboratories have now been set up at the C.S.I.R.O. Regional Laboratory, Stowell, Hobart, and two officers have been transferred from the Homebush laboratory of the Division of Food Preservation to start the investigations.

Fresh fruit storage investigations have been proceeding in Tasmania for some years, under the direction of Mr. D. Martin of the C.S.I.R.O. Division of Plant Industry. No systematic studies on the processing of fruits and vegetables have, however, been attempted, though there are a number of problems relating to berry fruits and apples which are peculiar to Tasmania and which cannot be studied conveniently elsewhere.

Similar considerations apply to studies on the preservation and processing of fish, for among other advantages Tasmania has relatively large supplies of many types of sea foods.

The work which has now commenced at Hobart is concerned with the canning of fruit and the preservation of fish.

The former is in the hands of Technical Officer R. A. Gallop, whose main work is on the problems associated with the canning of solid pack apples and the production of high grade berry fruit pulps.

The latter is being investigated by Technical Officer K. W. Anderson, who is engaged initially on the preservation of shark flesh: the relationship between the heat breakdown of urea and trimethylamine oxide and the development of particular flavours in canned fish; and the relationship between the post-mortem changes in scallops and the texture of the flesh.

It had been planned to build a large processing and cold storage block adjacent to the Stowell laboratory. The plans for this extension have been completed, but some time may elapse before the building operations can commence. A considerable extension of the activities of the Division of Food Preservation will be possible when these new facilities are available.

RECENT PUBLICATIONS BY THE STAFF

(1) Mechanism of Absorption and Transport of Inorganic Nutrients in Plants. By R. N. Robertson. Ann. Rev. Pl. Physiol. (1951), 2: 1.

This article reviews recent work on a subject which is of considerable importance in biology, and points out lines along which research may develop.

(2) The Physiology of Growth of Apple Fruits.

Investigations on this subject, which were carried out on the Australian variety Granny Smith, will appear in a series of papers under the above title.

(i) Cell Size, Cell Number and Fruit Development. By Joan M. Bain and R. N. Robertson. Aust. J. Sci. Res. B (1951), 4: 75. Fruit size was examined in relation to mean cell size number. It was found that cell division ceased within four weeks of pollination, and that variation in size of fruits at maturity was due mostly to variation in cell number. Cell enlargement continued throughout the life of the fruits on the tree.

(ii) Respiratory and other Metabolic Activities as Functions of Cell Number and Cell Size in Fruit Development. By R. N. Robertson and J. F. Turner. Aust. J. Sci. Res. B (1951), 4: 92. The chemical changes in carbohydrates, organic acids and nitrogen fractions in developing apple fruits have been studied by a number of workers and the relation of these changes to respiration rates has been defined. In this paper an attempt is made to relate the changes to cellular development of the fruit.

(3) Separation of Saturated Mono-hydroxamic Acids by Partition Chromatography on Paper. By Adrienne R. Thompson. Aust. J. Sci. Res. B (1951), 4 : 180.

This paper is concerned with the separation by partition chromatography of the simple saturated hydroxamic acids with a chain length of one to nine carbon atoms. The technique was developed for use in an investigation of volatile substances produced by fresh apples.

(4) Displacement Chromatography on Ion-exchange Columns of the Carboxylic Acids in Plant Tissue Extracts. By F. Bryant and B. T. Overell. Letter to Nature (1951), 167 : 361.

(5) Studies in the Preservation of Shell Eggs. VI. The Effect of Pasteurization on Bacterial Rotting. By M. R. J. Salton, W. J. Scott and J. R. Vickery. Aust. J. Appl. Sci. (1951), 2 : 205.

Notices of previous papers in this series have appeared in the FOOD PRESERVATION QUARTERLY (1950), 10 : 72, and (1951), 11 : 17. The sixth paper deals with the control of rotting by pasteurization. Immersion of shell eggs in water at temperatures between 57·5° and 70·0° C. proved capable of eliminating most of the bacterial rots which would otherwise have developed during storage. At temperatures below 64° to 65° C. virtually complete control of rotting may be obtained by periods of immersion less than the limits imposed by coagulation. Above 65° C., however, complete control of rotting cannot generally be achieved without some coagulation of the white.

(6) Studies of Bacterial Cell Walls. I. Electron-microscopical Observations on Heated Bacteria. By M. R. J. Salton and R. W. Horne. Biochim. Biophys. Acta (1951), 7 : 19.

(7) A Cycle Recorder. By M. B. Smith and J. H. Lipscombe. J. Sci. Instrum. (1951), 28 : 4.

During an investigation of the performance of a number of thermostatically controlled cool storage rooms it was found necessary to obtain a record of the times during which the rooms were being cooled. The recorder devised marks a strip of prepared paper when the motorized valves controlling the brine flow to the rooms are open.

(8) Cooling of Cans. By E. W. Hicks. Letter to Food Tech. (1951), 5 : 262.

(9) On the Evaluation of Canning Processes. By E. W. Hicks. Food Tech. (1951), 5 : 134.

CORRECTION

In the note on Food Technology in India (F.P.Q., Vol. 11 (2), p. 26), the name of the Mysore mansion which houses the Central Food Technological Research Institute of the Indian C.S.I.R. was spelt incorrectly. The correct name is *Cheluvamba* Mansion.