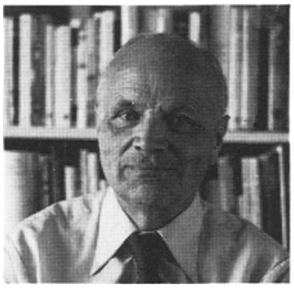

Technical Application of Protein Whipping Agents in Sugar Confectionery

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INTRODUCTION

Aeration, the incorporation in a food of a very great number of very small air cells, finds application in various food fields. By creating a foam structure, of course, primarily the density is reduced or the volume increased. At the same time, however, drastic changes occur in a number of aspects, including texture, consistency, appearance and digestibility.

Although aeration as a technique for modifying and improving foods has only fairly recently been studied to any extent, its practical value has been recognized long ago and a number of traditional candies depend on aeration for their typical characteristics. Among them: nougat de Montélimar, Torrone and Marshmallow. To create a foam structure, the system to be aerated must contain a suitable concentration of a suitable surface active agent and a sufficient amount of energy must be applied to the system.

SURFACE ACTIVE AGENTS

The surface active agent, used in aeration – usually designated as whipping agent – is essential for two reasons. In the first place, it will faciliate the creation of a foam and reduce the amount of energy needed for that purpose. Second, it will stabilize the foam. All dispersed systems show a strong tendency to collapse, they tend to revert back to the two constituent phases, in the case of foams: gas and liquid. Foam stabilization is due to the formation of stable molecular layers in the gas liquid interface. Substances that show good foam stabilization show a strong tendency to forming interfacial layers. Generally, whipping agents used in food production are proteins or are derived from proteins.

PROTEIN-BASED WHIPPING AGENTS

Although most water soluble proteins show a tendency to form foams in aqueous solutions, few can be considered as whipping agents in the sense discussed here. The requirements such a protein or protein derivative must meet can be summarized as follows: (a.) soluble in water and sometimes in concentrated sugar solutions; (b.) soluble at a wide range of pH; (c.) excellent foam formation; (d.) active over a wide temperature range; (e.) foams formed sufficiently stable; (f.) foams formed show minimum stability against the presence of lipids; (g.) in all respects acceptable for use in food; and (h.) reasonable cost price relative to use level.

A review of the protein products used for practical aeration purposes would in the first place include the traditional egg white and the products derived from it: pan-dried or spray-dried egg albumen (1). These products are used in a wide range of foods, including meringues, soufflés and nougats. They are typical "natural" products in the sense that their technical performance is difficult to standardize. Egg products are often contaminated through microbiological infection, including possibly infection with members of the Salmonellae group.

Modern processing – that includes a pasteurization step – has done much to reduce the danger (2). Careful pasteurization is essential, as overheating will adversely affect the whipping characteristics. Solutions of egg albumen in water will form rigid gels when heated to over 70 C. This thermal gelation is strongly affected by the presence of sugar in the solution. With increasing sugar concentration, the temperature at which gelling occurs is progressively increased, and at sufficiently high sugar concentrations, the formation of the gel is inhibited completely (3).

A second group of proteins used extensively for whipping is that of the gelatins. Gelatin, hydrolysis product of collagen, is unique in being at the same time a whipping and a gelling agent. This can be a definite advantage, but it may, under a different set of circumstances, easily be a considerable disadvantage. Such raw materials as eggs, skins, and bones inherently show wide variability, and it is difficult to standardize within narrow limits the functional properties of ingredients derived from them. The differences in performance between various lots of egg albumen or gelatin will perhaps not cause trouble in small, batch type production; they may well be large enough to give serious difficulties in automated continuous production.

Efforts have been and are being made to obtain better standardization. Consequently, there is, particularly for the industrial application, a wide interest in a group of whipping agents that we, for want of a better expression, will designate as the newer whipping agents. These are natural products, factory produced from animal or vegetable proteins by the aid of complicated processes. These processes, usually including some form of controlled hydrolysis, transform natural occurring proteins into whipping agents. By varying the hydrolysis conditions and by other means, the specific characteristics of the products thus obtained can be adapted to any particular set of requirements. Moreover, it is possible to eliminate the variability inherent to all natural products and to produce whipping agents that meet given specifications consistently. As starting material for these newer whipping agents, proteins isolated from soybeans (4), wheat and milk (5), have been proposed.

Foam stability, as mentioned earlier, largely depends on the formation of molecular layers in the gas liquid interface. In the case of protein-based whipping agents, these layers are stabilized by the formation of two dimensional protein networks.

Due to their surface activity, protein molecules tend to move into any new interface formed. During that transition, they undergo conformational changes (6). Originally present in the solution in some coiled form, on moving into the interface the molecules will unfold more or less completely. The elongated molecules will aggregate through chemical or other linkages to form networks.

EXPENDING MECHANICAL ENERGY

The second factor essential in creating foam structures is expending sufficient energy on the system. This energy is needed to overcome the interfacial tension during the very

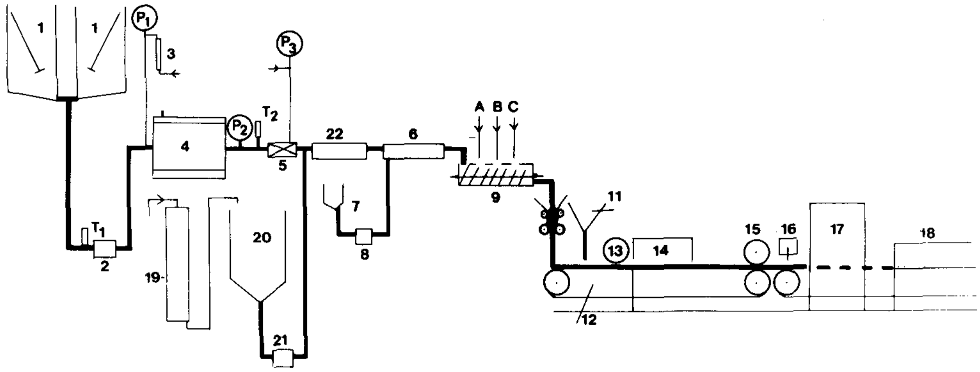

FIG. 1.

considerable increase in the amount of interface. The amount of energy actually expended on the system bears no direct relationship to the energy needed for surface expansion. Most of the energy supplied is consumed in overcoming viscous friction. Various techniques for supplying the energy exist. In the case of aerated candies, by far the most important method is the one that relies on the direct application of mechanical energy through beating or whipping. The liquid or semiliquid system is brought and kept in violent motion in the presence of the gas, usually air. During the process, the amount of gas incorporated steadily increases – provided that a sufficient volume of gas is available – until a maximum volume is obtained.

EQUIPMENT FOR AERATION

When considering the equipment available commercially for performing the whipping operation in an industrial manner, the following characterization based on type of equipment and operational conditions is proposed: (a.) batch operation at atmospheric pressure; (b.) batch operation using compressed air; (c.) continuous operation using compressed air and static dispersors; and (d.) continuous operation, using compressed air and rotating dispersors.

In batch operation equipment, a certain quantity of the mix to be aerated is placed in the machne and is then beaten until the desired volume of air is incorporated and the desired density has been obtained. The beating can either be performed in an open vessel, using atmospheric pressure, or in a closed vessel, where a higher pressure can be maintained. In the latter case, the foam formed initially will further expand when released to atmospheric pressure at the end of the process.

The typical examples of equipment for batch operation under atmospheric pressure are the small household beater and the planetary mixer. The latter is a most versatile piece of equipment widely used in all sorts of whipping and blending operations in the bakery, kitchens, small confectionery plant, etc. The planetary mixer is badly adapted to industrial processing because of the relatively large amount of labor needed. Batch operation pressure beating machines are far better adapted to large scale processing and are easily incorporated into a production line. This is mainly because the aerated batch is transported quickly and cleanly by ejecting it from the bowl by the use of residual air pressure.

Equipment for continuous whipping always consists of some sort of mixing head, into which the batch to be aerated is metered under pressure, together with the required amount of gas. A definite pressure is maintained in the mixing head and again, when leaving the machine, the foam will expand, giving an extra volume increase. The degree of aeration can be controlled conveniently by controlling the volume of gas going into the mixing head.

An important point in choosing continuous equipment is the heat exchange capacity provided. Beating, of course, generates considerable heat, and when the batch under consideration needs to be kept below a given temperature, heat exchange surface is an important factor.

Equipment using static dispersors is, due to limitations of the amount of energy available for whipping, restricted to systems that are fairly easy to aerate.Typical examples are the small whipped cream dispensers. In all those cases, where the output is sufficiently large to merit continuous operation, equipment using motor or driven dispersors is preferred. Continuous aerating equipment of this type, combined with continuous fluid and dry metering devices and continuous mixers, can handle the production of almost any type of aerated food.

FORMULATION

In establishing formulas and techniques for the production of aerated foods, the overall composition of the food under consideration is of prime importance. The performance of whipping agents is greatly influenced by such factors as viscosity, soluble dry solids content and the presence of foam-inhibiting substances, including fats and oils, alcohols, certain flavoring materials, etc. These factors, affecting different whipping agents differently, will determine what whipping agent to use and in which way aeration is best carried out. Formulation-wise, the actual aeration process can be carried out in two basically different ways.

In one-step or all-in aeration, all or nearly all of the ingredients entering into the recipe are combined and the whole batch is aerated by direct whipping. The system is very simple to use, but restricted in its application to fairly high moisture lines and to those cases where no foam-inhibiting substances are present. If for either of these two reasons the the one-step process is not feasible, use must be made of two-step-aeration, as shown in Figure 1. Now, first a part of the ingredients, always including the whipping agent, is aerated to a foam, and the rest of the ingredients, in the form of a hot concentrated sugar solution, perhaps including fat and fat-containing ingredients, is then blended in carefully. This process is more complicated to carry out, but its scope is very much wider. Whether in a particular case one step or two-step-aeration is chosen will not only depend on the composition and on the degree of aeration required, but also on the equipment already available and the output desired.

APPLICATION

It was earlier pointed out that in food processing aeration is proposed for two different purposes: (a.) improving texture and appearance and (b.) reducing the density. Both considerations are strongly affected by the degree of aeration used. The degree of aeration can be expressed as the volume percentage of gas incorporated or – more practically – by means of the density of the aerated product in comparison with that of the nonaerated product. Considerable improvement in texture, consistency and appearance can often be realized through a quite moderate degree of aeration: even as little as 10 or 20 (volume) % of gas incorporated may result in considerable improvements of the organoleptic aspects. Too high a degree of aeration will usually have a negative effect. Introducing gas into an article sold in a predetermined volume means a reduction of the piece weight, the amount of raw materials needed, and thus the cost price. Aerating an article sold at a predetermined weight means a bigger piece or pack volume and thus a better sales appeal. Quality aspects and economic aspects can often be combined profitably. It is, however, always essential to first establish the optimum degree of aeration and to control this degree accurately during production.

SUGAR CONFECTIONERY

We have already mentioned that sweets are perhaps among the oldest aerated foods produced industrially. Such long established articles as the "nougat de Montélimar" (7) and the Italian "torrone" are clear examples of foods where aeration is essential for obtaining the typical texture. We can usefully divide confections in three groups, based on their degree of aeration.

In typical light candies, marshmallows, and meringues, the density is reduced from 1.30 g cm^{-3} for the nonaerated batch to below 0.45 g cm^{-3}; for very light centers, it can even be reduced to 0.16 g cm^{-3}. These products show a very special texture, an extremely large volume compared to weight, a low price per unit volume, and are consequently popular with the very young.

In the second group of products, the volume of air incorporated is much more restricted, a density of ca. 0.80 g cm^{-3} is considered to be near the optimum. This is sufficiently low to produce the desired texture and to reduce sweetness and cost price, but not low enough to give the consumer the impression of buying air. Included in this group are the various nougats, the fruit chews and the chocolate coated bars.

Finally, we have in the third group those articles where the density is reduced by only 10 or 20% to perhaps 1.10 or 1.20 g cm^{-3}. Even this limited aeration is, as already mentioned, sufficient to bring about important improvements in consistency, texture, and appearance. Typical for this group are the fondant cream centers.

As an illustration of how aeration is used in confectionery, a more detailed discussion of the production of nougat bars is of interest. These chocolate coated bars have become enormously popular, and for many years have now been the line expanding most rapidly. The center of a nougat bar consists of a blend of sugar and corn syrup (glucose) with a moisture content of perhaps 6-10% that by means of 0.3-2% of a whipping agent is aerated to a density of 0.6-1.0 g cm^{-3}. A part of the sugar is usually present in the form of very small crystals, giving the mass its short texture. Auxiliary ingredients, such as cocoapowder, fat, milk products, flavors, nuts, etc. may have been added as well. The production by two-step-aeration may be carried out by continuously aerating a 65% sugar syrup containing the whipping agent to a density of 0.20 g cm^{-3}. The foam thus obtained is, again continuously, blended with a hot sugar-glucose mix boiled to 126-130 C, moisture content 5-7%, resulting in a heavy foam, density 0.50-0.60 g cm^{-3}. This heavy, hot foam is finally mixed with the auxiliary ingredients, generally including a few per cent of small sugar crystals to initiate crystallization. The finished batch, temperature ca. 80 C, is spread out in the desired thickness, allowed to cool and cut to the desired dimensions. The pieces thus formed are then chocolate coated.

FLAVOR REQUIREMENTS

Correct (consumer-accepted) flavoring of a food may well spell the difference between commercial failure or success. Finding the right flavor for a new food is therefore an essential part of the development work. Extensive consumer testing will be needed. In the case of aerated foods, the flavors chosen should meet a number of special requirements: (a.) not interfere with a whipping process; (b.) not adversely affect the physical stability - shelf-life; and (c.) be stable against air (oxygen). The first point particularly applies in those cases where one-step aeration is proposed and the flavors have to be added to the batch prior to aeration. Special flavors are now available for this purpose. Because of the special requirements mentioned, finding the right flavor needs, in the case of aerated foods, more than ever the full cooperation(8) of a well established flavor-house, preferably with experience in this particular field.

CONCLUSIONS

Aeration through the use of protein-derived whipping agents provides a versatile tool for improving a number of aspects of candies, including their texture and consistency. Accurate control over the degree of aeration is essential. To achieve this whipping agents that show constant performance are needed. The products obtained through controlled modification of natural vegetable or animal proteins fill this need. By using formulas based on these products and modern continuous processing units, the large scale production of various types of aerated candies can be achieved consistently.

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