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Food Quality Control—Past, Present and Future

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PART 1

This paper is largely concerned with matters in some way associated with the duties of the chief chemist in the food factory, but it should be appreciated that in practice the term quality control has different meanings according to the particular organisation involved. In some cases, quality control refers to a few on-the-spot tests made on the factory floor or adjacent to it, *e.g.* the lactometer and resazurin tests at the dairy, the determination of moisture by rapid drying or electrical meters in the biscuit trade or in the warehouse, or soluble solids control by total-reflection refractometer in the preserves factory. On the other hand, there may be a block of laboratories dealing, not only with control as such, but also with longer term activities associated with production control in general, such as product development or pure and applied research.

In the U.S.A. in particular, the term "Quality Control" has perhaps a more glamorous ring—the term being commonly used in advertisements—much more than over here. From a study of the U.S. textbook of Kramer and Twigg[1] one infers that quality control may be associated with the majority of the functions of the whole factory organisation. The following list appears to cover what is meant by the subject:—

Inspection of supplies and materials.
Inspection of raw products.
Scheduling of operations.
Measurement of production efficiency.
Measurement of equipment efficiency.
Inspection of the finished product.
Warehousing controls.
Shipping and storage controls.

Preparation of specifications and procedures in written handbook form.
Preparation of statistical procedures and schedules.
Sanitation inspections.
Conformance with local and federal regulations.
Waste disposal control.
Basis for pricing policy.
Basis for inventory policy.
Basis for budget policy.
Basis for evaluating individual personal performance.

This may be the future here, but taking the average large factory in the U.K., the organisation of Quality Control revolves round the following sequence of operations:—

Agricultural control.

Examination of raw materials entering the factory (often partly processed).

Process control (often preceded by trials on the raw material and examination of the product, and including storage characteristics not only in the warehouse and at wholesalers, but in the retailer's premises also).

Apart from these routine activities the chemist is also involved in development work, testing of new formulations, the training of personnel and trouble shooting. Reporting and decision-making functions are, of course, all important.

It should perhaps be added that engineers in food factories have been heard to say, "All laboratory control is unnecessary—statistics prove it"; but they may not realise that most, if not all, factories would in that event be relying on their suppliers sending them consistent raw materials, which would have to be controlled by tests somewhere along the line.

Let us next turn to a few basic definitions:—

Firstly, the term *Quality*, which can best be considered as the product of various attributes, including nutritional value, purity, appearance, taste, odour and consistency. It must be thought of as their product rather than their sum, because if any one of these attributes is low the general quality is low.

Secondly, *Quality Control* means, in spite of raw material variability due to its being of biological origin, a system which standardises the process at each stage of production.

Thirdly, the *Purpose of Quality Control* is the production of standardised products that do not vary significantly. Although this may ensure that overweight and super quality goods are not sent out, it equally ensures that the customer does not receive sub-standard products either.

THE HISTORICAL BACKGROUND OF QUALITY CONTROL

If we go back to the middle of the last century we find the Lancet Sanitary Commission and Government Select Committees damning the manufacturers for various frauds and malpractices. Even then, some manufacturers did present helpful evidence, and in some cases it is apparent that the offences were more concerned with ignorance than with deliberate deceit. On the whole, however, it appears that relationships between manufacturers and the authorities were far from friendly. Further, when the first manufacturers set up laboratories of their own, the main purpose was to ensure that products complied with legal requirements.

It was during the period between the wars that most food manufacturers established scientific organisations, which in most cases were soon expected to participate more positively in the production. The pioneer chemists who entered the food factories, however, had firstly to obtain the co-operation of the experienced personnel on the floor—a problem that is not unknown even today. They found what Bassett[2] has called a "rule-of-thumb regime", and the scientist had to study the physical and chemical changes which occurred in the processes, put formulae onto paper and attempt to standardise procedures. In addition, tests were worked out so that composition in particular fell between specified limits both during and after the process. On the occasion of the Pure Food Centenary in 1960, Hughes[3] aptly summarised what occurred as adding the "know-why" to the "know-how".

As time went on, some of the larger firms set up, in addition to control systems, departments dealing with product development and others carrying out pure or at least "less-applied" research. This required the study of various sciences, in particular the various branches of chemistry (including biochemistry), and the biological sciences (including microbiology). Gradually more sophisticated techniques for the examination of materials were developed and statistical methods for interpreting results were increasingly employed—notably for sampling procedures, the specification of buyer's and vendor's risk and for the visual representation of variations between specified limits on quality control charts.

AGRICULTURAL CONTROL

Nowadays the quality control of some foods begins at the farm. The idea of selecting the best variety of wheat for bread and the fruits to use for jam-making, canning and freezing has been in vogue for many decades. Varieties which become prone to disease are replaced by others. Also, with vegetables for canning, it is a common practice to grow a contract crop with the factory either supplying the seed or specifying the necessary variety, etc. From basic knowledge we know that respiratory activity (as measured by rate of carbon dioxide production) falls off slightly after picking, then rises up to the mature (climacteric) stage and then falls away again as the fruit or vegetable gets

over-ripe. Concomitant changes occur in the acidity and pectin, and, with apples, bananas and potatoes particularly, there is inter-conversion of starch and sugars, which are affected by the temperature and composition of the storage atmosphere. From such information one tries to pick just prior to maturity. Then, in jam manufacture, the boiling encourages the conversion of the remaining protopectin to the soluble, more-effective pectin to give the best "set". Somewhat similarly, if fully ripe fruit is picked for canning, the heat processing tends to soften it unduly and breakdown is likely. Slightly harder under-ripe fruit on the other hand tends to give a firmer, more desirable final product.

More recently there has been a greater interest taken in rapid growth and standardisation of poultry and animal carcases. With pigs in particular the factory demands supplies of animals with a high lean to fat ratio. This is ensured by specifying that the pigs selected fall within certain weight limits. In turn research into breed selection and feeding produces such an animal within as short a time as possible.

RAW MATERIALS

Strictly speaking, the term "raw materials" means anything bought by the manufacturer for direct or indirect use in food production. Apart from food materials and water, therefore, the quality control chemist may be required to examine such things as bottles, cans and flexible packaging materials, fuel and lubricating oils, paints, detergents and so on. Particularly if the material is to come from new sources of supply, a small buying sample is examined to see it has the desired composition and properties. Then the first delivery ordered and every subsequent one should correspond with that sample. With raw fruits and vegetables a certain percentage of defective units, worked out on a statistical basis, is laid down in specifications.[1] The material delivered should then be "up to sample" and the receiver has some protection here under the Sale of Goods Act. In practice, a decision is made for every material as to whether it is to be accepted or rejected, held pending further discussions or blended with other materials.

In some ways, the examination of raw materials resembles that performed by the Public Analyst. Materials are checked for identity and compliance with (a) standards of minimum quality and (b) limits of impurities. Specifications, either written down or implied, may require regular checks in order to standardise size, colour, clarity, flavour, particle size and aroma, together with factors which affect the palatability and general acceptability for the purpose intended.

One of the best examples is, perhaps, gelatine, which is an expensive processing aid that varies considerably in properties and is submitted to a fairly intensive examination. It is checked for ash, arsenic, copper, lead, zinc and sulphur dioxide as required by statutory regulations and is frequently submitted to a microbiological examination. Several other requirements must also be complied with, *e.g.*:—

a. *iron*, because of its effects on the colour.

b. *pH*, which is important in relation to settling and viscosity.

c. *colour and clarity*, which is important with table jellies from the visual acceptance angle.

d. *jelly strength*, measured quantitatively at the pH of the final product (rather than by use of the semi-quantitative, statutory test).

Flavour, odour and sediment are also of interest and whether the gelatine has suitable properties for the intended product. Also a high ash and calcium content suggest that calcium tartrate may be formed on adding water to jelly crystals made up with tartaric acid, but this should in any case be revealed when a trial batch is made into the final sweet.

Other raw materials of interest are colours. As delivered, these often contain blends of up to 5 or 6 different permitted colours. Apart from identity and purity however it is necessary to control the tinctorial power in view of the importance of standardising the appearance of the product. It is usual, therefore, to prepare from the first delivery a standard graph relating the optical density at the wavelength of maximum absorption against concentration. Subsequent deliveries are then made up at, say, 2 mg per 100 ml and the absorption is compared with the graph so that the tinctorial power can be expressed as a "percentage of the standard colour," *i.e.*, against the first delivery. If necessary the weight of dye used per batch can then be adjusted to standardise the colour in the final product.

Oils and fats arriving at the factory are examined for their present condition and keeping properties. At the National College of Food Technology it has been found that interpretation of rancidity values is a particularly difficult problem. Certainly, the free acid almost invariably increases logarithmically during storage and it should therefore be possible to apply limits of acceptability based on acid values, even if the determination is performed on fats extracted from foods of complex composition such as meat. On the other hand, the Kreis test not only seems to give figures which vary considerably from one sample to the next, but fresh samples often give a fairly strong reaction, which implies incipient rancidity.

Peroxide values usually rise after the induction period, but sometimes fall again when the sample is stored further. This phenomenon can possibly be explained as being due to secondary reactions predominating in the later stages of spoilage, but it is obviously difficult to apply limiting values if very spoiled samples give figures close to zero.

In studying rancidity problems it may be advantageous to determine the thiobarbituric acid value. If determined by the Tarladgis distillation procedure,[4] the rancidity of non-extractable lipids is also measured. For this test, the TBA reagent is added to an aliquot of the distillate obtained from the acidified food. As the lipids oxidise during storage the red pigment formed

with 2-thiobarbituric acid increases; the colour is measured at 538 mμ and expressed as malonaldehyde. The standard graph is prepared from 1:1:3:3-tetraethoxypropane which gives malonaldehyde on acid hydrolysis. The method has been applied to flesh and dairy products, and, although values may also fall after rising in spoiled samples, the distillation technique appears to give better reproducibility from the analytical point of view than the titrimetric methods of determining the peroxide value.

Apart from the present state of the oil or fat delivered we may be interested in predicting the stability during storage. The rate of rancidity formation can readily be accelerated by holding the fat at a temperature between, say, 63° and 70°C. Most of these methods measure the rise in peroxide value, but Ivanov has shown[5] that the refractive index change during spoilage is equally satisfactory.

In the best known Swift method, the fat is held at 98°C and air is bubbled in so that with lard the peroxide value reached in one hour corresponds to that which would be reached in one month's storage at room temperature.[6] The oxygen absorption method involves heating the fat at 80°C in a flask connected to a manometer which indicates the drop in pressure due to oxygen absorption. Unfortunately the results from stability tests on the raw material do not always give an accurate reflection of the course of rancidity in the final baked product. Steele,[7] however, studied the problem from a more theoretical angle and reported firstly that a simple relationship existed between the log of the induction period and the reciprocal of the absolute temperature and secondly that this applied to both fat and biscuit.

Flour is blended from grain obtained from various parts of the world and different properties are demanded according to whether it is required for bread, cake or biscuits. Further the grain has to be conditioned to a pre-arranged moisture content to render it suitable for milling—thus home wheats are often dried and imported ones may have to be wetted. Industrially, the moisture content of flour is normally checked by rapid methods such as moisture meters or Carter–Simon ovens.[8] For protein, special analyzers based on colorimetric dye-binding reactions are available. At the mill also, grading is quickly assessed by the Pekar test, which confirms that the colour of the flour pressed between glass plates matches the type sample of the corresponding extraction rate. Doubtful samples may be examined by the Kent–Jones and Martin flour grader,[9] which measures photoelectrically the colour of a paste made from the flour.

For breadmaking, the maltose figure (the maltose present after incubation) should be reasonably high for sufficient gas production. Also the water-absorption can be measured so that the amount of water required to produce a dough of correct consistency during fermentation can be assessed.

Various instruments have been devised to assess the properties of the hydrated gluten. The Farinograph records graphically the resistance of the dough to mixing, and the Extensograph measures the resistance to stretching,

which is in turn related to viscosity and elasticity. Such instruments are essentially empirical in nature, but the graphs and values produced are characteristic of the flour's strength and indicate suitability for the purpose intended.

With meat, consumer studies have shown that tenderness is the most important palatability factor in acceptance, especially with beef. In turn this depends on ante-mortem factors such as feeding and resting of the animal before slaughter, and, post-mortem, on the degree of conversion of tough collagen to softer gelatine during conditioning and cooking. Tenderness can be assessed by measuring the force required to shear through it, but unfortunately the values obtained on the raw meat do not correlate well with the tenderness of the cooked material.

The principal difficulty with raw material standardisation results from variability due to biological origin. Nowadays, however, certain prepared materials are available which not only are controlled by the manufacturers, but tend to be "cleaner" than the natural materials. In particular crude herbs and spices tend to show widely differing composition and require storing as the whole spice, because of the more rapid loss of volatile oil after grinding. They also have a high bacteriological count. Solid extracts which are ready for use, standardised in composition and virtually sterile are therefore becoming increasingly popular.[10] As far as raw materials are concerned perhaps one of the main changes in the manufacturing system which has affected the chemist is delivery in bulk rather than in smaller individual units. Thus, free flowing powders, such as sugar and flour, are delivered pneumatically straight from the vehicle. Similarly syrups and oils are pumped by pipeline into the factory ready for immediate metering into the process itself. This affects the sampling procedure whereby rapid tests may be applied or the laboratory sample may be taken during delivery.

TRIAL BATCHES

Trial batches of the product are prepared from certain raw materials, to check whether any recipe modification is required, *e.g.* jellies from gelatine, cake and bread from flour, and canned fruit from the new season's material, to ascertain whether the syrup is of the correct concentration. During processing, the added syrup is diluted by the juice in the fruit and the strength may require adjustment to give constant sweetness on cut-out. For jam, a trial batch of the fruit shows if the processing method gives a product of correct quality and ability to withstand storage. A pH above 3·5 gives a pectin-sugar-acid gel with a peculiar set—this can be corrected by added acid. A pH below 3·0 however encourages syneresis and suggests the addition of bicarbonate or sodium citrate. Also if the reducing sugars in preserves are below about 20 per cent., sucrose separation is likely on storage, whereas above 40 per cent. the formation of a honeylike mass of invert crystals can be expected. The degree of inversion can be increased by adding acid, by using more water to

lengthen the time of boiling to reach 70 per cent. soluble solids requirement, or by replacing some of the sucrose by invert syrup, which is a common procedure with vacuum boiling. Conversely, inversion is reduced by shortening the boil or reducing acidity.

More generally, having checked that raw materials are of suitable quality and commercially pure, it is often necessary to make checks during the process itself. This enables certain modifications to be made during the process. These should have been allowed for when the formulation and processing method were originally planned. Important considerations here are the best method of attaining homogeneity, the processing times and temperatures to employ and the relevant instruments, gauges, meters and charts to check that the procedure is standardised.

The correct metal to use for the equipment is also studied. Food containing acids, alcohol or salt are liable to corrode metals. The possibility of corrosion can be checked by holding examples of the metal in the food at an elevated temperature. The use of copper for new processing equipment has now largely been replaced by other metals—in particular by aluminium and selected stainless steels. Ordinary stainless steel containing 13 per cent. of chromium together with small amounts of carbon, silicon and manganese is unsuitable for foods containing salt or vinegar. The more complex types containing (also) 8–10 per cent. of nickel, together with small amounts of molybdenum and titanium, however, are not normally attacked. As plant may be used for a variety of foods, such grades would normally be selected for general use.

PART 2

PROCESS CONTROL

During manufacture, rapid on-the-spot tests are devised to check physical properties and composition (either directly or indirectly). A typical example is the use of the Chittick apparatus to confirm that the total carbon dioxide in baking powder is correct, coupled with a check that both acid and bicarbonate have been added by applying a filter paper impregnated with Universal Indicator.

Water removal from vacuum processes can be measured by direct-reading refractometers inserted in the pan, or alternatively the gravity can be automatically controlled. Manually, specially calibrated hydrometers are available. With syrups, for instance, Brix hydrometers give a direct reading of the percentage of sugar in a solution. Brineometers or salinometers give the salt concentration in brines as a percentage of saturation and adjustments can accordingly be made, if necessary. Also, big total reflection refractometers are commonly used in factories to control the concentration of soluble solids. In the boiling of preserves, for instance, the heating is stopped at a definite temperature (223°–224°F) and the solids are quickly checked. Other examples of

"intermediates" which are controlled to a definite soluble solids are pie fillings, jellies, purées and sweetened condensed milk.

The degree of heat processing can be assessed with certain foods. With milk for example the material from the farm is checked for smell, fat, solids, acidity and by the resazurin test. The use of the limiting phosphatase and turbidity tests is well-known, but the ferricyanide-reducing capacity test of Fellows[11] enables a more accurate colorimetric assessment of the degree of heat applied to be made. It depends on the fact that reducing substances are formed during the heat treatment of milk due probably to reactions involving protein and lactose. Using this method, raw milk gives an absorbance of about 0·2 and sterilised milk about 0·4. In canning and freezing, the adequacy of blanching by boiling with water or the application of steam is assessed by confirming that peroxidase has been destroyed, as shown by the absence of reaction with guaiacol/peroxide solutions or with papers impregnated with *o*-tolidine and urea peroxide.[12] A semi-quantitative modification of the former method has been used as a limit test for frozen vegetables in the U.S.A.[13]

PHYSICAL PROPERTIES

Viscosity control is important with foods such as salad cream, sauce, preserves, gelatine solutions and chocolate couverture. Whereas *fluidity* is the tendency to flow, *viscosity* or *consistency* represents the reverse—the resistance to flow. Food materials are "non-Newtonian", *i.e.* the viscosity changes with alteration in the rate of shear, so that the figure obtained differs according to the manner in which the measurement is made.[1] In determining the apparent viscosity of food materials, Redwood viscometers and those with paddles such as the Brookfield are sometimes employed, but control limits can be worked out using much simpler equipment, *e.g.* by taking either the time for a metal ball to fall a standard distance through the material, or, the time for the material to flow out of a factory "standard" funnel.

Jelly strength or consistency is measured on set gels of gelatine and pectin. The force or weight required to push a plunger a pre-determined distance into the gel is measured—the stronger the set the larger the weight needed. This is the basis of the Bloom Gelometer in the British Standard for gelatine and with the Boucher instrument,[14] which is popular in routine control and measures this force from the volume of water added to a bucket suspended on a balance beam. Consistometers measure the degree of spread or flow of a material in a given period of time and are used for plastic-type products such as tomato or apple purée and sauces.

Rapid determination of composition by chemical methods is less common. In recent years however the Linayer Corporation of Detroit have marketed "Quantabs",[15] which are small plastic strips containing an impregnated capillary element. The end tab is torn off and the strip is then immersed in the food or solution for a time which may vary from a few minutes to an hour. Concentration is then assessed from the height of the coloured column—as

compared with standards treated in a similar manner. Quantabs have been devised for measuring salt in cured meat, butter, cheese, sauces, etc., and for the acidity of pickles, jellies and so on.

Some interest has also been taken in the food industry in recent years in more automated analytical measurements, for example, the application of the Technicon Autoanalyzer in on-stream control.[16] The need for automated techniques arose firstly in the chemical industry, where qualified staff were being uneconomically used on routine work, and in the hospitals, where there was a serious staff shortage and it was therefore impossible to cope manually with the large numbers of samples requiring examination. In the Technicon system the samples are placed in small plastic beakers in the circular sampler plate. Each sample meets the tubes containing the appropriate reagents at the proportioning pump and the liquids are then mixed together before passing through a semi-permeable membrane which replaces normal filtration. The reaction takes place in a heated water bath. Usually the reaction is not completed, but every sample in the stream gets the same treatment and, for calibration, standards are treated similarly. The next stage in the line is usually a colorimeter or flame photometer and the degree of reaction of each is shown as a peak on an industrial-type recorder. The appropriate time and temperature for the reaction has to be worked out before proceeding in each case, but there have been wide applications of the system, *e.g.* in the determination of sugars, ammonia, vitamin C and numerous trace elements. The phosphatase test for milk can also be adapted to the Technicon instrument.[17] Although a rotating Kjeldahl digestor can be incorporated into the system for solids in suspension, the most common applications have been to liquids. Consequently the section of the food industry which makes most use of the technique is brewing.[18] Apart from the more chemical type techniques, on-stream measurements of moisture from humidity, sugar in solution by continuous polarimetry, and also of pH are used in certain industries.

The application of on-stream control in general tends to be limited therefore by the availability of a suitable sampling technique. As well as for liquids, the engineer has devised systems for free-flowing powders such as flour, in which samples are either drawn at timed intervals or a regulated sample is drawn continuously from the main stream. This must be one of the fields where improvements are bound to come.

Rapid results are of course difficult to obtain with bacteriological methods. Except for true chemical methods which reflect the bacteriological condition such as the resazurin and methylene blue tests, methods which involve incubation time for counts are too lengthy for perishable foods. Counts are, however, carried out regularly in industry and the results are tabulated or recorded on charts so that changes can be readily seen on a week to week basis. Such trends therefore give a general indication of whether hygienic standards are being adequately maintained. Additionally, daily inspections by qualified personnel play an important part in the control system.

THE PRODUCT

Examination of the product is not nowadays considered to be true control because it is then usually too late to amend anything. Nevertheless, product examination does confirm that the desired results have been achieved. For instance, although ingredient purity may have been checked, there may have been contamination during the process. Additionally, ability to withstand storage can only be confirmed on the product itself. In general, however, representative samples are drawn from coded or dated batches or streams to ascertain that the product complies with the specification and any legal or recognised limits—in short to ascertain that the written formulation has been adhered to.

A further important consideration to the manufacturer is weight. At the end of the production line, the packets pass to automatic checkweighers, which can be set to reject units at any selected level.[19] Also individual samples are drawn at random to ensure that the weights fall between the limits on the appropriate quality control charts. Such charts are not perhaps used so much for compositional data. In any case, due to the biological variation of the ingredients, there is a tendency to treat specification limits as not being as absolute as in, say, the engineering industry.

In the laboratory, general composition and properties are checked from assessments of colour and determinations of water, fat, sugar, acidity and so on. Special tests have to be applied to some foods however.

During the development of the recipe various factors influence the decision to incorporate additives and processing aids into the food. The factory laboratory must ensure that the correct amount has been put in, since, for instance, squashes and sausages will rapidly darken if insufficient sulphur dioxide has been added. It must be similarly ensured that sufficient artificial sweetener has been incorporated into a soft drink to produce the selected sweetness in the product. In other words, the amounts of additives present should comply with minimum as well as maximum factory limits.

Many tests applied to the product are related to organoleptic acceptability, *e.g.* the setting of gels; the particle size of sugar and cocoa in chocolate, which reflects the smoothness to the palate; the colour of ketchup; the size (and uniformity of size) of canned and bottled fruit; the strength of flavour in custard and blancmange and the balance of pepper in pork sausage. Also watch is kept on the texture of cake by taking photographs which are put in the files so that comparisons can be made on a long-term basis.

Keeping properties also have to be considered. Packages and cans are examined for faults after being stored at elevated temperatures and humidities. Storage characteristics can be predicted from the proportion of reducing sugars in preserves, glacé cherries and candied peel (anticipating possible crystal formation). One checks also whether the soluble solids are sufficient to prevent the growth of moulds and yeasts. For somewhat similar reasons, pickles,

sauces and dressings should contain sufficient volatile acidity in the aqueous phase.

Packaging protects the product from light and insect contamination and dry foods of low-equilibrium relative humidity have to be packed in material which is impermeable to moisture vapour. If the same material is used for wetter foods, however, condensation and mould growth rapidly arise within the package. Flesh products are therefore packed in a permeable material. In order to prevent the formation of unsightly dried-up patches on frozen fish, however, the material is preferably surrounded by a protective barrier of ice (known as glazing) before storing below 0° Fahrenheit.

EXTRANEOUS MATTER

Although no excuse is much consolation to the unfortunate consumer who finds some extraneous object as he bites into a cake or pie, there are certain points which should be borne in mind in attempting to put the problem in perspective. Firstly the proportion of the goods so contaminated is very small indeed, and secondly, ignoring occasional deliberate acts of employees seeking revenge, there is little doubt that many manufacturers go to great lengths to try to prevent such happenings. Thus strict rules and procedures are frequently laid down:—

a. No articles made of glass are allowed on the factory floor.
b. Crates and boxes closed with nail or wire should be opened in rooms away from the process.
c. Powders are sieved before use.
d. Magnetic devices are used for removing iron materials.
e. Maintenance engineers are instructed that machinery should be regularly examined for loose screws, nuts, bolts, washers and plating.
f. After maintenance, all loose material has to be taken away, *e.g.* wire, metal from drilling, solder and string.
g. Overalls are supplied which have no pockets and have tie-on tapes instead of buttons.
h. Women are discouraged from wearing clip-on jewellery; and protective headwear is provided to prevent hair-pins and hair falling into the food.

Also automatic grading plant is used for removing lower quality materials and unwanted matter, *e.g.* peas are separated by flotation; and discoloured beans, almonds and rice are deflected electrostatically. Flour and other cereals can be passed through Entoleters in which the powder is spun-out centrifugally and insects and mites and their eggs are killed by the impact.

Then there are various detection systems—magnets which show up the presence of metal; electronic devices which detect non-ferrous metals as well;

and X-rays which detect metal, rubber, stone or glass. These devices can be adjusted for varying sensitivity and the detector is linked with a rejection or process-stopping or warning system. Special inspection devices are also available for detecting extraneous matter in bottles.

None of these types of equipment is 100 per cent. perfect, but they do minimise the trouble. They are unfortunately expensive, and one suspects that the tendency with some firms, unfortunately, has been to purchase after trouble has occurred. One presumes, however, that the local Health Inspectors are giving useful advice on this perpetual problem. There is little doubt that they will invariably be well supported by the factory chemist.

THE FUTURE

Looking into the future, it must be assumed that food supplies will be basically dependent on raw materials of biological origin. No doubt, an increasing use will be made of raw materials which have been standardised before receipt by the food manufacturer—the sort of thing which has happened in the case of prepared, clean, spice extracts containing the total extractives on salt or dextrose as carrier.[10] As important losses may occur during preparation, the development of such materials is dependent on our having a fundamental knowledge of basic composition and the reactions that occur during processing. With the instrumental techniques now available it should be possible to investigate more thoroughly the complex reactions that occur during processing and storage that affect the organoleptic characteristics. This, however, needs a long-term effort, which should include the working out of simple tests (suitable for routine control) from the information supplied by the more elaborate basic work.

More immediately one can foresee an increasing use being made of:—

a. bulk handling of raw materials,
b. automation or semi-automation in sampling and processing,
c. on-stream control and continuous monitoring,
d. the statistical interpretation of results.

With sampling, greater use will surely be made of the more reliable methods of sampling in motion rather than from static containers. For this, circular and straight-line samplers, both of which can be operated either intermittently or continuously have been devised.[20] The sampling frequency can be adjusted to cope with varying rates of flow.

Because of the advantages of reducing the time lag between campling and analysis, a greater use is likely to be made of on-stream control of product composition. For instance, as the infra-red absorbance of homogenised milk shows peaks at 5·8 μ and 9·6 μ for fat and lactose respectively, the method can be adapted to continuous recording.[21] Also one can foresee further use being made of i.r. and microwave measurements of moisture and modifications of manual equipment such as automatic colorimeters, polarimeters, titrators and

so on. From the microbiological point of view one hopes that researchers will apply themselves further to the development of reasonably rapid methods such as direct microscopic counts.

More generally, with more students passing out of Universities and Technical Colleges with qualifications in food science, food technology, food engineering and so on, more pressure is bound to be put on managements to make greater use of statistics at each stage of the standardisation.

More work is also needed at the "front end"—in agricultural control. Here we have a reasonable amount of information on variety selection with fruits, vegetables and cereals, which has helped to produce a steady supply of standardised material.

Everyone is concerned with the dangers of contamination produced by modern methods of crop treatment. In spite of the large margin of safety which is allowed for in the Government scheme, there are far too many dangers involved for any complacency. The widespread presence of residues of chlorinated hydrocarbons and organo-phosphorus in birds and in the human diet is a known fact and the Public Analyst's work in this field is obviously most important in protecting the consumer. One wonders, however, if the manufacturers are equally checking their raw materials for the presence of pesticide residues. Some firms certainly are. Surely it is just as important to apply specification limits for pesticides as it is to have control over trace element contamination. Probably the best system, with raw vegetable foods at least, is that in which the manufacturer lays down specifications for what goes on at the farm—such that the treatment of the crop is controlled.

Another aspect where more knowledge is called for is in connection with animals and poultry. Here more knowledge is needed of changes that occur due to cross-breeding and other methods of genetic modification. With the continuing demand to feed an increasing population, further research on the agricultural side will become an economic necessity.

THE CONSUMER INFLUENCE

It is interesting to consider Galbraith's references to industry and the consumer in the fourth of his Reith lectures recently broadcast, whilst remembering that he was referring to industry in general.[22] The most appropriate passage of the American Professor's message was as follows:—

> "... the notion that the consumer is the sovereign influence in the economy—that all decisions begin with him—is a pure case that will not do. Or it will serve only for those who wish to believe in fairy tales.... The important decisions in the modern economy are made by producing organisations in the service of their own goals".

Obviously the food manufacturer is in business to make a profit. Nevertheless if one considers the millions of comments which must be made across meal tables over the country daily, it is obvious that food quality is being continually assessed—comparisons are made of the tenderness of the Sunday

joint, the flavour of a different brand of custard, jam, fish paste, pickles and sauce and (dare I mention) bread. Surely this interest is stimulating competition and improvement, particularly if we realise that with food the profit per individual item is extremely small indeed. Nevertheless, this same competition has undoubtedly reduced quality in certain foods. For example, following the desire to use up poor quality herring after World War I, dye was put in the brine and a lightly smoked kipper resulted—and, presumably owing to conditioning there is evidence that consumers now prefer the modern wetter kipper to the dryer more tarry product.

Also, in World War II, butter went virtually out of use in manufacturing and everyone is well aware that it has by no means returned in full measure to flour confectionery, for instance. Changes in the analytical figures for vinegar because of a change in the manufacturing procedure,[23] will no doubt be very familiar to analysts. With such products, the manufacturer has tended to call the tune, and in turn has probably conditioned the consumer.

On the other hand, it is quite easy to find products that contain amounts of ingredients well in excess of minimal statutory requirements. Immediate examples that come to mind are ice-cream, salad cream and baking powder. With the food industry, therefore, the Galbraith edict is about half right.

On the question of future standards, it is possible that some of our ideas will have to be altered when we implement the international specifications laid down by I.S.O. and the Codex Alimentarius. This should assist the manufacturer as he will not then be required to alter his recipe according to the country for which it is destined.

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