Changes in Nutritional Quality of Food in Catering

K. Paulus

Association for Food Legislation and Food Science,
Bonn, Federal Republic of Germany

Summary Three main parameters influence the nutritional quality of food preparation: the choice of raw materials, the recipe and composition of a meal, and the preparation process. In catering systems the temperature and time history during preparation and distribution, i.e. systems like cook-chill, cook-freeze, or warm-holding, need particular attention with regard to some sensitive nutrients, e.g. vitamins C, B1, folic acid. If the main parameters and influencing factors as described are taken into account, it should not be difficult to produce food in catering with high nutritional quality.

Key Words catering, food preparation, nutritional quality, nutrients.

For many people, processed foods form an integral part of a well-balanced diet. They provide not only carbohydrates, fat, and protein as energy sources but as well the essential amino acids, essential fatty acids, vitamins, minerals, and trace elements required to maintain normal body metabolism. Some nutrient losses do occur during food manufacture and some vitamins and essential amino acids are particularly sensitive. These losses during food processing however must be viewed in perspective as some changes are inevitable in order to allow the desired effect of a process carried out, as for instance to ensure bacteriological safety during preservation or to achieve a certain cook value during food preparation.

The catering market is an important subsector of food processing, food preparation is the most important technological unit operation in general. The nutritional quality of foods offered in catering facilities gains special attention, as these foods may cover a considerable share of or even the whole daily food intake for a certain part of the population. The more foods are eaten in catering facilities the more the offer must fulfill the recommended dietary guidelines assessed by nutritionists in order to prevent deficiencies as to one or more nutrients. In this regard the caterer is in a totally different situation from that of a food manufacturer in the normal sense.

What are the parameters influencing nutritional quality of foods during preparation?

As a statement of principal importance it should be realized, that there exist...
3 main parameters which determine the nutritional quality of products in catering (1).

From Fig. 1 it can be seen that between the theoretical activity of menu planning and the ready-to-eat product the raw materials, the recipe or composition of a whole meal, and the preparation process have to be considered as the main factors. So, the procedure between the planning stage and final product, if looked at from the qualitative point of view, comprises not only actual process operations, as usually assumed and discussed. The selection of the appropriate raw materials already decides largely upon future quality. In addition the composition of the meals over a certain time as well as the recipes used for the individual meals determine the quality of the foods as well.

Figure 1 reflects not only the nutritive value but in addition the sensory quality, which is most important from the viewpoint of the consumer. Economic considerations have frequently led to neglect this overall view. But apparent financial advantage is realized often only at the price of severe shortcomings in quality. And this relates to the usually most important factor, the raw material. Such practise, no doubt, will not promote a favourable consumer attitude.

The relative importance of these 3 parameters on nutritive value and sensory quality is expressed in Fig. 1 with the connection arrows. For the nutritive value the theoretical planning has first priority, and that refers to the composition of the meals and the individual recipes. This is an optimization procedure, of course. But it is necessary to realize, that in principal through this theoretical approach and/or calculation it is possible to set up the desired nutritive value taking into account the type and quality of the raw materials and the possible changes of some nutrients during preparation. So it is only logical that the second priority belongs to the

selected raw materials and only the third priority concerns the preparation procedures.

From the discussion of this first statement it becomes obvious that the nutritive value of foods in catering is largely depending on the right composition and selection of meals and of raw materials. At least this is correct for energy, fat, protein and carbohydrates, as the content of these macro-nutrients is rather constant. It is more difficult for micro-nutrients as vitamins, minerals, and trace elements, where the biological variance of the absolute content depends upon several uncertain conditions. So the content of such a substance in the same food, maybe only from different origin, can vary over more than one order of magnitude, which is much more than the possible change through processing. And therefore, the biological variability is the real factor of uncertainty in the calculation and not the process induced changes. This problem is to be overcome only through selecting a large variety of raw materials from different origin. Over a certain period of time the average values listed in food composition tables are fulfilled and realized, at least approximatively.

Nevertheless, the importance of preparation processes on sensory properties should be mentioned, as can be seen from Fig. 1. If therefore in catering a high sensory quality is strived for and if realized in practise, it means always that the relative changes of substances with a certain importance for the nutritional quality are only small. Even though it seems interesting to check the preparation techniques and the different catering systems as to their possible influence on nutritive quality of the final meals.

What preparation techniques and systems are used and how do they influence nutritive quality?

A technological procedure usually is separated into the basic unit operations. The possible process steps are listed in Table 1 and serve as basis for a discussion of different unit operations and their possible influence on quality (1). A detailed

<table>
<thead>
<tr>
<th>Step</th>
<th>Treatment</th>
<th>Possible critical point</th>
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</thead>
<tbody>
<tr>
<td>Storage</td>
<td>storage of the raw material/products</td>
<td>suitability storage conditions</td>
</tr>
<tr>
<td>Processing</td>
<td>mechanical and thermal operations</td>
<td>induced changes process conditions, recipe</td>
</tr>
<tr>
<td></td>
<td>preparation/cooking preservation</td>
<td>process conditions</td>
</tr>
<tr>
<td>Storage</td>
<td>storage of prepared and preserved products</td>
<td>time-temperature tolerance</td>
</tr>
<tr>
<td>Reheating</td>
<td>thermal treatment</td>
<td>process conditions</td>
</tr>
<tr>
<td>Storage</td>
<td>warm holding</td>
<td>time-temperature tolerance</td>
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</table>
discussion is subject of several books and therefore only a few general remarks seem useful.

**Unit operations in food preparation.** Preparation comprises unit operations of mechanical and thermal nature. Mechanical operations are usually reserved for treatments preceding preparation, whereas preparation itself comprises primarily thermal operations.

Mechanical unit operations include comminution, separation, mixing, agglomerating, conveying, fluidizing, with comminution, separation and mixing being of special importance. Comminution includes breaking, grinding, cutting; separation means primarily sorting, peeling, washing; mixing comprises stirring, kneading, dispersing. These mechanical operations could have a certain importance on quality. However there has been immense progress in this field in recent years which should be utilized also in food preparation processes. Mechanical unit operations may cause some quality problems since they may initiate secondary processes otherwise impossible such as e.g. direct contact to the environment after the separation processes.

Preparation comprises mainly 2 categories of thermal unit operations, namely heat transfer and separation by heat. The first includes cooling, freezing, heating, cooking, blanching, pasteurizing, sterilizing, solidifying; the second category includes evaporizing, concentrating, extracting, drying.

Food can be prepared in most different ways; this is evident already from the large number of cooking terms such as baking, boiling, cooking, frying, griddling, grilling, parboiling, parcooking, poaching, pressure cooking, roasting, simmering, steaming, toasting.

The most frequent thermal unit operations in solid foods can be assigned to two categories, moist cooking and dry cooking. In moist cooking operations, water activity of the food remains more or less constant whereas with dry cooking the water content of the product changes due to the dry cooking medium. The drying process advances from the surface to the product centre as a function of time.

Summarizing one may say that all measures pertaining to food preparation are mechanical or thermal unit operations. Whereas mechanical operations precede preparation, food preparation itself is mainly the result of thermal processes. Food to be processed may be flowable/pumpable or solid. Solid foods are of greater importance, but present far more problems with regard to thermal processing.

**Catering systems.** Figure 2 illustrates some thinkable catering systems on the basis of a very rough temperature-time history. Such a diagram can be used for later quality considerations.

The predominant system in terms of meals produced is by conventional production of meals intended for direct consumption, i.e. food preparation in the strictest sense, however, using products of different processing levels such as dried, frozen or sterilized. These preprocessed products enter the system and define the initial quality as much as in the case of unprocessed raw material.

If longer storage times of the prepared meals or meal components are required,
the thermal treatment has to be "interrupted". This means reduction of the product temperature after preparation, preservation and packaging to the desired or necessary storage temperature, and finally adequate storage and reheating to eating temperature immediately before consumption.

The system most preferable from the view-point of quality is the cook—chill system in which preparation is followed by chilling and cold storage (2–4°C) for not more than a few days. The chilled components have to be reheated to eating temperature before consumption. Number and kind of individual operations show already that this system involves much more treatments compared to direct food preparation which increase the danger of quality losses. The individual unit operations and their significance for quality changes therefore have to be investigated and evaluated.

The cook-freeze system is mostly a part of a complete system and only in a few cases used as an individual or pure system. This applies especially in the case of sterilized meals.

Finally a system will be mentioned having some importance in Germany, meals held warm. After cooking and packaging the meals have to be held above 60–65°C, for hygienic reasons. They are distributed than within a few hours. But longer holding times at such high temperature lead to substantial changes in the product.

Summarizing one may state that direct meal production, using fresh, semi preserved or preserved raw materials, is by far the most important system followed by the cook-chill system. In some countries the cook-freeze system has to be considered as well.
What nutrients are reduced during catering operations?

Vitamins are the most sensitive of the nutrients, since they are, to varying degrees, damaged by heat, light, acid, and/or alkali. The greatest losses take place through the extraction of water-soluble nutrients, and this would include minerals and trace elements, into the processing and cooking water. Such losses are inevitable if the food is subjected to wet processing. The extent of the losses will be influenced by the surface-to-volume ratio (specific surface) of the food and will be considerable if the food is minced or chopped. When the aqueous fraction is consumed then the extracted nutrients are recovered.

Proteins are reactive and during food processing and storage, the side chains of some amino-acids can react with other food components to give covalent complexes or oxidation products (2-4). Carbohydrates, dietary fibre and fat are relatively stable to processing and their influence on the nutritive value is due more to their type and level. Unsaturated fats, including the essential fatty acids, may be oxidized, isomerized or further degraded during frying or even during storage but there is no concern on the nutritional consequences of these reactions (5).

Catering operations usually are less intense than preservation procedures, so it seems realistic to concentrate on vitamins and minerals as indicator substances for nutritional changes.

To judge the influence of process conditions on vitamin retention it is useful to take the kinetics of vitamin changes into account which describe mathematically their behaviour. For most heat sensitive vitamins (as C, B1, B2, folic acid) the changes follow a first-order reaction and the influence of temperature can be described according to Arrhenius (6-8). Minerals undergo changes only due to diffusion and leaching.

In Table 2 results of extensive investigations with starch containing meal components are summarized (9). Different foods were subjected to different cooking procedures. Boiling of potatoes resulted in around 10% less retention than steaming. Important is that the process is carried out only to the optimal cook value. Overcooking increases losses. If potatoes are cooked 15 min longer than necessary the losses are higher, for minerals 12% and vitamins around 5%. During boiling of noodles and rice water uptake causes an increase in product weight by

<table>
<thead>
<tr>
<th>Product</th>
<th>n</th>
<th>Minerals</th>
<th>Vitamin C</th>
<th>Vitamin B1</th>
<th>Vitamin B2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato¹</td>
<td>30</td>
<td>70–95</td>
<td>80–86</td>
<td>76–86</td>
<td>83–99</td>
</tr>
<tr>
<td>Noodles/Pasta²</td>
<td>42</td>
<td>10–85/50</td>
<td>—</td>
<td>43–81/65</td>
<td>66–76</td>
</tr>
<tr>
<td>Rice²</td>
<td>33</td>
<td>72–100/90</td>
<td>—</td>
<td>37–92/60</td>
<td>30–100/75</td>
</tr>
</tbody>
</table>

¹ data related to fresh weight.
² data related to dry matter.

factor 2.5–2.8 and 2.8–3.3 respectively. This soaking effect is responsible for sometimes rather high loss.

In the case of cooking products with a high specific surface, it is even more important to observe optimal process conditions. Figures 3 and 4 represent data on losses of vitamin C and B1 during boiling of spinach leaves (10). Assuming a preparation time of 3 min at 90°C the retention of vitamin C is about 75% and vitamin B1 about 85%. Thus appropriate process conditions cause only minor losses of water soluble and heat sensitive constituents.

Some data on the effect of boiling on total folate content underline this statement as demonstrated with Table 3 (11). Folate seems to be relatively stable to heat, whereas earlier work indicated that this was not so. Considerable extraction takes place into processing water if boiling is used, which probably accounts for this incorrect former conclusions.

Finally the average changes of vitamins during warm holding and storage of meals are summarized in Fig. 5 (1). The diagramme is based on the results of a great many experiments with individual products, so for a special meal component somewhat different data may occur. But the figure shows, that components of different preparation and preservation procedures can be put together, to draw a rough picture, but different time scales have to be considered. Under normal storage conditions the reduction in vitamin contents is again moderate.

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Referring to the different catering systems described under 3.0 it has to be stated that in all systems foods have to be cooked first. In addition to the changes during preparation system specific changes have to be taken into consideration.

During warm holding considerable losses may occur after longer holding times. Therefore the holding time at around 60–95°C should not exceed 3 h. The cook-chill
CONCLUSION

Discussing changes in nutritional quality of food in catering, first of all the possible parameters have to be considered influencing the nutritive value of the meals offered. It was mentioned, that selection of raw materials with a high quality and combining them in the right way according to a systematic menu planning is most decisive for the nutritional quality of the final products.
Nevertheless preparation and processing procedures have to be considered as well because of a possible detrimental effect on some food constituents.

Assuming appropriate processes and optimal process conditions the changes are restricted to a few water soluble and/or heat labile constituents.

If these main parameters and influencing factors are taken into account, it should not be difficult to produce food in catering with a high nutritional quality.

REFERENCES


DISCUSSION-CONTRIBUTIONS

Speaker: Paulus, K.

*Question*: Fujiwara, M.

Do you have some good methods to distribute from the cooking to customers?

*Answer*: Yes! Of course it depends on how flexible you are. If you are rather inflexible that means you cannot plan within few hours or within few days, you have to preserve foods.

So traditionally when we developed catering systems in Western Europe and in the United States, we have more or less preserved food components. We had for a long while a pure frozen catering system or catering system based on only frozen foods. We have changed today, because of course we cannot, let me say, take most important menu components from a frozen food. But we can add for example soup, dessert, salad in a fresh way and in fact what is done today. So for different systems, you have different storage time. And it gives you flexibility to distribute the food. Of course some body has to make distribution.

Speaker: Paulus, K.

Question: Murata, K.

1) You have reported that the loss of folate after cooking is less than that expected. I would like to know the method used for the determination of folate. Some amounts of folate could be transformed becoming active forms after cooking. After cooking, also some folic acid could be destroyed. That is why I am asking.

Answer: You are right. I am not expert on folic acid analysis. The presented results on folate were taken from a paper published by Bender. So the details are discussed in that paper. As Bender has been working for a very long time on folate analysis we can assume that his results are correct.

2) Comments: Murata, K.

You have mentioned loss of nutrients after storage in general. Probably you know that quite different results will be obtained depending on the qualities of the foods.

Answer: Of course we have to consider the very different stability of our foods as to storage. Therefore, I tried to explain the critical points of suitability for storage and—if given—the storage conditions. The unsuitable products will lose quality very rapidly, not only as to nutritive value. The storage as a thumb rule we can say: the temperature should be as low as possible to freezing point. But we should keep in mind that daily foods in tropical countries show some susceptibility against cold storage. But, this again is a point of suitability which has been mentioned already.

Speaker: Paulus, K.

Question: Mueller, H. R.

Various systems of catering can lead to variable losses of nutrients because they undergo prolonged storage and warm holding. What are the criteria for choosing the cooking system for satisfying nutritional quality?

Answer: A system to be chosen depends upon other things as well, of course, as for instance the location of the facility, economical factors, number of people to be fed, etc. So, before deciding what system should be selected, the critical points must be considered, e.g. as to the economical side of the chosen system, the losses, its values and if quality does meet the requirements and preferences of the eaters.

The development in catering at least in western countries was influenced by these considerations and we can state that the systems now in use are approaching more and more the optimal situation, which may be different from case to case.