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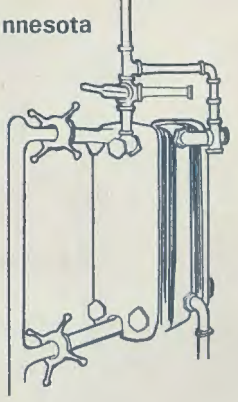
MINNESOTA DAIRY PRODUCTS PROCESSOR



Editor - V.S. Packard
Extension Specialist, Dairy Products

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Cheese processing in the United States generates about 30 billion pounds of by-product, whey. About 60 percent of that whey is processed as useful feed or food products. It's too bad all of it can't be processed, but the high cost of transporting whey output of small plants to an efficiently sized whey processing operation is a deterrent. Nevertheless, Minnesota recently has added some large cheese plants and whey process technology is a topic worth reviewing. But first, let's look at the composition of whey: very much like skim milk.

COMPOSITION OF SWEET CHEESE WHEY

The following figures show a comparison of the gross composition of sweet cheese whey with skim milk.

Component	Skim milk(%)	Sweet cheese whey(%)
Water	90.6	93.1
Protein	3.5	0.8
Carbohydrate	4.9	4.9
Fat	0.1	0.2
Minerals (total ash)	0.7	0.5
Calcium	0.13	0.08
Phosphorus	0.10	0.10

The main difference between skim milk and whey is protein content. The casein has been removed during cheesemaking leaving only the whey proteins: a smaller fraction of the total protein, but one actually more nutritive than casein. By the Protein Efficiency Ratio (PER) method, the procedure most commonly used to determine food value of protein, whey protein concentrates have a value of about 3.2 compared with casein's 2.5. One whey protein, alpha lactalbumin, has been found by some researchers to yield a PER of 4.9. The other major whey protein component, beta lactoglobulin, has a slightly lower PER than casein. By another method of measurement, the Net Protein Ratio, it comes out ahead as good protein. But, how to get it out in useful form? The processes are still being evolved, but a brief coverage will highlight the possibilities.

THE TECHNOLOGIES

There are several technologies being tried -- some in commercial operation -- to extract protein from whey. The common methods involve heat or acid and/or salts. Anyone who has operated a spray drier knows that high acid milk quickly clogs the lines. The protein simply coagulates and cooks on. Similarly, acid or heat or both can be applied to a protein solution to pull out the protein. However, these are harsh methods. The protein is usually denatured. It will never function again quite as it did in its native state. Sometimes this is an advantage, as in the use of denatured protein in sausage processing. Other times it is a distinct disadvantage. There is always need to consider and improve methods of isolating protein by gentler processes. Some such methods follow.

1. Osmosis -- This is not a way of concentrating protein in a liquid, but it is the underlying scientific principle of certain technologies. Place two liquids, one more concentrated of dissolved substances (sugar, salt, etc.) than the other, on either side of a semipermeable membrane. The weak solution will flow into the stronger (more concentrated) one. The process continues until an equilibrium is reached. This is how nutrients enter the bloodstream, body tissues serving as the semipermeable membrane.

2. Reverse osmosis -- As the name implies, this is osmosis in reverse, which simply doesn't happen without force. Put whey on one side of the membrane, water on the other, then apply pressure to the whey to force the movement of liquid in the direction of the water. Though lactose crystallization stops the process at about 25 to 30 percent concentration, whey will be concentrated. Sanitation tends to be a problem and the membrane (cellulose acetate, 1/3 micron thick) tends to clog. Nonetheless, liquid may be expelled from whey without use of heat.

3. Ultra filtration (UF) -- This process is related to reverse osmosis. Less pressure is applied (10-100 psi as compared with 400-800 psi in reverse osmosis). Dissolved substances pass through a relatively coarse membrane, larger particles are held back and concentrated. While water passes from whey in reverse osmosis with the original components retained, UF permits escape of some dissolved substances (sugar and salts), somewhat purifying the protein. Reverse osmosis and UF may be used singly or combined.

4. Electrodialysis -- In this process semipermeable membranes are stacked, an electrical charge is set up, and particles attracted toward oppositely charged poles. A new twist in a technology now in actual operation establishes a negative charge only; the other side, left neutral. Positively charged particles (certain dissolved minerals) are attracted to the negative pole, but proteins simply bounce off the neutral side and are retained. A product containing 29 percent protein (compared with an initial 0.8 percent), and 51 percent lactose results.

5. Gel filtration -- Production models of the technology are presently in operation. Referred to as a molecular sieve, this technology in huge columns of a special gel (Sephadex), allows continuous fractionation of protein. After pretreatment, clarification, and concentration, lactose is allowed to crystallize; the crystals are removed and the mother liquor (containing protein) strained through gel filters. Fractions of from 15 - 85 percent protein are continuously eluted, evaporated, and spray dried.

AND WHAT DO YOU END UP WITH?

These technologies provide a variety of whey products. These foods have not been given official standards, but the Cheese Institute is suggesting the following:

1. Partially demineralized whey -- whey from which a portion of the minerals have been removed: contains no more than 7 percent minerals (or ash) on a solids basis.
2. Demineralized whey -- whey from which minerals have been removed to less than 1.5 percent ash on a solids basis.
3. Partially delactosed whey -- whey from which some lactose has been removed; contains not more than 60 percent lactose on a solids basis.
4. Whey protein concentrate -- a modified whey product containing not less than 25 percent protein on a solids basis.

SUMMARY

Whey products have use in just about any food that uses nonfat dry milk as an ingredient. There are technologies available to process whey into many different products, with different applications for a variety of food systems. The industry having this capability could have a competitive edge in the food industry of the future. For some of these very processes are now being studied for their applicability to protein sources all the way from potatoes to alfalfa. They loom important in our future.

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA
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