SOME RECENT VIEWS ON RECONSTITUTABILITY AND KEEPING QUALITY OF MILK POWDER

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(Received for publication April 22, 1968)

The chemical and physical properties of milk powder are influenced by several factors, including its composition, method of manufacture, storage conditions, and the reconstitution procedures *(18)*. The predominant use of milk powder has been in human nutrition. The complex nature of milk powder poses several problems for its evaluation. For example, the physical state of casein is a factor limiting the rate of dispersion of dried milk *(4)*, and in the manufacture of milk powder, if condensing of preheated milk is omitted, wettability is poor but any additional heat treatment after condensing the milk produces an adverse effect. With the introduction of a recombination process, which involves reconstitution of skim milk powder and emulsification of milk fat into skim milk, the study of the physico-chemical aspects of milk powder is becoming of greater interest. This article deals with reconstitutability and keeping quality of milk powder and their relation to dairy problems.

Of the various processes that are used to dry milk, spray drying is by far the most popular. Lesser quantities of milk and other dairy products are roller dried.

RECONSTITUTABILITY

In recent years a considerable emphasis has been placed on the problem of manufacturing very readily soluble skim milk powders, often called "instant" powders. Since 1954, the production of instant nonfat dry milk has increased rapidly. Practically all nonfat dry milk for home use is now instantized.

Instant nonfat dry milk may be made by any one of the three general methods viz. *(a)* single-pass instant, *(b)* agglomerated instant, and *(c)* puff instant. In most commercial manufacturing methods, agglomeration of powder particles is accompanied by surface wetting, clumping, then redrying. Among the factors affecting instantizing (or agglomeration) moisture content and particle size are quite important. A mimimum of fine particles, less than 20μ in diameter is desired with the preferred particle range of 25 to 50μ.

The problems in manufacturing a satisfactory instant dry whole milk, have been more difficult largely because of the presence of milk fat in the system. Disperisibility of dry whole milk (26% fat) is the lowest (31.9 g) compared to products with lower fat contents *(21)*. There is presently some commercial production of foamed spray dried nonfat dry milk as well as dry whole milk. The foam-dried whole milk although little different in wettability from the normal spray dried particles, disintegrates rapidly once contacted by water.

A perusal of the literature shows that increasing attention is being paid to the reconstitution of dried milk *(18)*, although the reconstitutability of milk powder is a poorly defined and complicated concept. The subject has been quite extensively reviewed by Coulter and Jenness *(12)*. The task of describing a method which includes all properties and definitions involved and which applies to different local conditions therefore, is difficult.

The first stage in reconstitution after the initial contact of water is the wetting of particle surfaces *(16, 20)*, which is followed by water absorption and swelling of proteins and solution of soluble constituents *(7, 22)*. However, smooth progress of the reconstitution process and properties of the product obtained depend upon manufacturing and storage conditions, which affect the nature of the powder particle.

Part of the difficulty of rapidly reconstituting milk powders in water lies in the number of different reactions which occur when milk powder and water are brought into contact with each other. Wettability, dispersibility, and solubility appear to cover most of the reactions involved and are suggested as a basis for discussion by Abbot and Waite *(2)*. These workers define them as:

Wettability: the rate at which a mass of milk powder is penetrated by, or sinks into, quiescent water.

Dispersibility: the degree of separation of wetted powder particles in water.

Solubility: the degree to which the constituents

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of milk powder can be brought into solution or stable suspensions.

Experiments of Abbot and Waite (2) demonstrate that in characterizing the reconstitutability of milk powders, particularly in relation to domestic use of "instant" milk powders, the test method should take into account all three characteristics of wettability, dispersibility, and solubility rather than of any single characteristic. However, for day-to-day factory control, a wettability test coupled with a solubility measurement, both providing results quickly, would provide useful information. The surface of the individual particles of skim milk powder is readily wettable. However, wettability decreases with an increase in the fat content *(21, 24)*.

Rate of dispersion of milk powder during reconstitution is also considered as one of the factors by which a powder is judged. The first stage of the dispersion of any powdered material is the wetting of the solid particles by the solvent. Milk powders have a very wide range of wettability. Some samples sink readily upon coming in contact with the solvent, whereas others remain floating on the surface. Several methods for the estimation of wettability are already in use *(5, 6)*. Muers and House *(22)* have proposed a simple method for comparing the wettability of "instant" spray dried separated milk powders. According to this method a layer of powder, spread evenly over a defined area of a piece of easily permeable cloth, is caused to float on the almost quiescent surface of water rising through the cloth. The time taken for the sample to be wetted is recorded. Wetting times vary from a few seconds for good "instant" powders, to several minutes for ordinary spray dried powders. Muers and House *(22)* have also demonstrated that particle size is the most important factor controlling ease of wetting. As rightly pointed out by Coulter and Jenness *(12)* the situation of dispersibility with dry whole milk is somewhat confused. Rapid cooling of the powder and coating with a surface active material (e.g. lecithin) are suggested for improved wettability *(24, 26, 31)*.

According to Samkammer *(25)* wettability of whole milk powder depends upon the amount of free fat only to a certain degree, and solubility of "instant" powders is somewhat decreased after extracting the fat. The reason for this is supposed to be an impairment of the capillary active effect of the spaces between the agglomerated particles. Ultimate solution of any powder, is dependent upon the extent of casein destabilization. Reduction of the hydrophilic properties of the milk protein has been claimed by Kennedy and Spence *(15)* to improve the reconstitutability of dry milk.

Numerous methods for determination of the solubility of milk powder have been devised. Broadly they may be divided into two groups: *(a)* those which may claim to a more exact determination and *(b)* those which give a more or less conjectural figure. The more exact methods are too elaborate to be of any practical importance to industry. A simple and fairly accurate method has been proposed by the American Dry Milk Institute *(8)*. Both Falkenhahn *(13)* and Cone and Ashworth *(9)* also find a certain correlation between the more exact methods and the American Dry Milk Institute (ADMI) method. Steen *(27)* is of the opinion that better results for the solubility of milk powder can be obtained if a more gentle mixing is used in the ADMI method.

KEEPING QUALITY

The keeping quality of milk powder is limited by bacteriological and chemical processes. Decomposition of milk solids by bacteriological transformations can be effectively checked by reduction of moisture contents to a level below the minimum required for their growth *(14)* because the stability of dry milk during storage is critically affected by the moisture content and storage temperature. High moisture levels, resulting from inadequate dehydration or reabsorption of atmospheric moisture promote insolubilization at relatively mild storage temperatures. The rate of solubility loss is a function of both concentration and temperature *(10)*.

A number of other significant changes also occur in high moisture milk powder in addition to loss of solubility. For example, *(a)* the lactose is gradually bound by the protein, *(b)* the pH decreases steadily, and *(c)* characteristic changes associated with the Maillard reaction between sugars and amino nitrogen become apparent including development of brown discoloration and production of carbon dioxide *(30)*. The loss of protein solubility in dry milk is generally attributed to the sugar-protein interaction. Changes in the stability of the caseinate-phosphate complex are also responsible for the loss of solubility. According to Manus and Ashworth *(19)*, the solubility of spray-dried powder is unaffected by preheat treatments of fluid milk that cause serum protein denaturation. The influence that forewarming of milk exerts on stability of the evaporated product to sterilization temperatures indicates that proteins of milk interact in a way which interferes with and reduces heat denaturation of the proteins when they are subsequently given a high temperature treatment. Heat-induced reactions, which have been shown to increase the stability of milk proteins include a casein-β lactoglobulin interaction and protein-lactose binding. Addition of stablizers is used mainly in commercial practice to ensure a fluid finished product. Stabilizers are soluble salts whose anions complex or precipitate calcium, and as the casein in heated milk is more sensitive to calcium than it is in unheated milk, stabilizers are considered to exert their protecting influence by removing calcium which might otherwise form an interpolymer link between altered casein molecules causing them to aggregate and precipitate.

According to King *(17)* the dry milk particle has a primary physical structure comprised of the milk solids in which is dispersed the moisture and air cells. The physical mass of the particle (nonfat dry milk and dry whole milk) is dominated by lactose presumably in which the proteins, fat, and minerals are more or less dispersed. Lactose in dry milk may be in the amorphous or glass (non crystalline) form and as α monohydrate crystals and β anhydride crystals. In the amorphous state lactose is very hygroscopic and as sorption occurs, the lactose becomes sticky and this initiates adherence of the milk particles to each other. With sufficient moisture and time a solid mass is formed through continued crystallization of lactose. The instantizing process for producing readily soluble powder is somewhat similar. The surfaces of milk powder particles are humidified or partially dried so as to facilitate partial crystallization before the particles are redried *(23)*. This produces a clustering of the particles in loose, spongy aggregates which are readily dispersible in water. Careful control of conditions of rehydrating, holding to allow agglomeration, and redrying are very important to preserve the solubility of the powder. Unfortunately little technical information is available on the process.

Spray process dry whole milk is normally prepared from milk which has been preheated to a temperature sufficient to denature essentially all of the whey proteins. The effect of heat treatment of the fluid milk in stabilizing against oxidation of the fat in the dry product has long been recognized. Assuming average conditions of milk quality and processing, oxidation off flavors become noticeable in about three months when dry whole milk is held at 70 to 75 F (air packed). Among the many factors influencing the rate of milk fat oxidation, metallic contamination from copper and iron is one of the most important. Attempts have been made by several workers to use antioxidants to avoid high heat treatment of the milk but, unfortunately, none of the antioxidant has been claimed to be more effective than heating the fluid milk *(1, 28)*.

Milk powder in hermetically sealed packings is safe against reabsorption of moisture under unfavorable conditions and therefore, any deterioration of the quality of the powder is seldom of a bacteriological nature. The chemical processes in whole milk powder are very difficult to stop completely. The most common defect in whole milk powder is the tallowy flavor caused by the oxidation of the butter *(14)*. Aceto et al. *(3)* have reported on some storage aspects of continuous vacuum foam dried whole milk made, handled, and packaged with virtually no contact with oxygen. Difficulties encountered in producing low oxygen content packs apparently relate to milk powder particle structure *(29)*.

Keeping quality of milk powder has become increasingly important in recent years particularly in view of shipping dry milk to developing nations of the world having widely ranging weather conditions and lack of other facilities.

Browning as such is not a primary problem in dry milks. Milks dried to moisture levels below 5% show essentially no change in color even during a 2-year storage at 37 C. However, because of the very hygroscopic nature of milk powder, initial satisfactory moisture levels are no guarantee against browning. The subjects of browning and related changes in dry milk systems have been reviewed quite extensively by Coulter et al. *(11)*.

ACKNOWLEDGEMENT

The interest of Professor Robert Jenness, Department of Biochemistry, University of Minnesota and of Dr. J. M. deMan, Department of Food Science, University of Guelph in this article is gratefully acknowleged.

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AMENDMENT TO 3-A SANITARY STANDARDS FOR MULTIPLE-USE PLASTIC MATERIALS USED AS PRODUCT CONTACT SURFACES FOR DAIRY EQUIPMENT

Serial #2003

Formulated by
International Association of Milk, Food and Environmental Sanitarians
United States Public Health Service
The Dairy Industry Committee

The "3-A Sanitary Standards for Multiple-Use Plastic Materials Used as Product Contact Surfaces for Dairy Equipment, Serial #2000," are hereby amended as indicated in the following:

Section I. Standards for Acceptability, Sub-paragraph (2):

Add the following material to the list of Generic Classes of Plastics:

Reinforced Epoxy, molded, natural (no color added), and black.	.20	.25	.35

This amendment shall become effective Aug. 28, 1969.