ROSLYN E. KRAMER

R56-19

(Reprinted from Activities Report, Vol. 8, No. 4. Published by The Research and Development Associates, Food and Container Institute, Inc.)

flavor

The concept of flavor is many things to many people. In order that the reader might have little chance for misunderstanding, flavor will be defined as that complex of sensations resulting from the stimulation of the senses of taste, odor, feel, and sometimes vision and audition.

From this definition it is easy to see that all of the aspects of food technology are tied to this complex of sensations known as flavor. Also from the definition it may be seen that every aspect of a food contributes in some measure to its particular flavor. This latter concept would mean that a white or blue pea might have a flavor *similar* to a green pea but certainly not exactly the same as a green pea. Again, celery would not be exactly celery without an audible crunch. To what degree the senses of sight and hearing might affect the consumer is beyond the scope of this article. We could call these problems psychological and concentrate on satisfying the senses of taste, odor, and feel. In fact, it might be stated that the main problem of the food technologist is that of providing the ultimate consumer with a product which will have a typical taste, typical odor, and typical texture regardless of how it was produced, processed, packed, or stored.

natural flavor propagation

The propagation of natural food flavors depends almost entirely on the effects of enzymes. Very few seeds have, of themselves, a flavor equivalent to the edible portion of the mature plant. These flavors develop naturally with the

plant and reach their climax at maturity.

Few foods stop flavor production at maturity. In the case of fruits and vegetables, respiration takes place after picking and during storage. During this period desirable flavors may be produced providing storage conditions are optimum. In the case of meat products, enzymatic action also takes place after the death of the animal, causing flavor changes which are considered desirable.

Unfortunately, enzymatic action does not cease with the attainment of the most desirable flavor characteristics. Fruits become overripe and "spoiled" while meat becomes old and rancid. Inhibiting enzyme action by processing steps leads to many flavor changes. Therefore, it is important that any processing which takes place is sufficient to inactivate the undesirable enzyme action and yet cause little change in the flavor.

Broadly speaking, almost everything has some influence on natural flavor. In vegetables, for instance, the variety, climate, growing season, fertilizers used, and even the crop grown the previous year will have bearing. In raising cattle for meat purposes, there are an equal number of factors which will contribute to the flavor of the carcass.

flavor from processing

Processing does many things to flavor. As in all treatments of food, the processing may be beneficial or detrimental, depending upon the process used and the product processed. Boiling of vegetables, for example, results in a large loss of volatile flavor, whereas a pot-roast must be subject to much the same treatment in order to acquire flavor.

Other processing steps also are used to develop flavor. Roasting, at comparatively high temperature, is necessary to develop the flavor of coffee, chocolate, or peanuts. All of these foods owe their typical flavor to a controlled pyrolysis. In baking of breads, cakes, and cookies, a mild browning takes place at the surface, causing a crust. The relative color and thickness of this crust, which in bread contributes most of the flavor, are dependent upon the temperature of the oven and the pH of the batter.

Examples of processes which result in loss of flavor are blanching, condensing, and dehydration. Regardless of how these steps are carried out, a type of steam distillation takes place which results in a loss of volatile flavor compounds. As these compounds are not readily replaced, processing steps involving heat treatment should be limited. This is especially true for vegetable products which have a large amount of such highly volatile compounds.

flavors from storage

All foods, when held in storage, are subject to myriad chemical reactions which will affect their flavor. The chemical changes are not always undesirable. The tang of an aged cheese, the fullness of an aged steak, and the mellowness of some beverages are examples of desirable flavors which are formed on storage. Conversely, products of the browning reaction, uncontrolled hydrolysis, and oxidation normally result in unpleasant flavors.

Physical factors play a most important role in the development of storage flavors. Temperature, light, and vibration are among the more important. Potatoes, for instance, develop a sweet flavor, due to starch

---

Dr. George W. Kurtz, this article's author, is pictured and biographized on page 315 of this issue.

breakdown, if held below 40° F. In storage of citrus fruits, temperatures below 50°F. do not allow the production of desirable flavor, yet do not inhibit the production of undesirable flavor compounds. The effect of light is best illustrated by the adverse effect light storage has on fatty foods, particularly in the presence of oxygen. Vibration causes bruising of a storage item by rupturing the cell structure, allowing enzyme action to take place uncontrolled.

Another factor which is manifest in storage is the location of the commodity. Odors may be picked up from the ambient atmosphere, as is known by any housewife who may have stored melons or onions in the household refrigerator.

flavor enhancement

The natural flavor of a food prior to processing is due to distinct chemical compounds present in the food, some of which are volatile and some non-volatile. During processing, in which heat or vacuum treatments are used, a large portion of the volatile material is lost. In addition, the processing step may cause some of the chemical compounds in the food to interact, yielding a noticeable processed flavor. The resultant food is thus changed from the natural product.

However, most foods contain a large amount of chemical compounds, called "flavor precursors," which survive the processing step. In a natural environment these precursors would ordinarily be converted to flavor compounds by enzymatic action during the period of ripening or overripening. In the processed foods the enzymes have been inactivated so that the flavor precursors, although present in the food, are never utilized. Thus, natural flavors should be capable of being generated if the proper enzymes are added to the food prior to consumption.

This already has been found to be the case. Recently, the Quartermaster Research and Development Command has sponsored research which has led to successful flavor enhancement in processed foods by use of enzyme systems. Foods thus prepared have a flavor which has distinctly more natural quality than untreated control samples. Cabbage, horseradish, onions, tomatoes, watercress, carrots, and even skim milk have been used successfully as substrates for the regeneration of natural flavor. In almost every example cited, the typical flavor of the fresh product has been produced from the dehydrated form of the food. The advantages of utilizing this system in feeding dehydrated rations are tremendous, both from an acceptance and a logistical viewpoint.

The source of the enzyme systems is worthy of particular mention. In all cases, the enzyme systems can be isolated from the raw product upon which they are to act. An example of how a complimentary process might be worked into present processing can be given for cabbage. In the dehydration of cabbage, the outer leaves and the core, which make up the waste material of the process, amount to about 25 percent of the raw material. Enzyme systems isolated from this waste have been successful as flavor enhancers of the dried form.

A rather novel discovery in this field has been that members of the same botanical family are capable of contributing enzyme systems which will react with another member of the same family to give the natural flavor. The enzyme system, myrosinase, available in comparatively large quantities from white mustard, will enhance the flavor of dried cabbage so that it tastes more nearly like the fresh product. The myrosinase reacts with the flavor precursor, sinigrin, to give three products: a salt, potassium

bisulfate; the sugar, glucose; and the compound actually responsible for the flavor, allyl isothiocyanate. This latter compound is one of the major chemicals responsible for the sharp, biting flavor in cabbage.

flavor future

In general, the complex of sensations called flavor has both objective and subjective aspects. Objectively, it is known that: (1) every component of a food contributes in some measure to its flavor and cannot be removed or altered without change in over-all product flavor; (2) any processing operation will have an effect on flavor (although this is not always deleterious); and (3) storage of foods brings about many chemical changes from without and within, most of which are undesirable. Subjectively, it is known that the natural flavor of a food is a result of preference at any given stage of maturity (e.g., some persons have a distinct preference for tree-ripened oranges, while others prefer those picked green and ripened in storage. In either case the flavor is different).

Recent research success has been achieved in employment of enzyme systems to regenerate volatile flavors. Since this method of flavor enhancement depends to a large extent on the amount of non-volatile flavor precursors present in the food, methods of processing should be used which preserve precursor content. For this reason processing methods are being re-evaluated at the Institute and elsewhere in order to determine optimum conditions both for flavor content and precursor content.

REFERENCE

HEWITT, E. J., MACKAY, D. A. M., KONIGSBACKER, K., AND HASSELSTROM, T. The role of enzymes in food flavors. *Food Technology*, 10, 487 (1956).