

Milkman  
John Bruhn

New Processing  
Concepts

WESTERN  
**Milk**  
AND ICE CREAM NEWS



PHOTO BY JERRY FARR



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On the Cover: "Mr. Milkman" is the definitive title of Dr. John C. Bruhn, dairy processing specialist at the University of California, Davis.

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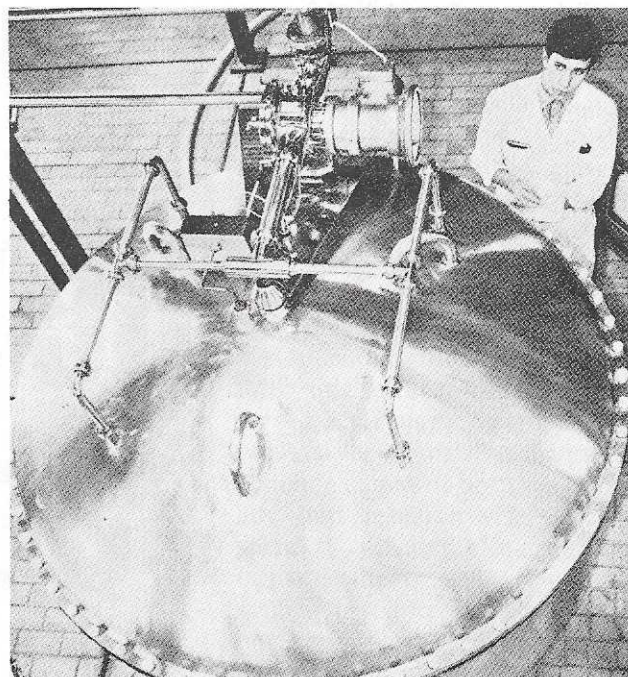
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As the dairy extension specialist for the State of California, John Bruhn translates pure, basic research into a practical form for dairy industry application. Standardization of taste and quality are of particular interest to the "off-campus arm of the University of California."

### Dairy Day at Davis

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The 51st annual meeting of the California Dairy Industries Association was highlighted by the election of officers, presentation of the 1971 dairy awards, and talks by two very distinguished spokesmen of the western dairy industry; Alex F. McCalla speaking on "The Demand for Filled Milk", and R. L. Merson's "New Concepts in Processing Technology".

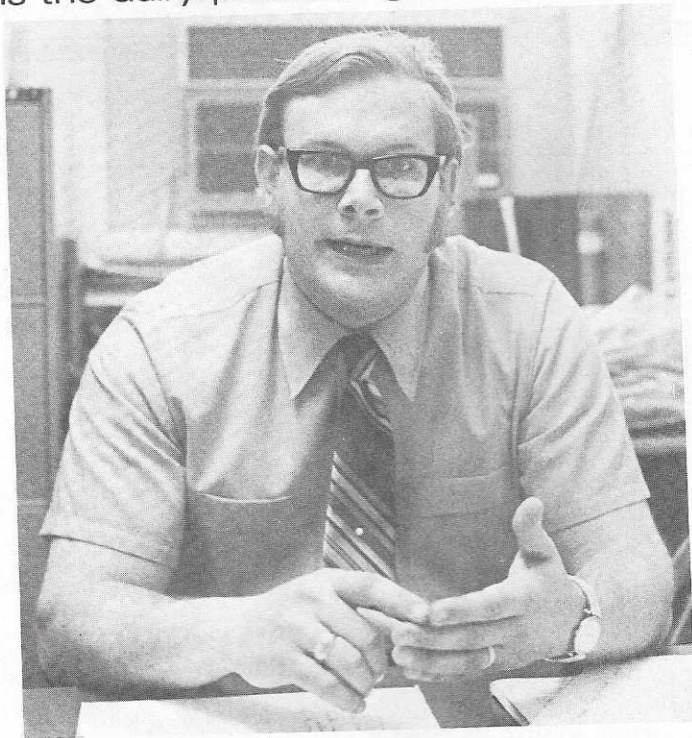


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Dr. John C. Bruhn probably comes closer than anyone else in California to being the definitive "milk man". At least officially, for he is the dairy processing extension specialist for the State of California,



and if as a functioning member of the region's immense dairy industry, you haven't had the opportunity of meeting him, we'd like to introduce you now.

Not only is his own considerable expertise at your disposal, but also the resources of the University of California at Davis, whose findings Dr. Bruhn disseminates to the industry.

# The Milkman: John Bruhn

By RICHARD CLARK CASSIN



**D**r. Bruhn's office and the center of dairy research and education at U.C., Davis are located in the ancient Roadhouse Hall, which until about five years ago was referred to as the Dairy Industries Building. Much of the information you receive from your county extension agents is developed here in the laboratories, and translated into useful, practical information by Dr. Bruhn himself.

Bruhn sums up agricultural extension as the "off-campus arm of the University of California". Along with the Teaching Division and the Experiment Station, the Extension forms the third integral part of the College of Agriculture.

"Administratively," says Bruhn, "we are separate from the Department of Food Science and Technology, but they house the Extension Staff in the departments where their interests lie. The dairy scientists do all their work in the Department of Food Science and Technology, so I'm officed with them. As they develop new information, I take it either directly to the field to solve a particular problem, or—if necessary—I adapt and modify it so that it can be used by the industry. Sometimes it requires my taking it through additional experimentation on the applied level in order to produce usable results.

"The whole concept of 'extension' is to provide a means of translating pure, basic research into practical application. This necessitates a continuous flow of information from the research and teaching staff through the extension people who take it into the field to help a particular industry. The ultimate benefit of this process goes to the consumer. If we can assist the dairy industry to produce and process milk more efficiently, the savings which result are, in some measure, passed on to the consumer . . . through stable or lower prices, or through better quality products."

Except for occasionally being asked in as a guest lecturer, Bruhn

does not teach formally in the University. Some of the Extension Staff people hold down regular teaching schedules, but by and large, they consider their classrooms to be spread throughout the counties of California, where they hold meetings with various groups.

Within the Department of Food Science and Technology, there are four extension food technologists, one for each commodity area: vegetable, meat, poultry, and . . . in Bruhn's case . . . dairy processing. All of them are backed up by the research personnel of that department as well as by those in all of the other agriculture departments and by the farm advisors across the state.

Bruhn travels quite a bit, spending much of his time with the county dairy farm advisors. While they're primarily production oriented . . . trying to get that cow to give more milk . . . Bruhn is attempting to educate them to the needs and problems of the processors. What he's striving for at the county level is to have farm advisors who can work equally well with the processor *as well as* with the producer so that they can form a bridge between the two. One of Bruhn's principal roles is to provide continuous training for the dairy farm advisor, and to bring him new information which will better enable him to work effectively with the industry.

In describing the Extension Service's current program emphasis, Dr. Bruhn explained: "In the two years I've worked for the Extension Service our major thrust has been in the area we refer to as 'milk quality', which is an all-inclusive effort wherein we look at all the factors which effect and/or influence the ultimate quality of the product.

"Currently, most of our milk-quality educational efforts are with the producers, because we feel that the first place to improve milk quality is the point where it is first produced: on the ranch. Then we work through the pro-

cessors on particular projects, and have even held a few meetings with retail store people. The latter isn't a full-blown program yet, but we hope it will be in the future. We want to teach them how to properly store milk and other dairy products, and inform them of the flavor defects which can be caused by improper handling and storage. In one such meeting, we had store owners and managers taste milk in coded containers so they couldn't tell what brand it was, and the manager from whose store the milk came said 'God . . . that's *terrible* milk'. After the meeting we quietly met with that manager to help him solve the specific problems he had which made the milk taste bad. In the few instances where we've been able to meet with retailers, our efforts have been very effective.

**"A**t the dairy level, we're looking principally at feed and management practices, and in the processing plant we deal with any and all procedures which influence quality. We have specific research programs looking at quality problems peculiar to California, and tied into those research programs there are educational projects wherein we meet with various industry groups to discuss the importance of quality, how they can maintain it, and if they have a quality problem . . . how they can correct it.

"Although the broad area of milk quality includes many factors—bacteriology, composition, etc.—flavor control remains our primary concern, both educationally and research-wise, and we spend a considerable amount of our time there.

"We recognize of course, that not being spiced up with paprika and such, milk is a bland product. The consumer is also aware of that fact, and if there are off-flavors, they are noticed immediately. The homemaker tells one milk from the other by flavor. I don't think she's all that aware of the nutritive quality of a particu-



lar brand of milk, but if it doesn't taste good she won't buy it again. Therefore, our emphasis is on encouraging producers, processors, and anyone else who's involved in handling the milk, to market a product that has uniform flavor."

According to Bruhn, most flavor standards are now measured subjectively by tasting the product. Although human taste buds have functioned well in this regard, he feels it would be ultimately beneficial to develop an instrument which would measure flavor . . . or at least the very critical flavors that the consumer considers objectionable. As yet, however, the University has no active program along these lines, although Dr. Dunkley and others

"The technology to develop such equipment is now available. We have, for example, an instrument which measures oxidized flavor quite accurately, but its cost is really quite high. This means that the industry has to evaluate the cost-benefit of an instrumented approach to measuring flavor. There are many who feel that using one's own taste buds gives adequate control, and indeed in California, at least, that seems to be true, for on the whole, California milk is an extremely high-quality flavored product. This is consistent with our findings in meetings across the country that the California dairy industry is far ahead of other states in its consciousness of fla-

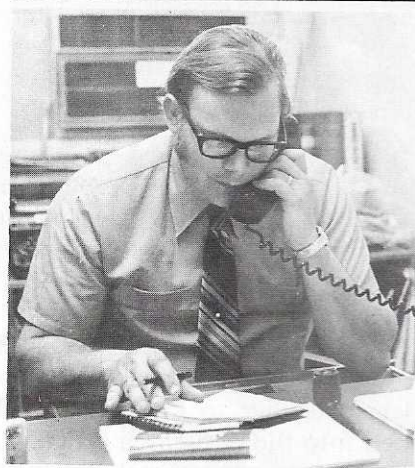
customers have become accustomed to it. This is where an instrument measuring flavor would be extremely valuable, assuring that flavors such as the slight feed flavor would remain at desirable intensities. It would then be possible to market a uniform product with uniform flavor.

"I'm pleased," says Dr. Bruhn, "that the dairy industry in California has accepted our milk-flavor program, and is striving to market products with uniform good flavor. I'd like to see other states become involved in this program, and at national meetings we've given papers describing the California program in hopes that it will catch on elsewhere.

"Compared with other food processing industries, the dairy industry is way ahead in terms of sanitation, engineering, and almost all related processing steps. In the early days, legislation regulating sanitary standards for the dairy industry gave us a head start. More recently, however, legislation has not played as important a role in generating improved technology. Today it's economics . . . the need for greater efficiency . . . that motivates such changes.

"In the future, the principal efforts of technology will be directed toward the development of products with longer shelf-life, applying techniques of ultra-high temperature heating, and aseptic techniques associated with surgical procedures to be sure the product doesn't become contaminated while being processed. Sterilized milk products are an example of a relatively recent technological change designed to increase shelf-life of the items. Although such sterilized products are extremely acceptable, they do have a somewhat different flavor, and present problems of stability in sealed containers. Condensed products have a tendency to thicken in storage . . . their physical properties are subject to change.

"However, I don't feel it's necessary to move in the direction of sterilization of fresh milk yet, because properly applied, the con-



"Compared with other food processing industries, the dairy industry is way ahead in terms of sanitation, engineering, and almost all related processing steps."

at Davis have done some work in the instrumentation of flavor analysis. Bruhn indicated that there are plans for the coming year to use currently available instruments in an effort to quantify flavor. If this is achieved, it will be possible to set flavor standards . . . at least guidelines.

"If you can quantify a flavor," says Bruhn, "like oxidation . . . at least you can eliminate doubt (within the accuracy of the instrument) that it's oxidized. Whenever we conduct a program where the participants taste milk with various flavors, there's always somebody who questions whether or not the milk we identify as being oxidized is *in fact* oxidized. Having an instrument of this sort to verify our contentions, would add considerably to the credibility of our programs.

vor control and its importance."

Dr. Bruhn feels that it would be exceedingly desirable to be able to monitor the flavor of milk as it's processed to be sure that it falls within certain predetermined tolerances. It would be particularly advantageous in controlling the common flavors we find in milk, such as *feed* flavors, for example. This feed flavor is very common in all California milk, regardless of brand, but to most consumers this isn't objectionable. In fact, they like the feed flavor, and research has been done which revealed that the consumer even *preferred* a slight feed flavor in the milk. The best way to describe such flavoring is to imagine a slight alfalfa touch in the milk. The important point is that dairies market milk with this feed flavor day after day, and the



ventional technology we have today is capable of producing a shelf-life up to thirty days. Most milk now being produced has a shelf-life of about fourteen days.

"The principal determinant of how fast we advance on this front is economics again. It depends on how fast the processors want and need to put more capital investment into their operations. In this industry you don't make much profit on a quart of milk . . . about a tenth of a mil per quart . . . so when you start talking about putting out large sums of money for new equipment, you've got to run a lot of milk through that equipment to pay for it.

**"O**n the other hand, by marketing products with longer shelf-life, you can make longer production runs on products which have traditionally short shelf-life. The economics become more favorable as the operation becomes efficient. Economics will force important decisions on the dairy industry in the years ahead."

Although very pleased with the general progress of the dairy business, there are, Dr. Bruhn feels, some areas that need improving. One such area is legislation . . . particularly on the federal level . . . which he views as either restrictive or inadequate. He feels the industry should begin reviewing restrictive laws to determine how they can best be modified or eliminated. Butter is a case in point: one of the few products which is defined by a legislative act of the United States Congress. If you wanted to change the standard of identity for butter from what it is now—at 8% fat—to something else, you've got to go to Congress to do it. This, according to Bruhn, stems from a time when the dairy industry tried to remove its competition by legislating it out of existence.

On the other hand, there are many states who have not legislatively defined certain types of dairy products, making it difficult or impossible to market those

products in such states. It seems as though federal law would be the logical vehicle to assure the unrestricted sale of all dairy products in interstate commerce, but it will take the full weight of the dairy industry nationwide to effect this much needed legislation.

If he gets your ear, John Bruhn could go on almost endlessly about the dairy business. He really loves it. Ever since leaving his hometown in suburban Cleveland in 1958 to attend Michigan State University, dairying seems to have gotten into his blood. Someone recently commented that if you scratch John Bruhn, he "bleeds white". It would seem that way. Even while attending Michigan State—majoring in food science—he spent his summers working in Fairmont Foods' dairy processing plant in Cleveland.

"Being just part-time help," he reminisced, "they'd just throw us into the freezer at forty below to work for a half hour, then up to the heat of the milk room and the pasteurizers, and then back to the freezer dripping with sweat. I was kind of a handy man, jumping around all the departments. It was a good job, and I gained valuable, practical, first-hand experience in the dairy business."

**"W**hile at Michigan State, I was exposed to their very strong dairy department, and by the end of those first two summers with Fairmont Foods, I'd developed a strong professional interest in the dairy field. After graduating from Michigan State, and spending a summer with the Continental Can Company in Chicago, I enrolled here at U.C., Davis in the fall of 1962. Initially I was going to come out here for a Master's degree in food science, and had plans to return to Michigan State for my Ph.D., but I found the department, the courses, and the people I met here to be very stimulating, so I stayed here for my Ph.D. in microbiology, which I finished two and a half years ago.

"This job was particularly attractive to me because most of my interests are in the area of *applied* research, where I can see its more immediate application. The Extension Service does a great deal of this kind of practical research. I also find it really exciting to go into the field to meet with different groups around the state, talking about new concepts, technologies, etc., and communicating with the industry . . . providing information they can use."



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# Dairy Day at Davis

Processing, pricing, contests and elections marked the University of California Dairy Industry Conference.

## C.D.I.A. OFFICERS

**Rolland Nelson**, Petaluma Co-operative Creamery, was elected president of the California Dairy Industries Association at the C.D.I.A.'s 51st annual meeting held in March during the Dairy Industry Conference on the University of California's campus at Davis. Nelson is Field Production Supervisor for Petaluma Co-operative Creamery with offices in Ripon, California. He is also the current chairman of the California Fieldmen's Conference.

Other officers elected were: **Gary Gilman**, Dairymen's Co-operative Creamery Association, with offices in Los Angeles, vice president; and **Dr. John C. Bruhn**, U.C. Agricultural Extension Service, Davis, ex-officio secretary.

Each year the California Dairy Industries Association awards to a de-



Rolland Nelson, C.D.I.A. President.

serving and outstanding member of the dairy industry "Honorary Membership for Meritorious Service to the Dairy Industry." This year a plaque was presented to **Gil H. Brockmeyer**, Arden-Mayfair, Los Angeles, for his many contributions to the C.D.I.A. and to the dairy industry, both state-wide and national.

The objectives of the C.D.I.A. are to stimulate interest and study aimed at self-improvement, by all persons engaged in the dairy industry and to cooperate in educational activities for the advancement of the Dairy Industry. The state-wide membership represents all segments of the dairy industry.

Scholarship funds have been established by the C.D.I.A. for qualified college students with interest in the field of dairy industry. During the past decade, over \$18,000 has been made available to worthy students.

During the Dairy Industry Conference executive and technical personnel within the state's dairy industry, put their taste buds to test annually against various California dairy science college experts, as well as industry experts who pre-test samples of milk and ice cream.

For the first time in the fifty-one years of milk and ice cream judging the Grand Award (Sweepstakes) winner won first place in both Class A Milk and Class A Ice Cream. The winner was **Guy Leggitt** of Foremost Foods Company, Sacramento. Through its Dairy Roadside Appearance Program (DRAP),

the organization is credited with making a major contribution in presenting the dairy industry to consumers as an attractive part of the state's agricultural interests.

Directors elected were: **Lew McAdam**, Foremost Foods Company, San Francisco, for the Bay Area; **Dr. Gary Reif**, Dairy Science Department, Cal Poly, San Luis Obispo, Central Coast Section; **Tom T. Zurcher**, Penn Walt Corporation, Pomona, Metropolitan Los Angeles; **Ernest Waldee**, Meadow Gold Dairies, Los Gatos, Monterey Bay-San Jose; **Frank Leo, Jr.**, Foremost, North San Joaquin Section; **Bob Jones**, Foremost, Sacramento Section; **Eddie Hodges**, Golden Arrow Dairy, San Diego, San Diego Section; **Mike Liddi**, Real Fresh, Visalia, South San Joaquin.

State chairman appointed were: **Jay Close**, Knudsen's Borden Division, San Francisco, policy advisory board; **Bob Boynton**, Drew Chemical, San Mateo (U.C.), **Jim Johnson**, Knudsen's Borden Division, Fresno (Fresno State), and **Austin Olinger**, Jerseymaid, Los Angeles (Cal Poly), scholarship co-chairman; **DRAP** is **Don Lord**, Foremost, Los Angeles; **Hank Spini**, Guitard Chocolate, Burlingame; **Charles Brickley**, Guitard, general chair, assisted by **James Notley**, Sacramento County Health Department for Northern California, and **Jack Gould**, Los Angeles County Health, Huntington, for Southern California; and **Jack Shea**, Milk Advisory Board, publicity.

## 1971 DAIRY WINNERS

**GRAND AWARD**—Sterling Silver Bowl. **Guy Leggitt**, Foremost Foods Co., Sacramento.

**FIRST AWARD**—Sterling Silver Sugar, Creamer and Tray.

Class A Milk: **Randall S. Young**, Dairy Products Laboratory, San Francisco.

Class A Ice Cream: **Oak Russell**, Foremost Foods Co., San Francisco.

Class B Milk: **Fred Garner**, Foremost Foods Co., San Francisco.

Class B Ice Cream: **Jack Ratekin**, Arden Mayfair, Los Angeles.

**SECOND AWARD**—Le Gran Binoculars.

Class A Milk: **Jay B. Close**, Knudsen Dairy Products, San Francisco.

Class A Ice Cream: **James Johnson**, Knudsen Dairy Products, Fresno.

Class B Milk: **Timothy R. Eskew**, Safeway Stores, Inc., Los Angeles.

Class B Ice Cream: **Rolland Nelson**, Petaluma Co-op Creamery, Petaluma.

**THIRD AWARD**—Realtone Solid State AM-FM Portable Radio.

Class A Milk: **Edward G. Walker**, Berkeley Farms, Oakland.

Class A Ice Cream: **Ernest G. Waldee**, Meadow Gold Dairies, Los Gatos.

Class B Milk: **Frank Leo, Jr.**, Foremost Foods, Hughson.

Class B Ice Cream: **Louie Ellsworth**, Blanke Baer, Santa Ana.

**FOURTH AWARD**—Leather Billfold.

Class A Milk: **Ray C. Rausch**, Knudsen Corp., Los Angeles.

Class A Ice Cream: **Glen Carlson**, Dairy Products Laboratory, San Francisco.

Class B Milk: **Gay L. Bettencourt**, Safeway Stores, Inc., Hanford.

Class B Ice Cream: **Robert L. Fulton**, Alpha Beta Acme Markets, La Habra.

**FIFTH AWARD**—Owens-Illinois Glass Set.

Class A Milk: **D. E. Lord**, Foremost Foods, Los Angeles.

Class A Ice Cream: **Byron T. Dodds**, Lucerne, Oakland.

Class B Milk: **Morris L. Stewart**, Golden Arrow Dairy, San Diego.

Class B Ice Cream: **Lew McAdam**, Foremost Foods, San Francisco.



# THE DEMAND FOR FILLED MILK

By ALEX F. McCALLA

Associate Professor of Agricultural Economics and Dean, College of Agricultural and Environmental Sciences, University of California, Davis.

Let me begin by reviewing what we did before. We attempted to ascertain the responsiveness of consumers to changes in the price of filled milk (i.e., milk where the butter fat is replaced by vegetable fats) and to determine the potential impact of filled milk on fluid milk sales. We began the experiment at a time when filled milk sales were rising. During the experiment and subsequently, the trend has been reversed.

Compared to other scientific disciplines where researchers have access to the laboratory, economists have had to make do without experimentation under a controlled environment. They have had to take real world historical or cross-section data for their analyses rather than ideally keeping their experimental environment constant and manipulating only those few variables of interest. Data for demand analysis then is often unsuitable and may at best give an estimation of only a fraction of a total demand relation. For example, the three price zones in the Los Angeles metropolitan area had retail prices for regular whole milk of 48.5 cents, 50 cents, and 51.5 cents respectively. And this spread is rather greater than for many other adjacent areas within California.

We sought to overcome these problems by using a technique called experimental pricing. By manipulating price levels outside their normal limits, the technique permits analysis of consumer response to a wider range of prices. It is realistic to assume *ceteris paribus* conditions, i.e., variables such as advertising, size and location of displays, size and grade of product, and so forth, may be held constant.

As filled milk was not sold in Northern California, we chose to conduct the experiment in the Los Angeles area. This also facilitated a greater range in the sample data because stores could be chosen in both high and low income areas.

Our experimental design provided for fifteen retail outlets for filled and regular milk products and the experiment ran for twelve weeks starting in September of 1969. Weekly sales of nineteen fluid milk items were recorded. Thus, we obtained 180 observations of prices and quantities sold for each item. The price of filled milk was changed at the end of each third week according to a quasi latin square de-

sign which permitted a maximum variation of prices, given certain logical constraints such as a particular price could not occur in a store more than once, and that no two stores were alike in their particular combination of prices changes. Prices varied from 43 cents per half-gallon down to 35 cents, a range of 4 cents on either side of the prevailing price of 39 cents. The gathering of weekly data permitted us to examine any structural or learning effects over the three weeks any price was in effect.

## The Results

The direct and cross elasticities (i.e., the direct elasticity is the per cent change in quantity consumed as a result of a one per cent change in price; the cross elasticity is the percentage change in consumption of one product as a result of a one percent change in the price of another product) of demand for two filled milk products and for five regular fluid milk products, with respect to the price of filled milk, were estimated with regression analysis. It was not possible to generate the direct demand elasticities for regular milk products, given the presence of filled milks, because the retail prices for the regular products are controlled by statute.

The elasticity (direct) estimates for filled milk and filled chocolate milk were -.828 and -1.560 respectively. Both these estimates were highly significant. Estimates of cross elasticities for homogenized whole milk, lowfat milk, and nonfat milk were respectively .147, .386, and .147. For lowfat milk this estimate was significant at the 1 per cent level and that for homogenized whole milk was significant at the 5 per cent level. The estimate for nonfat milk was nonsignificant.

From the estimated elasticity coefficients it is clear that neither filled milk nor filled chocolate milk are substitutes for any one regular fluid milk product in particular. Household opinion surveys conducted in Phoenix, Arizona, have suggested that the degree of substitution between filled milk and lowfat milk is greater than between filled milk and any other regular fluid milk product. This is strongly supported by the results of this study, the implication being that consumers tend to regard filled milk as a dietary beverage.

Given that the fifteen stores selected

in Los Angeles were situated in areas of substantially different income level and ethnic makeup, we were able to get some results regarding these variables.

Filled milk is consumed in relatively greater quantities by low income whites, and to a lesser extent by higher income whites. Minority groups purchase relatively less of the product than white groups. No such conclusions were reached for filled chocolate milk, but the regression results infer that this product is preferred by white clientele, particularly those with higher income levels. Homogenized milk is preferred by lower income clientele, with relatively greater quantities being purchased by whites rather than minority groups. Both lowfat milk and nonfat milk are purchased in significantly greater quantities by high income whites. Extra rich milk is preferred by lower income minority groups. The results suggest in general that fluid milk products are consumed in relatively greater quantities by whites than by minority groups.

Given the different elasticity of demand estimates for filled milk and filled chocolate milk, the analysis shows that maximum returns to the retailer and processor-handler from the sale of these two products may be achieved when their retail (and wholesale) prices are not necessarily identical. Analysis of the shape of the demand curves for both filled milk products indicates that it may be profitable for retailers to lower the price of these products for a limited period in order to attract a larger number of purchasers. The retail prices may then be returned to the former level and, because the demand elasticity is probably less when the price is increased, most of these newly attracted customers should remain regular purchasers of filled milk. Returns from the sale of filled milks would be correspondingly increased.

Now a few comments about what we might have done differently if we had to do it over. A greater range of price for filled milk and filled chocolate milk in the pricing experiment may have provided more accurate elasticity estimates for the test products, particularly at the extremes of the demand curve. A wider price range might also have yielded elasticity estimates with higher levels of statistical significance.

In retrospect, more information may have been obtained from the same basic experimental design at no extra cost if the price of filled chocolate milk had been independent of the price of filled milk. It may then have been possible to estimate the cross elasticity of demand between both these filled milk products. No such information is available from the present experimental data because the prices of both products were identical over the course of the experiment. Further research might



also examine whether there is any substitution between filled milks and SNF powder at retail. Filled milk is not necessarily the lowest priced source of desired milk nutrients. An analysis of this type might be particularly revealing for stores with predominantly low income and minority clientele.

From the producers' point of view, it can be concluded that the price of filled milk is unlikely to have a major impact on classified pricing and its function to enhance producer returns. This suggests that the dairy industry's concern with increased competition for filled milk, if its SNF ingredient is priced at non-Class I prices, is unwarranted. A reduction in the price of filled milk, following a change in pricing policy for the SNF ingredient, may well be to the ultimate advantage of the dairy industry. It is likely that if it would tend to discourage current efforts to produce and market an equally acceptable synthetic milk, and should maintain for the dairy industry a demand for basic milk products which might otherwise be lost to the producers of the synthetic product.

In summary, let me recapitulate what the results seem to imply.

- Filled milk is considered by consumers to be a "different" product than fluid milk. This is the reverse of the statement that it is not, on the basis of this study, a close substitute regular fluid products.
- Consumers buying filled milk, especially chocolate, are quite responsive to price changes. The elasticities of .8 (regular) and 1.560 (chocolate) are substantially greater than any comparable estimates that I know of for regular milk products.
- It seems that once a consumer has switched to filled milk as a result of a price drop, she is less likely to switch back when the price rises. This implies that a short-run retail policy of reducing filled milk prices substantially to gain consumers and then increasing the price again could be profitable.
- High income consumers appear to consider, erroneously, that filled milk is a diet drink.
- Low income whites consume more filled milk than low income members of ethnic groups.
- Filled milk does not appear to be a threat to the classified pricing system as long as the SNF is priced at Class II prices.
- And, finally, the dairy industry might have double benefits from exploiting rather than fighting filled milk. First, because it appears to be somewhat of a separate product, it would provide an expanded outlet for SNF and second, that as long as filled milk is kept moderately priced, the encouragement for the development of a purely synthetic product is less appealing.

# NEW CONCEPTS IN PROCESSING TECHNOLOGY

By R. L. MERSON  
Dept. of Food Science and Technology  
University of California, Davis

## INTRODUCTION: Processing of Whey with Reverse Osmosis, Ultrafiltration and Gel Chromatography.

I would like to introduce you to three relatively new processes which are on the threshold of being important in the dairy industry. These processes are reverse osmosis, ultrafiltration, and gel filtration (or gel chromatography). I would like to try to indicate the principle behind each process, some of the equipment which could be used, and what we can expect each process to accomplish. Where possible I will try to point out costs and prospects for commercial operations. Finally I will point out remaining problems and where you can go for further information or commercial help.

To help focus our discussions, let us consider the processing of cottage cheese whey. You are all painfully aware of the pollution problem caused by this by-product from cheese making. But you are also aware that whey is a potential source of soluble milk proteins and lactose for which markets can be found.

However, there is another reason for us to consider whey processing. Much of the work and most of the success with these three processes has been with whey processing.

## WHAT IS REVERSE OSMOSIS?

Reverse osmosis is a membrane process for separating components of a solution. It makes use of a semipermeable

membrane which allows the solvent to pass through while retaining the solutes. Water is forced to pass through the membrane in a direction opposite to the flow by normal osmosis. The driving force is hydrostatic pressure applied to the solution in excess of the osmotic pressure of the feed.

## Osmosis, Reverse Osmosis, Osmotic Pressure.

In Figure 1, consider the solution labeled "fruit juice" to be whey. Suppose that the membrane will allow water to pass through but will not allow protein, sugar, acids or salts to pass through. If both sides of the membrane are at equal pressure water will transfer across the membrane into the whey by *normal osmosis*. If, however, sufficient hydrostatic pressure is applied to the whey, pressure in excess of the osmotic pressure of the whey, then the direction of water flow can be reversed and the whey can be concentrated. The pressure at which no net transfer of water occurs is called the *osmotic pressure*.

## WHAT IS ULTRAFILTRATION?

The difference between reverse osmosis and ultrafiltration lies in the membrane. In principle a reverse osmosis semipermeable membrane rejects all dissolved solutes, even microsolutes such as sugars, acids, and salts. An ordinary filter, on the other hand, will reject only undissolved particles such as lactose crystals or curd particles. Somewhere

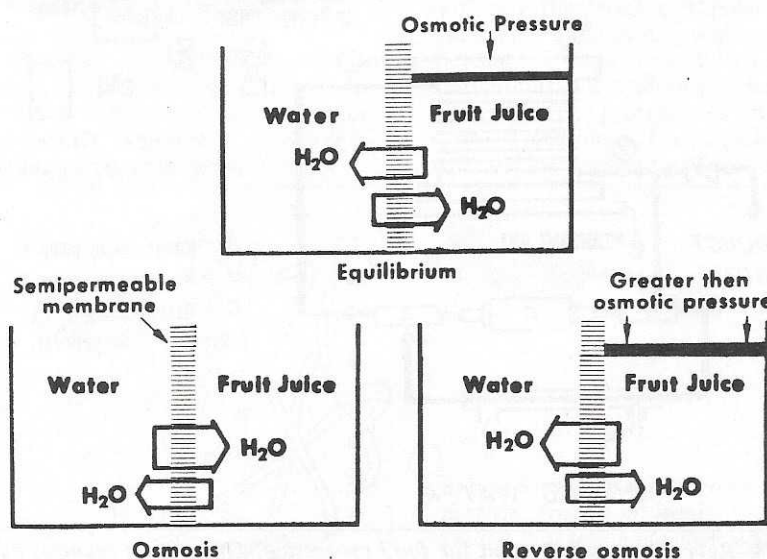


Figure 1—Osmosis, osmotic pressure, reverse osmosis.



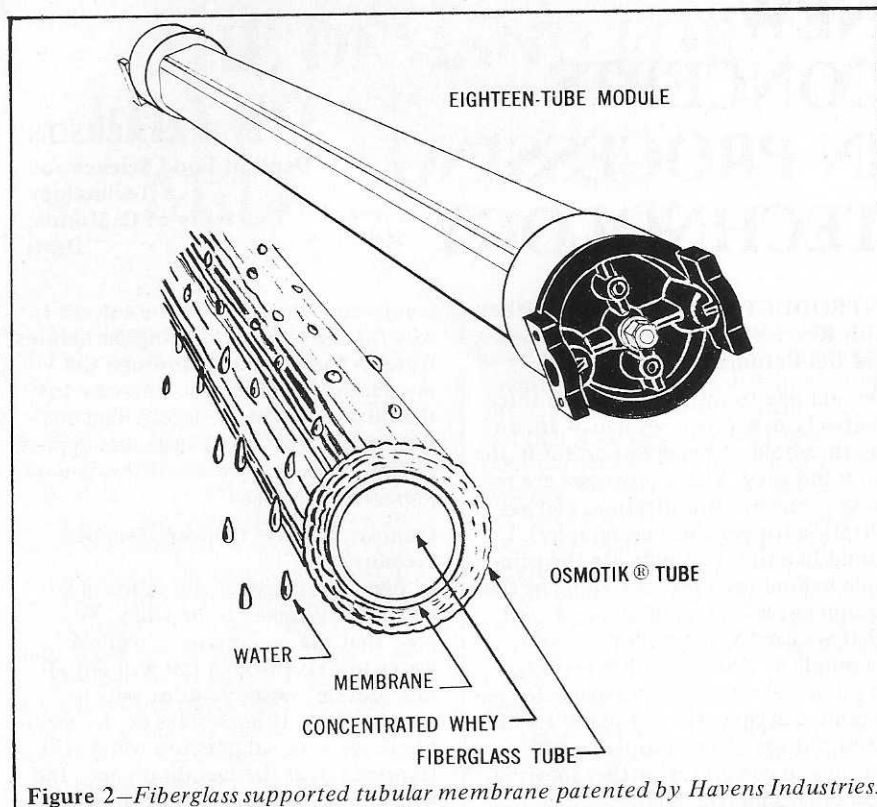


Figure 2—Fiberglass supported tubular membrane patented by Havens Industries.

in between these extremes is *ultrafiltration*. An ultrafiltration membrane retains (or rejects) macrosolutes (i.e., large dissolved molecules such as proteins) but allows microsolute (such as salts, lactic acid, or even lactose) to pass through. Actually even most practical reverse osmosis membranes allow some salt and lactic acid to leak through.

#### WHAT EQUIPMENT IS NEEDED FOR REVERSE OSMOSIS AND ULTRAFILTRATION?

Large membrane areas are needed since permeation rates are low per unit area. The membranes must be supported to

withstand the operating pressure. Low pressures (10-50 psi) are used for ultrafiltration. High pressures (450-800 psi or even higher) are necessary for reverse osmosis. A feed pump is needed for pressurizing the feed. Also, mixing is necessary to keep fresh feed near the membrane. Provision must be made for cleaning the equipment.

Figure 2 shows a tubular membrane support in which mixing is provided by flow of the whey through the tube. Water permeates through the membrane and through the porous walls of the tube. Tubular membranes and thin

channel devices are most common in food processing.

Figure 3 shows a plate-and-frame membrane device. Mixing is provided by recirculating part of the concentrate. Feed is added to make up the volume lost as permeate and concentrate are withdrawn. Here you can also see the feed pump and feed tanks needed.

#### WHAT CAN THESE MEMBRANE PROCESSES DO?

Table 1 shows some typical data for processing of cottage cheese whey by reverse osmosis (McDonough and Mattingly, 1970) and by ultrafiltration (Horton, et al., 1970).

Reverse osmosis is used primarily for concentration of the solids in whey. In this example, the whey solids were concentrated 5-fold (80% of the water removed) from 6.5 to 33% solids. Notice that the solids concentration in the permeate (the water passing through the membrane) is very low, resulting in a low BOD waste stream (or source of processing water). The small amount of "protein" listed in the permeate is actually non-protein nitrogen (urea, ammonium salts, or free amino acids) not lactalbumin or lactoglobulin. Lactose is retained better by this membrane than are monovalent salts or lactic acid.

Ultrafiltration, on the other hand, is used for fractionation. The filtrate which passes through the membrane has about the same concentration of lactose, salts and lactic acid as the original whey. But the true proteins are concentrated (without loss), in this example up to 12.5% in the concentrated liquid. So the proteins are concentrated 20-fold while removing 95% of the water and low molecular weight solutes.

A variety of membranes are available which can produce variations of the results shown here. For example an intermediate membrane might concentrate both lactose and proteins while removing a higher proportion of salts and lactic acid.

#### WHAT IS GEL CHROMATOGRAPHY?

##### What is "Gel"?

Gel is manufactured in the form of porous beads that swell in water (Figure 4). Gels are manufactured from a number of materials; those of most interest to us are the Bio-Gels made by Bio-Rad Laboratories and Sephadex made by Pharmacia Fine Chemicals.

The gels are cross-linked polymers that leave uniform sized pores or holes (Figure 5). Low molecular weight substances (or more exactly, substances whose molecules are relatively small, in our case salts, lactose, and lactic acid) can get inside the gel matrix. High molecular weight substances ("large" molecules) can not get inside but must remain in the surrounding fluid.

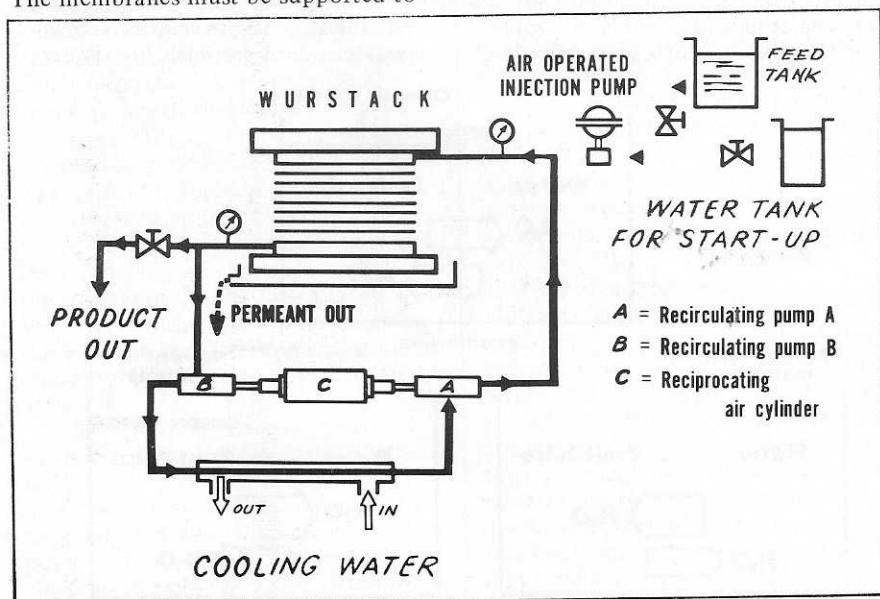


Figure 3—Reverse osmosis system for food processing. This system recycles part of the concentrated product. Thin channel membrane unit developed at USDA Laboratory in Albany, California.



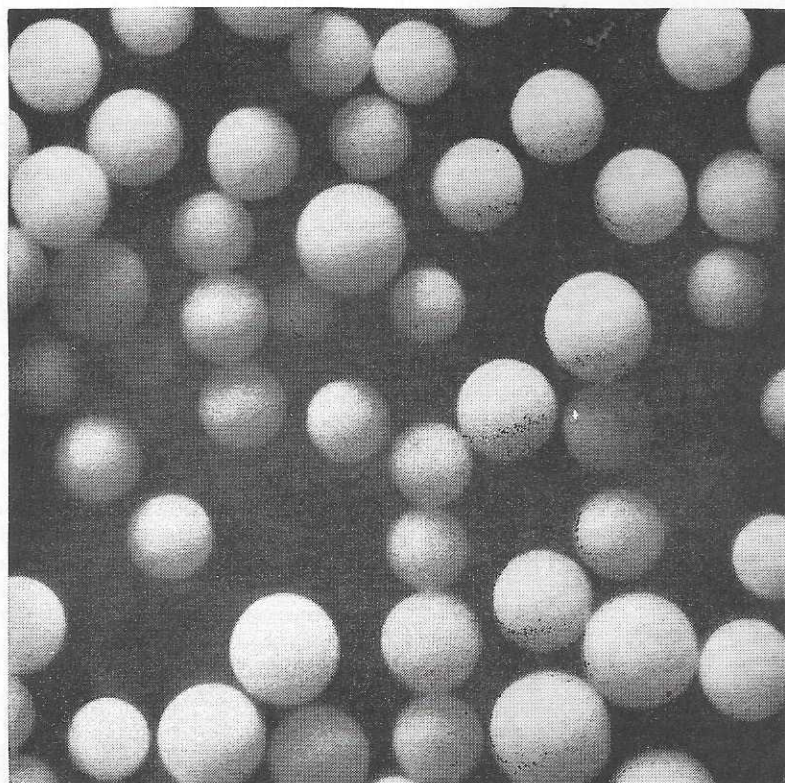
**Table 1—Membrane Processing of Cottage Cheese Whey.**

Component	Feed <sup>1</sup>	Reverse Osmosis <sup>1</sup>		Ultrafiltration <sup>2</sup>	
		Permeate	Concentrate	Filtrate	Concentrate
Total Solids	6.5%	0.3 %	33 %	5.7%	18 %
Proteins <sup>3</sup>	0.7	0.09	4	—	12.5
Lactose	4.5	0.07	22	4.5	4.5
Salts	0.6	0.18	2.5	0.6	0.6
Acid	0.6	0.12	2.5	0.6	0.6
Water	93.5	99.7	67	94.3	82

<sup>1</sup>Data from McDonough and Mattingly (1970).

<sup>2</sup>Data from Horton et al., (1970).

<sup>3</sup>6.25 x N



**Figure 4—Spherical gel particles.** (Pharmacia Fine Chemicals, 1968)

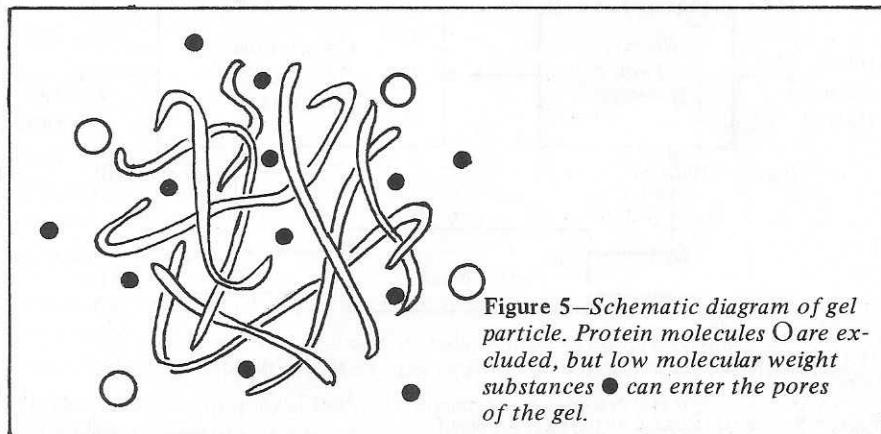
#### How is gel used to “desalt” whey?

In principle the use of gel is very simple. The gel must be brought into contact with the whey. Time must be allowed for “salt” (low molecular weight compounds) to transfer into the pores of the gel. The gel and the supernatant must be separated. Finally the “salt” must be removed from the gel.

#### Column Operations.

The standard method of procedure is to place the gel in a *column* (Figure 6). The sample of whey is placed on the top (or bottom) of the column and washed through (eluted) with water. The protein can not penetrate into the gel pores, so it remains in the outer fluid and is eluted off the column first. Salt, lactic acid, and lactose enter into the pores and are retarded, so they come off later.

If we plot the concentration of the various components in the fluid coming off the column, we get an *elution diagram* such as Figure 7. This is equivalent to a chromatogram in other



**Figure 5—Schematic diagram of gel particle.** Protein molecules O are excluded, but low molecular weight substances ● can enter the pores of the gel.

forms of chromatography. By collecting suitable fractions, for example from 100 to 200 liters on this diagram, we could obtain a product which is mostly protein, with little lactose and salt. Another fraction (from 200 to 350 liters) would be rich in protein, but have higher percentages of lactose and salt.

Column operation is equivalent to contacting the gel and whey over and over again. The result is equivalent to many single stages. The *advantages of column operation* are (1) simple equipment (2) the column is automatically regenerated as the low molecular weight solutes are washed off and (3) the entire procedure of switching from feed to eluant (wash water) and of collecting fractions can be automated. *Disadvantages of column operation* are (1) although we get many stages, mixing caused by flow through the column “undoes” part of the separation. (2) This same mixing dilutes the fractions, although in large operations the dilution is limited to 10-20% of the original whey volume. (3) Although it can be automated, the process is not continuous. (4) Finally, removal of salt from the column is the slowest step and regeneration might be hastened in another type of device.

#### Other Methods of Using Gel.

Figure 8 represents the basket centrifuge method (Morr et al., 1967). A gel bed is prepared and the feed sample is applied to the surface. The protein is spun through the bed with practically no dilution. The salt is then washed from the bed. The centrifuge method reduces dilution, increases the speed of the operation and allows the use of more viscous feeds (e.g. concentrated whey or skim milk).

Another method, under investigation at the University of Minnesota, uses a *continuous desludging centrifuge* (Morr and Roseneau, 1970). I do not know the details of this operation, but Figure 9 indicates one possibility. Gel and whey are mixed into a slurry and fed into a continuous desludging centrifuge. The protein solution is spun off undiluted. The gel, together with the low molecular weight sub-



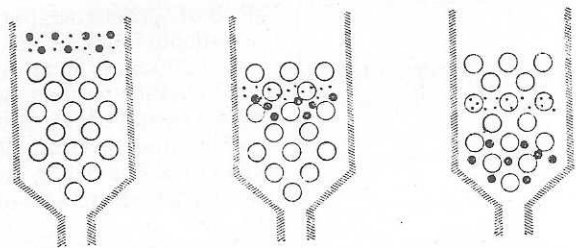


Figure 6—Column gel chromatography. Sample placed on top of the column (left) is eluted through column with water (center). Protein ● emerges first, low molecular weight components ○ emerge later.

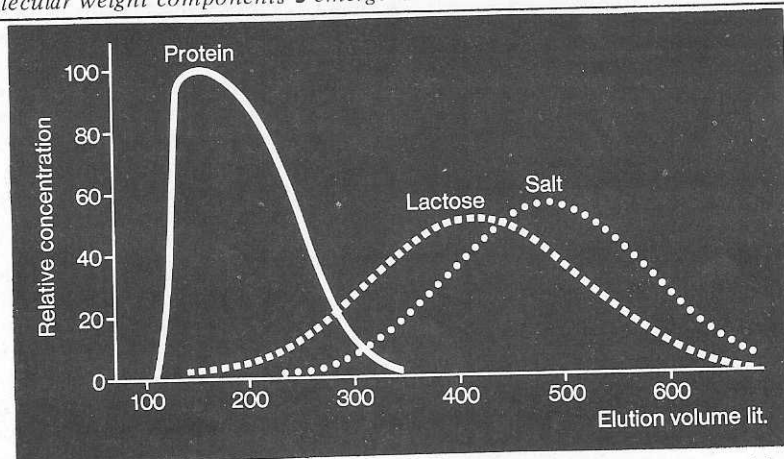


Figure 7—Elution diagram showing the separation of high molecular weight and low molecular weight material in whey. Concentration in charge solution = 100 for each component.

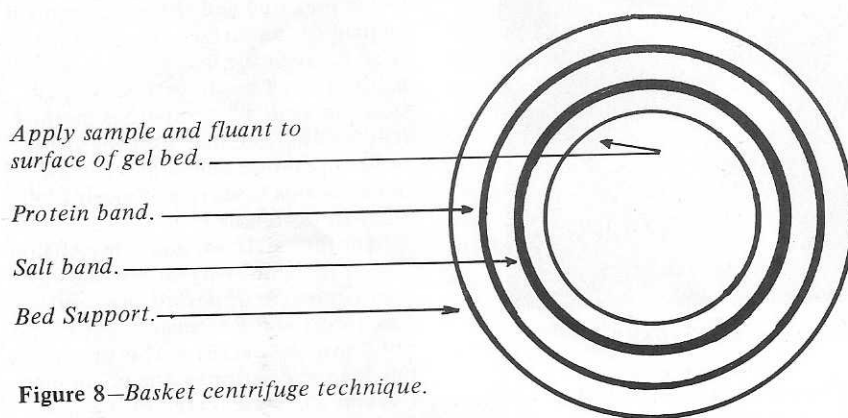


Figure 8—Basket centrifuge technique.

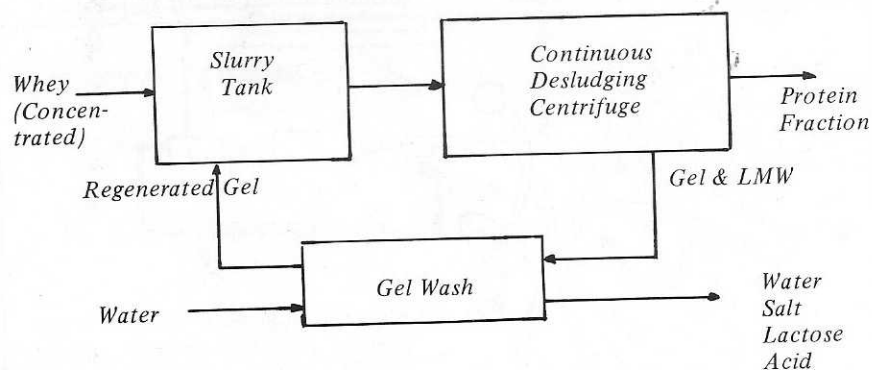


Figure 9—Continuous Centrifugal Method.

stances is removed to a separate operation for regeneration.

Finally I will mention the rotating annulus method (Fox et al., 1969) which is intriguing because it uses simple equipment but is truly continuous (Figure 10). This method was developed by Dr. Fox at the USDA research laboratory in Philadelphia. Sample is fed continuously to the top of a gel bed in the shape of an annulus (between concentric plastic cylinders). The bands separate vertically as they are eluted through the bed. At the same time the rotating annulus moves the bands around the circumference of the bed. The fastest component reaches the bottom first at its fixed collection point. By the time the next fraction reaches the bottom of the bed the annulus has rotated to the next fixed collection point.

## COMMERCIAL OPERATIONS

### Gel Chromatography.

Figure 11 is a picture of a gel filter which is installed in a dairy in Gotene, Sweden. This unit is made by Pharmacia and uses the Sephadex gel which that company manufactures. The unit is nearly 6 feet in diameter and over three feet deep (660 gallons volume). It can process approximately 400 gallons of concentrated whey or skim milk per hour. Allowing for cleanup time I estimate this unit could process about 500,000 lbs. of whey per day.

ENRG International Corp., Rochester, Minn. has been operating a gel filtration plant since August, 1970 (Anon. 1970). This plant (Figure 12) is capable of processing one million lbs. of whey per day. In the ENRG process, whey is concentrated by evaporation to 60% solids and lactose is recovered by crystallization. The mother liquor from the centrifuge-decanter is processed through gel filtration units giving the protein fractions and the waste salts, acid and residual lactose. The protein fractions are concentrated and spray dried. The company is currently marketing two products (Grindstaff, 1971) of which one is 50% protein (minimum protein content) and one is 15% protein. Company literature indicates plans for ten such plants, enough capacity to process 15% of all whey produced in the U.S. The pretreatment step is apparently important for the gel filtration step.

### Membrane Processes.

Membrane processes have also been scaled up. A full scale demonstration plant, Crowley's Milk Company in Binghamton, New York uses both ultrafiltration and reverse osmosis to process 250,000 lbs. of cottage cheese whey per day. This work is supported by a grant from the U.S. Dept. of Interior (Federal Water Quality Administration) and Abcor, Inc. is the subcontractor.



The USDA dairy products laboratory is sponsoring a similar study with H.P. Hood and Sons, a dairy in St. Albans, Vermont.

## PROBLEMS TO SOLVE

### Gel.

When processing concentrated whey, protein precipitates when it is separated from the salt. The precipitate clogs the gel bed. Apparently this problem can be overcome by concentrating the whey by precipitation with hexametaphosphate, separating the supernatant and redissolving; or by concentrating by reverse osmosis. Both of these procedures prevent the whey protein from being denatured and so it remains soluble even in the unbuffered water in the gel column.

### Membrane Processes.

Probably the biggest problem with the membrane processes is "fouling" of the surface of the membrane. Skim milk irreversibly fouls the surface so rapidly that permeation rates are essentially zero. Operation with whey is satisfactory under suitable operating conditions, namely high turbulent flow rates. When conditions are not correct, a white deposit results. A high percentage of the deposit is casein, but we do not know its exact chemical or physical nature or how it forms.

## PROCESS COMPARISON

Dry products which might be obtained from cottage cheese whey with the use of reverse osmosis, ultrafiltration, or gel chromatography are shown in Table 2. A dried reverse osmosis product is similar to dried untreated whey except for some removal of salt and lactic acid. Ultrafiltration results in much greater reduction of the lower molecular weight constituents. Gel chromatography probably gives the highest purity protein in a single operation but results in a dilution of the fractions.

I should emphasize that the values in Table 2 are only typical (perhaps optimistic) values which can be ob-

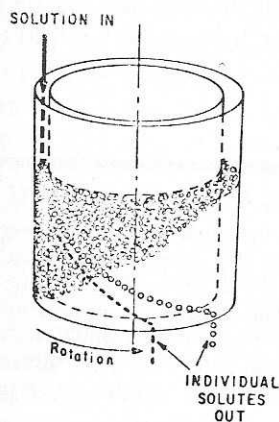
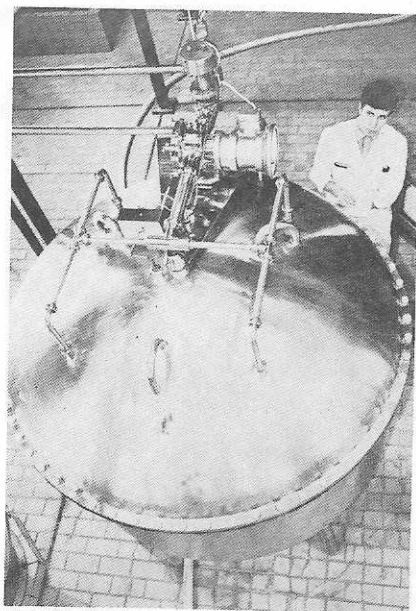


Figure 10—Rotating annulus method of Fox (1969) — faster moving component. ooo slower moving component.



tained. The cost values especially are subject to error. Although the values are taken from the literature one is never certain whether the same basis has been used in the calculations.

What I have tried to do is to simply introduce you to these three processes. If any of the methods or products which they produce are of interest to you, I would urge you to contact the manufacturer directly for firm cost estimates and product compositions.

**FOR A LIST OF COMMERCIAL SUPPLIERS, SEE PAGE 30.**

Figure 11—Completely automated production unit for treatment of whey in dairy in Gotene, Sweden. Gel filter volume 660 gallons. (Pharmacia Fine Chemicals, 1969).

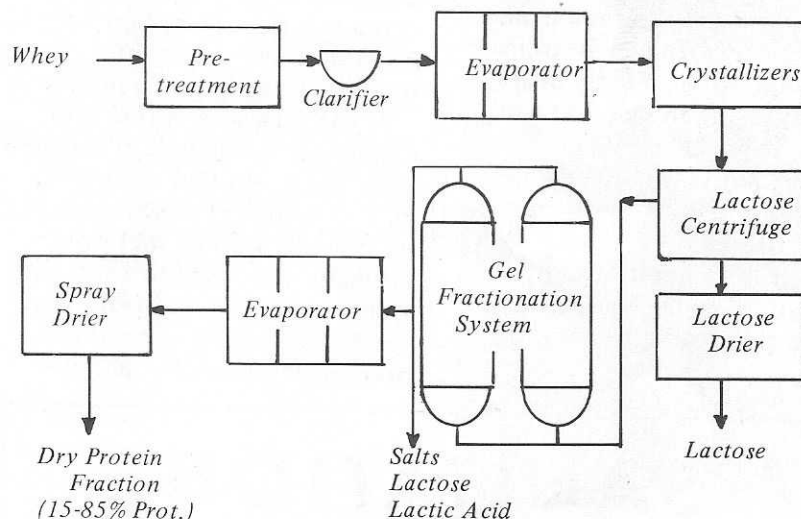


Figure 12—ENRG plant in Rochester, Minn. for treating one million lbs. of whey per day.

Table 2—Process Comparison.

Compositions are given as % of total solids (dry basis). Costs are given per lb. of dry solids.

	Untreated Whey	Reverse Osmosis	Ultra-filtration	Gel Chromatography
Protein	13%	12%	69%	75%
Lactose	68%	69	25	15
Ash	9	8	3	8
Acid	9	8	3	—
% water removed in fractionation	0	80	95	10-20% dilution
"Operating" <sup>1</sup> cost	—	1¢ <sup>2</sup>	6¢ <sup>2</sup>	13¢ <sup>3</sup>

<sup>1</sup> Does not include cost of pretreatment or drying.

<sup>2</sup> Does not include labor, might not include equipment depreciation. Data from McDonough and Mattingly (1970) and Horton et al. (1970).

<sup>3</sup> Includes labor, equipment depreciation, but not concentration. Data from Easterday et al.