DEVELOPMENTS SERIES

Developments in Food Preservation – 4

Edited by
STUART THORNE

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DEVELOPMENTS IN FOOD PRESERVATION—4

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PREFACE

The food preservation industry has attracted considerable, and usually unjustified, criticism recently. Most of this has been directed at ingredients used in foods, but it seems to be 'preserved' foods that are associated, in the public mind, with these additives. The main source of this misinformation about the quality and safety of preserved foods has been toxicological data published in the scientific press and misinterpreted by journalists untrained in the methods of science and the need to interpret results as probabilities. To them, one sick rat is synonymous with acute toxicity in a food component.

Although popular journalists must take some of the blame for the supposed horrors of preserved foods, the industry must accept much itself. It has in general adopted a superior attitude and declined to explain, without the technical jargon behind which the insecure shelter, what the problems of ingredients and additives are, and how toxicological investigations work. So often, representatives of the food industry talk down to their popular audiences: '... but you wouldn't understand this'. Try them; popular audiences will understand a great deal if it is explained clearly and properly. The alternative is for the unreasonable condemnation of all preserved foods to gather momentum until it is unstoppable. The interests of food producers and consumers are similar: provision of wholesome and safe foods at reasonable prices. Foods, indeed, are safer than they have ever been before. The only way to demonstrate this and the industry's high ethical standards to the public is to instigate a truthful dialogue between consumer and producer.

The public relations problem that the food preservation industry faces is derived from doubts cast on the safety of a few food additives, particularly colours. Such doubts as have been established represent a very small probability indeed that a food containing the additive is less safe than one without it. But such doubts are taken out of context and all synthetic additives become potential poisons. Many toxicological investigations are concerned with short-term ill-effects of additives, which have to be included in diets, usually of rats, in unreasonably high concentrations if any ill-effects at all are to be found. And when an ill-effect is found, whether or not this was a result of the additive in the diet can only be deduced in terms of probabilities. Misinterpretation of such results often means ill-effects are attributed erroneously to the additive.

Long-term toxicological studies of food additives, for example as potential carcinogens, are even more fraught with problems, for results can only be concerned with ill-effects in a very small proportion of experimental animals. During the study, death and disease from other causes will certainly exceed that caused by the additive by many orders of magnitude.

In the common mind, science is concerned with certainties. It is not, it is concerned with probabilities. No food component can be proved safe. One can only establish that the possibility of a food being unsafe is very small indeed. We must make a very great effort to explain to our final customers that the food industry has their welfare very much in mind, and to explain just what food safety is all about. The only criterion by which a food component can be judged is the ratio of benefit of its use to the potential hazards of its use. The former — the benefit — will represent, mainly, safety aspects of the food, but it may also include economic and sensory attributes. The potential hazards, which cannot be zero for any food component (since we cannot *prove* any food completely safe), are essentially toxicological hazards. Now use of an additive such as a nitrite, which is a powerful inhibitor of *Clostridium botulinum* spores, could be justified even in the face of some toxicological doubt, because the benefits of its use are considerable. Little toxicological doubt could be accepted in the case of, for example, a food colour which is essentially cosmetic in effect.

The consumer should be able to make up his mind about the acceptable risks and benefits of additives. First of all, however, he must have the concept of benefit/hazard relationships explained. This is not some suspect invention of the food industry, but a fundamental truth. Some additives are essential to the provision of safe food and no component of food (either natural or synthetic) can be proved to be free of any risk whatsoever. But we must make sure that our customer has all the information, both about benefits and hazards, available in an unbiased form so that he can make his own decisions.

Some foods do, undoubtedly, contain unnecessary additives, and all food processors have an obligation to ensure that all synthetic or artificial additives used in foods really are necessary and to consider the economic and safety aspects of their elimination. Perhaps, when we do this, the consumer will again accept foods as wholesome and safe (which they usually are). It is salutary to remember that a recent poll in Britain revealed that over 60% of the large sample considered that the presence of any 'E-numbers' in the list of ingredients was indicative of poor quality and of health hazard!

So far, it has been additives that have been associated in the public mind with health hazards. But, since additives are associated with processing, processes themselves have been implicated by association. We must make considerable efforts to ensure that the false assertion that 'Fresh foods are wholesome; processed foods are hazardous', which appears to be the catch-phrase of popular food journalism, is laid to rest by proper, true and honest information.

The main emphasis of Volume 4 of *Developments in Food Preservation* is on the quality of preserved foods. There are no great revelations for, as Professor Bender makes clear in the first chapter, processing does not usually effect gross nutritional changes in foods. There are, of course, always subtle changes in quality — not always in nutritional quality — when foods are processed and preserved, and these are discussed for refrigerated, frozen and pickled foods by Margaret Hill and Messrs Holdsworth and Steinbuch. Jeremy Selman's chapter deals with the effects of blanching on foods. Although blanching cannot usually be considered a preservation process on its own, it nevertheless plays a major role in other processes, and its effects contribute to the success and effect of the processes to which it contributes. The packaging of foodstuffs is the most important factor determining their storage life, so that it is particularly appropriate that we have a contribution on developments in packaging materials. The remaining chapter, by Graham Bown, on modern methods of process control, is also very much concerned with the quality of processed foods, for improved process control results in a more consistent product, processed in the most economic way possible. Process control in the food industry has, until recently, remained crude, but the introduction of computer-based systems, capable of controlling entire processes, promises to effect immense improvements in this field.

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Chapter 1

NUTRITIONAL CHANGES IN FOOD PROCESSING

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SUMMARY

There is a general tendency to regard foods cooked at home from raw materials as being nutritionally superior to factory-produced processed foods. There is little evidence for this belief; nor is it possible to attempt to compare the enormous numbers of household preparations with factory-produced counterparts. Clearly the skills of housewives cover the entire possible range so that any average, assuming that it was practicable to examine a valid cross-section of domestic output, would be misleading.

In general it might be expected that a factory under the control of a competent food scientist should be able to maintain somewhat higher nutritional standards than some home kitchens. It is not possible to generalise, and each preparation, each process, and each factory employing ostensibly the same process would need to be examined. As discussed later, there is a considerable difference between the product expected, as predicted from laboratory investigations, and the achievement.

One practical point may be made; namely, that there is no evidence that modern processing has had any detrimental effect on the nutritional status of the population. Indeed, the very fact that processing makes available a much wider variety of foods at all seasons of the year should ensure a higher nutrient intake than at any previous time in man's history — so long as a reasonable choice is made. At the same time the wider choice and availability could mask any fall in the nutrient content of foods from the factory as compared with traditional home cooking.

1. PRACTICAL PROBLEMS

In attempting to assess the effects of processing, model systems are often examined. Analysis of the factory end-products provides little information about the principles involved, so model systems are devised which are simple enough to study but which, at the same time, are far removed from the complex mixtures encountered in practice.

So far as nutrients are concerned the difficulties are exemplified by what might be considered a simple system of vitamin C, itself a relatively simple molecule, in solution in a fruit juice. Since vitamin C is the most sensitive of the nutrients, and juices are often marketed as a source of the vitamin, manufacturers need to be able to predict losses during manufacture and storage. However, unexpected and inexplicable problems arise.

Marchesini *et al.*[1] examined 15 cultivars of green peas grown under identical conditions which might be expected to show identical properties. However, considerable differences were found between three sets of measurements. First, there were significant differences between the amounts of ascorbic acid (AA) and dehydroascorbic acid (DHA) in the various cultivars. Both forms of the vitamin are biologically active but the second form is far less stable. Secondly, the rates of loss of the two forms differed a great deal when subjected to the same canning process — one cultivar, for example, lost all the AA and three-quarters of DHA, while another lost one-quarter of the AA and one-quarter of the DHA. Thirdly, when two different canning procedures were examined, namely, heating at 116°C for 25 min or 124°C for 8 min, the relative amounts of each form lost differed. Even more difficult to explain is the observation that differing amounts of the vitamin were leached into the brine from the different cultivars.

If cultivars grown under the same conditions can vary to that extent then generalisations become impossible.

Attempts have been made over the years to formulate mathematical predictions of the losses of vitamin C in various preparations, but later work revealed the difficulties.

Some reports[2] found that the loss of vitamin C followed a first-order reaction; but others, in their products, did not obtain the same results and different mechanisms appear to be involved. Wanninger[3] produced a mathematical model to take into account temperature, water and oxygen using the values of Vojnovich and Pfeifer[4] but Labuza[5] pointed out that the anomalies in the literature indicated that different mechanisms were involved in different food preparations. For example, in the loss of vitamin C through non-enzymic browning the activation energy increased with decreasing moisture while the reverse took place in vitamin-enriched cereal preparations. As regards the presence of oxygen, losses in crystals of orange juice were the same in air or vacuum. Labuza suggested that the mechanism of destruction of vitamin C may differ at different moisture contents — possibly oxidation being the main cause of loss when the moisture content is low, and browning when high.

As regards temperature, Stephens and McLemore[6] found that temperature had no effect on the loss of vitamin C from carrot flakes, in contrast with enriched cereal preparations where the destruction increased with temperature and followed a first-order reaction.

A second major problem that occurs when attempting to assess the effects of processing is the failure in many reports to follow up the losses during subsequent storage. For example, an experiment was designed to ascertain whether the common occurrence of rickets among Asian immigrants in Great Britain was due to the destruction of vitamin D when butter was clarified to prepare ghee. Since no loss was detected during the process it was concluded that this was not the cause. However, since commercial ghee is usually stored for many months after manufacture it is possible that oxidative destruction of vitamin D could take place during this period, but no measurements were made so, in fact, the problem was not resolved.[7]

TABLE 1
VITAMIN LOSSES AFTER CANNING AND STORAGE OF WHOLE MEALS (22 ± 2°C) (PERCENTAGE LOSS)[56]

Vitamin	*Initial value*	*After canning*	*Storage* 1·5 *years*	*3 years*	*5 years*
Vitamin A	16·5 μg	50	100	—	—
Vitamin E	80 mg	0	0	50	50
Thiamin	9 mg	50	75	75	75
Riboflavin	6 mg	0	0	0	0
Pyridoxine	5 mg	0	0	0	0
Vitamin B12	18 μg	0	0	0	0
Niacin	110 mg	10	20	20	20
Pantothenate	21 mg	25	50	50	50
Folic acid	14 μg	0	0	0	0
Inositol	26 mg	0	0	0	0
Choline	27 mg	0	0	0	0

An example of the loss that can take place subsequent to the immediate processing loss is that of thiamin from potatoes treated with sulphite. Thiamin is damaged by sulphite, so the prevention of browning of peeled and chipped potatoes by sulphite dipping destroys part of the thiamin. When the potato chips were subsequently fried there was a greater destruction of thiamin in the chips that had been sulphited than in the controls.[8]

One of the few investigations where the process has been followed throughout the storage period is shown in Table 1. This involved an examination of canned whole meals immediately after processing and at stages during a 5-year storage period. There are few such reports in the literature.

2. PRINCIPLES AND PERSPECTIVE

Some nutrients are damaged, some severely, during certain processes, but such findings must be viewed in perspective. Table 2 lists 10 principles which serve to provide such perspective.

TABLE 2
PERSPECTIVE FOR CONSIDERING THE EFFECTS OF FOOD PROCESSING ON NUTRIENT COMPOSITION

1.	Some processes are nutritionally beneficial.
2.	Some nutritional losses are intentional.
3.	Some losses are inevitable.
4.	Losses, where incurred, are often in place of losses in the home.
5.	There is often a difference between what should and what does take place in the factory.
6.	Comparisons must be made of foods ‘on the plate’.
7.	The whole diet must be taken into account.
8.	Consideration must be given to vulnerable groups of the population.
9.	Disadvantages must be balanced against any advantages.
10.	The comparison is often between the factory and the home-made food.

Principle 1: Beneficial Effects of Processing

While there is much discussion of nutritional damage during processing, there are certain specific benefits and even nutritional advantages.

The obvious benefit is preservation of foods that would otherwise be lost. A second obvious benefit is the destruction of pathogenic organisms.

Less obvious is the destruction of natural toxins such as haemagglutinins (lectins) and antienzymes, particularly in legumes. Raw and incompletely cooked red kidney beans (*Phaseolus vulgaris*) were responsible for some 100 outbreaks of food poisoning affecting about 900 individuals in Britain between 1976 and 1980.[9] Such dangers would not occur with canned beans, which are subjected to sufficient heat to destroy all toxins.

There are also specific increases in the nutritional value of some foods through processing. Niacin in cereals is largely unavailable since it is complexed as niacytin. Heat, as employed during baking, liberates much of the niacin. The amount liberated depends on the severity and time of heating enhanced in an alkaline medium.[10]

The nutritive value of the proteins of some legumes is relatively low in the raw state — partly because of the presence of enzyme inhibitors and partly, it seems, because some part of the amino acids is unavailable. Heat, as shown in Table 3, can increase protein quality — up to the level when heat damage occurs.

During the roasting of coffee trigonelline is converted into niacin in amounts sufficient to supply about one-fifth of the RDA in one cup.

TABLE 3[56]

EFFECT OF HEAT ON QUALITY OF TWO VARIETIES OF LEGUMES

	Net protein utilisation (percent)	*Biological value (percent)*	*Digestibility (percent)*
Dun peas (*Pisum arvense*)			
Raw	52	77	68
Boiled 5 min	55	82	67
Boiled 10 min	50	80	63
Heated 120°C for 120 min	37	75	49
Michigan pea beans			
Raw	15	37	41
Boiled 5 min	48	71	68
Boiled 10 min	53	80	66
Boiled 60 min	49	77	64
Heated 120°C for 120 min	38	76	50

Finally, enrichment with nutrients can take place during processing either for commercial reasons or for reasons of public health.

Vitamin C

Although vitamin C is damaged during most if not all processes such treatment can result in an aggregate conservation of vitamin C. This is because the destruction of the vitamin begins in many foods immediately after harvesting. The enzyme, ascorbic acid oxidase comes into contact with its substrate and destruction can be very rapid under conditions where the food is bruised or wilts so that there is sufficient damage to cell walls to allow access of the enzyme to substrate.

The rapidity of such loss under conditions of heat and humidity is illustrated by the report of Fafunso and Bassir.[11] Leaves were harvested at 8 a.m. and samples were analysed hourly (Table 4). Similarly kale was shown to lose 1·5% of its vitamin C content each hour after harvesting — a loss that amounts to 30% in 24 hours.

TABLE 4[11]

LOSS OF VITAMIN C FROM FRESH GREEN LEAVES (NIGERIA)

Hours after purchase	*Percentage loss*
2	5–18
4	10–30
8	35–60
10	38–66
24	90

Folate is similarly labile. The folate content of endive (*Cichorium endiva*) was found to fall at the rate of 15% per day (45% loss was observed in 72 hours) when stored at 23 °C.[12] Storage at 4 °C reduced this rate of loss to 5% per day.

Heat treatment prevents further enzyme destruction of the vitamin C and folate after the initial loss during processing. Clearly the vitamin content of the final product depends on the initial level — and, as explained later, the initial level of vitamin C and folate may be higher in the fresher foods available to manufacturers than is available to the housewife — and the length of time elapsing before the 'fresh' food is cooked.

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