The Preparation and Use of Sweet Whey in Powder Form

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THE PREPARATION AND USE OF SWEET WHEY IN POWDER FORM

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In considering the many products which are produced from milk, such as milk sugar, casein, milk flour, butter, cheese and condensed milk, it seems strange that one of the most valuable by-products of milk, namely whey, has never been preserved in permanent form.

Whey contains very valuable food materials, but in a very dilute state. An average composition is that given by König as the result of forty-six analyses :

Fat.....	0.32
Proteid.....	0.86
Sugar.....	4.79
Salts.....	.65
Total Solids.....	6.62
Water.....	93.38

Eliminating the water, the solids show the following composition :

Fat.....	4.83
Proteid.....	13.00
Sugar.....	72.36
Salts.....	9.81

Practically speaking whey may be considered as milk from which the casein and most of the fat have been removed. It may be produced in two ways, either by the action of a dilute acid, or by means of an enzyme, such as rennet or pepsin. If the whey is to be used for food purposes, rennet is usually employed, as it will act in neutral or slightly acid solutions, and may be used to produce a sweet whey. The addition of rennet to milk causes the casein to coagulate, carrying down with it the butter fat enmeshed. The whey separates from the curd as a clear yellowish liquor, sweet at first, but developing acidity rapidly. The proteid of the whey is largely lact-albumen. The carbohydrate is milk sugar, and the ash comprises the mineral matter of the milk. Rennet acts best at a temperature of 106° F (41° C). At this temperature, and for several degrees on either side, the curd produced is very firm ; at low temperatures, 15° to 20° C, the curd is quite soft, and when the temperature is raised to 50° C. the curd produced is also soft.

Whey usually contains some butter fat and more or less small particles of curd depending on the temperature at which the rennet action takes place and the care used in cutting the curd to free the whey.

The value of whey as a modifier of milk or cream is accepted. It contains, as we have seen, all of the ingredients of fresh milk except the casein and fat. Its proteid is largely lact-albumen, which together with the milk sugar and mineral matter form a desirable adjuvant with which to properly balance the ingredients of cows' milk to produce a synthetic milk for the use of the infant.

The ratio of albumen to casein in cows' milk is 1 to, perhaps, 4 or 5. The ratio in human milk is 1 to, perhaps, 1 or 2. The desirability of increasing the lact-albumen of cows' milk in proportion to the casein by the addition of whey is at once apparent.

As a matter of fact fresh liquid whey, in spite of its many advantages, is but little used. For one thing it is not easy to prepare, for another it is rarely uniform unless the greatest care be exercised as to temperature and methods. It usually contains a varying amount of coagulated curd in small particles. It must often be freshly prepared, as it sours rapidly. Last but not least, it contains so much water, 93% or more, that when mixed with milk or cream it forms a milk which is so dilute that it furnishes insufficient nourishment for any but very young infants.

To put this a little more plainly, let me say that 15 ounces of whey contains approximately 14 ounces of water and 1 ounce of whey solids. Modified milks usually require 10 or 11 ounces of water to one ounce of whey solids in order to agree closely with human milk as regards the proportions of the different ingredients.

Whey is quite frequently used as a food for adults on account of the ease with which it is assimilated. Liquid whey cannot however be used exclusively to nourish an adult on account of the large amount of water which would necessarily be ingested to secure the requisite amount of nourishment.

It is quite evident that to fulfill its greatest usefulness whey should be prepared in the form of a permanent dry powder after the fashion of milk sugar so that it need only be dissolved to be ready for use.

A little study of the history of milk preservation makes plain the reason why whey has not hitherto been thus prepared. It contains nearly all of the lact-albumen of the milk. This albumen coagulates at a comparatively low temperature and is rendered partially or wholly insoluble if an attempt be made to reduce or remove its water content by any process which necessitates the use of a

temperature above 160° F. An illustration of this fact is found in the albumen of condensed milk which is considerably reduced in solubility by the sterilizing heat used to make the condensed milk keep.

Whey is even more sensitive to heat than milk, for on account of its large milk sugar content, acidity develops rapidly and coagulates the albumen, a result which is even less desirable than that produced by too much heat. For this reason it is difficult to remove the moisture content of whey at a low temperature because a slow process would furnish ideal conditions for the development of sufficient acidity to coagulate the albumen.

Many obstacles present themselves in the attempt to produce a powdered sweet whey, but they are not insurmountable, as evidenced by the fact that the author has succeeded in obtaining the solids of whey in the form of a dry powder without in any way altering the solubility of the albumen.

Some description of this process may prove of interest. Sweet whole milk, selected for freshness and quality, is subjected to the action of rennet. The whey is separated from the curd as expeditiously as possible to avoid the development of acidity in the whey. The whey is then pasteurized just above 150° F. to destroy any rennet remaining, which might otherwise act upon milk or cream with which the whey might subsequently be mixed. The whey is then condensed in vacuo at a temperature below 135° F. to about one-fourth of its original bulk. The concentrated whey is then desiccated by projecting it in the form of a fine spray into a current of hot dry air. The liquid particles are deprived of their moisture immediately, and fall like powdery snow.

Strange to say the current of drying air into which the sprayed material is projected may be very high in temperature, say 300° F., without injuring the solubility or life of the most delicate substances, that is to say without even producing pasteurization. At first glance this seems absurd. I will describe how this "air boiling" may be done.

In the first place let me say that I have selected the term "air boiling" to distinguish this process from those in which the liquid is boiled by contact with heated metal. This process boils or evaporates the liquid by contact with heated air. If the liquid is boiled in a kettle, the steam has no way of escape except upward through the liquid. Can you imagine what would happen if each particle of vaporous steam were greedily absorbed by the metal of the kettle as soon as formed?

If a tiny drop of liquid is suspended in heated air what happens?

Evaporation proceeds on all sides of the little sphere, drawing heat from the center of the particle. On account of its spherical form the particle is really being cooled by the rapid evaporation of its moisture. Logically, the hotter the air current the more rapid the evaporation of the moisture, and the greater the cooling effect on the remaining tiny mass of solids. Of course the air current itself is cooled somewhat by the evaporation in which it takes part, and, provided the temperature of the air is reduced below the point of combustion, no harm results from this temporary exposure to heat, and a state of dryness is produced which protects and preserves the tiny particles of material.

The solids of fresh whey evaporated by this process appear under the microscope as amorphous semi-transparent quartz-like masses. The powder is instantly soluble in water, hot or cold, and nothing settles out of solution. In fact upon examination, the fluid cannot be distinguished from fresh whey.

The efficiency of this drying is best understood when I say that I have produced materials containing less than half of one per cent of moisture. Two per cent is the least amount of moisture found in materials dried by any other process with which I am familiar; and ten to fourteen per cent is not uncommon.

The keeping quality of dried organic matter depends largely on its moisture content, and the author is in a position to say that materials of this nature do not keep well if the moisture content runs much above three and one-half per cent.

Chemical change is inhibited by this extreme dryness, and I can say from personal observation that such powders (hermetically sealed) may be exposed to any temperature below the point of combustion without injury. Albumen dried in this way is not coagulated by a temperature of 212° F, and I should deduce from this fact, that the presence of water in certain quantity is essential to coagulate albumen by heat.

To illustrate the delicacy with which this process will remove moisture from organic matter without injury, I will say that I have dried such materials as yeast, diastase, pepsin and certain forms of beneficial bacteria to less than 2 per cent moisture content without impairing their strength, preserving them for two years or more hermetically sealed, and find them unimpaired in vitality on adding water. This extreme dryness can therefore be produced without injuring the most delicate organic substances and is effective in preserving them from deterioration.

The process lends itself with equal facility toward producing powders from fresh eggs, milk and cream. This egg powder has

been used for some time by the United States Navy, and the Navy Department has included seven tons of it as well as a considerable amount of whole milk powder in the supplies for the Pacific Fleet which sails on December 15. The powder made from whole milk has been used for some time by one of the largest Soldiers' Homes in the United States. This is restored with water and served as fresh milk for drinking purposes for the veterans, and the officer in charge prefers it to the local supply of fresh milk, which is of questionable origin.

To return to the subject of whey, I should like to compare the powder with some of the materials commonly used either as complete foods or as milk modifiers.

There are two classes of such materials—those to be used with water and those to be used with milk. Most of the latter require cooking, and contain a considerable percentage of insoluble carbohydrates, usually from 35 to 80%, there being only two foods of this class whose carbohydrates are entirely soluble.

The chief value of all cereal foods is their power of attenuating the curd of cows' milk. It is well known that whey also possesses the power of producing an exceedingly fine coagulum when digested with milk or cream, and in fact nothing else will produce equal results unless perhaps barley water. This characteristic is retained by the powdered whey and must be due either to the albumen or the ash, for I do not know that any one has ever claimed any attenuating power for milk sugar which is so often used to modify milk.

Among the foods intended to be used with water probably the most prominent are malted milk and nestle's milk food. I desire to compare these two products with the powdered sweet whey.

	malted milk _o	nestle milk food _g	whey powder
Moisture	2.55	2.18	1.20
Fat	1.41	4.45	.27
Proteids	14.00	10.72	14.25
Soluble carbohydrates	63.87	43.84	74.45
Insoluble carbohydrates	15.68	35.34	None
Ash	3.57	1.60	9.80

_o Bul. 59 Laboratory of the Inland Rev. Department, Canada.

On examining these analyses we find that the powdered whey contains more proteid than either of the others. This proteid is mostly lact-albumen and is entirely soluble, whereas the proteids of the other two are only partially soluble.

We also find that the whey has no insoluble carbohydrates, and a much higher percentage of soluble carbohydrates than either of

the others, and this carbohydrate is milk sugar. It is also very much richer in ash than the others, and it is safe to assume that the ash of whey is very desirable in promoting the growth of bones and teeth.

It has been suggested to me that a large proportion of the digestive troubles of young infants are caused, directly or indirectly, by difficult or deferred cutting of the teeth. If this should prove to be the case, the use of a whey powder containing a considerable amount of milk ash might be of great value.

The amount of fat in all these products is so small that it should be disregarded. A 10% solution of any one of them would contain less than half of 1% of fat. This is about as close as a centrifugal separator will skim milk, and we are not in the habit of considering that skimmed milk contains any fat.

My reason for showing this comparative table is to illustrate the fact that powdered sweet whey dissolved in water is a much more desirable food for adults or infants than either of the other products above mentioned. You will note that the ratio between the proteids and carbohydrates in whey powder is about 1 to 5 $\frac{1}{4}$, which is well above the accepted nutritive ratio of 1 to 6 or 7.

Probably the best method of using whey powder is to prepare it with water and cream. The cream is low in casein, sugar and ash, but high in fat. The whey is low in fat, but high in ash, sugar and albumen, which the cream lacks. The fact that the whey is dry makes the arrangement of percentages comparatively easy and the number of modifications is practically infinite.

As an illustration of the way in which mixtures containing any desired proportions of fat, proteid and carbohydrate may be produced by the use of cream and whey powder, I have prepared a few formulæ for 20-ounce mixtures. This quantity is easily divided or increased so as to give any desired amount of modified milk. For instance one-half of the ingredients given makes a 10-ounce mixture; one-quarter more of the ingredients makes 25 ounces; and one-half more makes 30 ounces.

I have assumed that the upper 4 ounces from a quart bottle of milk contains 20% fat, and that the upper 11 ounces contains 10% fat. One ounce of 20% cream in a 20-ounce mixture represents 1.00% of fat, 0.15% proteid and 0.20% milk sugar. One ounce of 10% cream in a 20-ounce mixture represents 0.50% of fat, 0.16% of proteid and 0.20% of sugar. Two ounces of milk represents 0.40% fat, 0.35% proteid and 0.45% sugar. One dram of sweet whey powder represents 0.10% proteid and 0.50% milk sugar. It will be evident that if any or all of these ingredients are placed together in a graduate glass, and

water added so that the total quantity equals 20 ounces, the relative proportions of fat, proteid and sugar represented by the percentage given will be maintained.

A suitable mixture for a child three months of age might be prepared as follows:

3 ounces of 20% cream	This represents 3% of fat, .45% proteid and .6% milk sugar.
11 drams of whey powder	This represents 1.1% proteid and 5.5% sugar.
Lime water (if desired)	

When water has been added to make the total quantity 20 ounces there will be 3% fat, 1.55% proteid and 6.1% milk sugar.

For a child 10 months of age the following formula might be utilized:

8 ounces 10% cream	This represents 4% fat, 1.28% proteid and 1.60% sugar.
1 $\frac{1}{4}$ ounces of whey powder	This represents 1% proteid and 5% sugar.
Lime water (if desired)	

When sufficient water has been added to make the quantity up to 20 ounces we have 4% fat, 2.28% proteid and 6.68% milk sugar.

A very desirable formula for adults might be constructed as follows:

20 ounces milk	This represents 4% fat, 3.5% proteid and 4.5% milk sugar.
1 ounce of whey powder	This represents .8% proteid and 4% milk sugar.

The finished mixture would have a total of 4% fat, 4.30% proteid and 8.50% milk sugar. In this case it would not be necessary to add any water. Milk modified in this way would contain about 17% of solids, which is about half as much again as cows' milk usually contains. In this way a very nourishing food is produced which does not require the ingestion of so great an amount of water to secure complete nourishment as if milk alone has been used.

We have seen from the foregoing that a powdered whey may be used in two ways, either as a modifier of milk and cream or as a complete food in itself. The fact that it is a natural product, and that its ingredients practically do not differ in character from their original condition in fresh milk, makes the material especially desirable from an ethical standpoint. The methods used in its manufacture are in nowise secret, and the utility of whey is so well known that it is unnecessary to make any extraordinary claims as to the beneficial results it will produce in cases where its use is indicated.

I wish to say that whey produced by the processes usually employed in making cheese is not suitable for nutritive purposes.

The milk is, as a rule, handled less carefully than that used for domestic consumption or for making butter or condensed milk, for the cheesemaker can add a culture of lactic bacteria (commonly called starter) and induce a vigorous growth of lactic bacteria which will kill off any other germ life which the milk may contain. Both the acidity and the lactic bacteria are very necessary to the ripening of the cheese curd but their presence is not compatible with the production of a sweet whey.

Whey manufactured for nutritive purposes must be prepared from the best and freshest milk from inspected dairies, and must be quickly and carefully treated by laboratory methods under competent superintendence, to produce a sweet and uniform whey in the form of a powder.

NOTE: Its proteids (whey) consist almost entirely of lactalbumin, with a very small proportion of lactoglobulin, and perhaps other soluble proteids in minute quantities. These bodies collectively have been termed the whey-proteids by White and Ladd. The term, however, is rather awkward, and, since lactalbumin forms almost the entire proteid content of the whey, it seems best to speak of the whey-proteids specifically as lactalbumin, and as such the term will be hereafter used.—*Thompson S. Westcott, M. D., Instructor in Diseases of Children, University of Pennsylvania. The American Journal of Medical Sciences, Oct., 1901.*

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