# SOME RECENT DEVELOPMENTS IN THE MANUFACTURE OF MARGARINE

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**Abstract**

The author presents a general history of the manufacture of margarine. Special attention is given to one of the recently developed continuous methods.

THE history of margarine dates back to the Franco-Prussian wars. At that time there was a serious shortage of butter, and in 1870, Napoleon III offered a prize for the successful production of a fat food which would be as appetizing, as nutritious, and as stable as butter.

A French Chemist, Mege-Mouries, had been working on such a problem, and in 1870 he claimed and secured this prize.

Mege-Mouries reasoned that in the animal, the tissue fat was changed into milk fat by the action of pepsin, so, accordingly, he digested fatty beef tissues in water, at 45° C., in the presence of pig or beef stomachs. After a few hours, due to the temperature, and to the action of the pepsin, the fat was freed from the tissue and skimmed off the surface. He then cooled, grained, and pressed this fat, separated the soft portion, and mixed it with a little salt and some casein. This mixture, after chilling, had about the consistency of butter, and was termed "oleomargarine."

It is interesting to note that this name was bestowed upon it, because it was believed that the principal constituent was the glyceride of so-called margaric acid, with the formula $C_{17}H_{34}O_2$. Later it was shown that margaric acid was not a definite compound, but was a eutectic mixture of stearic and palmitic acids.

Mege-Mouries believed that he had prepared artificial milk fat, but, of course, he had not. He had not given it the flavor of butter, and in fact, the flavor must have been such as to make its use possible only under the stress of those times. Later he replaced the casein in his product with about 10% of cow's milk, and water containing a small amount of macerated cow's udder. This resulted in some improvement in flavor, but it was not until some time later that the use of ripened or cultured milk as a source of flavor gave to margarine the characteristic flavor with which we associate it.

In spite of the obvious drawbacks to this early product, it met with surprising demand, and after only four years it is reported that 300 tons per day were being made in Paris alone.

From this point on, the development of margarine from the standpoint of oils used paralleled closely the advances in processing of edible oils. First the use of fatty tissues was changed to beef fat rendered separately, and the macerated cow's udder discontinued. For quite a long time, beef fat was nearly the sole fat employed, but later some lard was added to increase the plasticity of the margarine. Then, as improvements in methods of refining and deodorizing permitted, vegetable oils were used, first as blends with harder beef fats, later in the hydrogenated state with no animal fats. This change was partly a matter of economics, and partly due to the fact that bland, deodorized fats gave less interference with the lactic acid flavor and aroma which characterizes margarine, and also stood up better under storage. At the present time, in this country, over 90% of the oils used in margarine are of vegetable origin. These vegetable oils in the order of their use in 1937 were:

| | Approximate percentages |
|---|---|
| Cottonseed Oil | 56% |
| Cocoanut, Babassu and Palm Kernel Oils | 30% |
| Soy Bean Oil | 10% |
| Miscellaneous Oils | 4% |

At this point I want to digress to the extent of saying that this 10% of Soya bean oil offers a challenge to the oil chemist. The supply of soya bean oil is constantly increasing, and it is very desirable that methods of processing it be developed to the point where more of it can be used in margarine and shortening. Soya bean oil can be used in margarine. I know this, because several margarine companies have used hundreds of tank cars of it, with satisfaction. However, this does not mean that the problem is solved by the vegetable oil industry as a whole, because not all of the processors can now produce a soya bean oil that meets the requirements for margarine oil. It is a problem confronting the oil chemist, and its solution will pay dividends to the farmer, to the refiner, and to those of us who use the oil.

While these changes were occurring in the kind of ingredients used in margarine, methods of manufacture were also progressing. It will be necessary to consider the various steps in manufacture in order to trace this development.

The first step is the manufacture of the emulsion. Very few fundamental changes have occurred here. Almost universally, the oils, together with pasteurized milk that has been ripened or soured by inoculation with a pure culture of lactic acid producing bacteria, are churned together in a tank equipped with agitators. Various processes for increasing the degree of emulsification, as for example homogenizers, have been recommended, but since the liquid emulsion is always solidified before any separation can take place, such devices have generally failed to justify themselves.

The second step is the solidification of the emulsion, or crystallization. At first this was accomplished by running the liquid emulsion into a tank of ice water. The fat was instantly chilled and rose to the surface in white, snow-like crystals. These crystals were removed with a cloth seine, or by other means, and placed in a truck for draining. Later the emulsion was run into a sluice or trough, into a stream of running ice water, and still later it was sprayed into this sluice where it met a spray of cold water which washed the crystals down into a truck.

This method of chilling was far from satisfactory, although it is still used in some factories today. It was very wasteful of water, some thousand gallons being required for one thousand pounds of margarine. It was also wasteful of refrigeration. The water was chilled down to about 36° F. and was run to the sewer at about 45° F., so the refrigeration represented by the difference between its original unchilled temperature and its final temperature, perhaps 20 degrees Fahrenheit, was lost. There was also another serious objection, which was that a considerable portion of the milk, and consequently a portion of the flavor, might be washed out by this crystallizing water. In addition, the crystallizing water always offered the possibility of contaminating the margarine, unless it were carefully filtered and sterilized. The writer knows of cases where many thousands of pounds of margarine were rendered inedible because of trade wastes suddenly appearing in the water.

Because of the disadvantages of the water crystallization, the industry soon turned to dry chillers, which were essentially the same as lard or compound rolls. Here the emulsion was fed onto refrigerated rolls, solidified, and scraped off by knives after almost one revolution. This was so great an improvement that soon the roll system was in operation in a large proportion of the factories.

The third step in manufacture is to knead together the crystals, and in the case of water crystallization, to work out the excess water, sometimes amounting to 10 or 15% of the total weight. This operation is called working. The first workers were flat, revolving round tables, with wooden rollers tangential to the table surface. Here the crystals were placed on the table, and it was revolving until the product reached the desired condition. Here, also, the salt was usually added and worked into the margarine.

This was a slow, costly method of handling, and it was soon replaced with continuous workers. These consisted of single or double horizontal spiral shafts, enclosed in a case and fed from a hopper. These spirals forced the product through a series of perforated plates, usually with revolving knives between each set of plates. Passage through that worker kneaded the crystals into a homogenous mass, and at the same time removed excess moisture and permitted salt to be incorporated.

Still later, there was developed a blender, which was used in conjunction with, or in a place of, the worker. This device was a box type holder, equipped with double horizontal agitators. The margarine was loaded into it, a cover placed over it, and the load agitated rapidly for a few minutes. This method insured regular and uniform distribution of the salt, and at the same time permitted additional milk to be added, if desired. It also tended to give the margarine a more plastic, less brittle consistency. However, it was costly in labor and power.

The fourth step in the manufacture comprised the packaging of the goods. In the beginning, the margarine was formed into single prints by means of form, similar to those still in use on farms for printing butter. These were soon replaced by boxes holding about ninety pounds. These boxes had bottoms that fitted loosely inside the side walls. The margarine was tamped into these boxes, and then covered with a frame having cross wires spaced in both directions. The bottom was then raised, by means of a ram, forcing the margarine up through the wires. At a desired height, a bow was then drawn across the top, thus cutting the portion above the box into a number of prints, which prints were then wrapped by hand.

Later, mechanical printers were developed. These used spiral screws much like the workers described above. However, instead of being forced through perforated plates, the mass was forced through a rectangular forming nozzle, having two of the dimensions of the margarine prints. The product thus came out as a slab, which at intervals was cut into prints by having wires, fixed in a frame, drawn through the slab crosswise. These prints were then wrapped and cartoned by hand.

Soon automatic wrapping machines were developed that did away with the hand wrapping.

When we consider these four steps in margarine manufacture; emulsification, crystallization, working, and packaging, it appears that each step has progressed more or less independently, and indeed in many plants are still distinctly separate operations, often being carried out in separate rooms or on different floors. Oftentimes the solidified emulsion or crystals must be transported in trucks, either to the next operation (the workers) directly, or after having rested for a period of hours in a cooler or tempering room. From the workers the margarine may be trucked to the print machines direct, but in the case of some formulae it may be necessary to chill in a cooler before it is firm enough for the print machines to handle it. If it is blended it must be shoveled into the blender and then shoveled back into trucks for further transport to the printers.

All of this handling costs money. It requires a large amount of labor; there is too great a time lapse between the formation of the emulsion and the final packaging; there is a great chance of bacterial contamination in the various coolers and tempering rooms, as well as trucks or conveyors; there are many trucks or conveyors which have to be kept scrupulously clean; unless a blender is used, it is difficult, if not impossible, to have a rigid control of the amounts of milk, salt and fat in the finished material.

It is obvious that many advantages would result from a continuous method of manufacture, where definite and controlled amounts of ingredients would be mixed, chilled, worked and packaged without stoppage, and in a closed system, where no loss of milk, salt or flavor could occur. Such a system should be simple in design, sturdy in construction, and capable of being easily and thoroughly cleaned. Much effort has been expended and is being expended in trying to perfect such apparatus or such a system. Rather recently considerable progress has been made, and I propose to devote the remainder of this paper to a description of one such system, for which permission has been granted by the Vogt Processes Company.

It might be well to discuss the various points which arose in the development of this system. The operation is as follows. A weighed amount of oil is placed in an emulsion tank, and the calculated amount of milk and salt, previously mixed, is dumped into the oil. The emulsion is then made in the conventional manner.

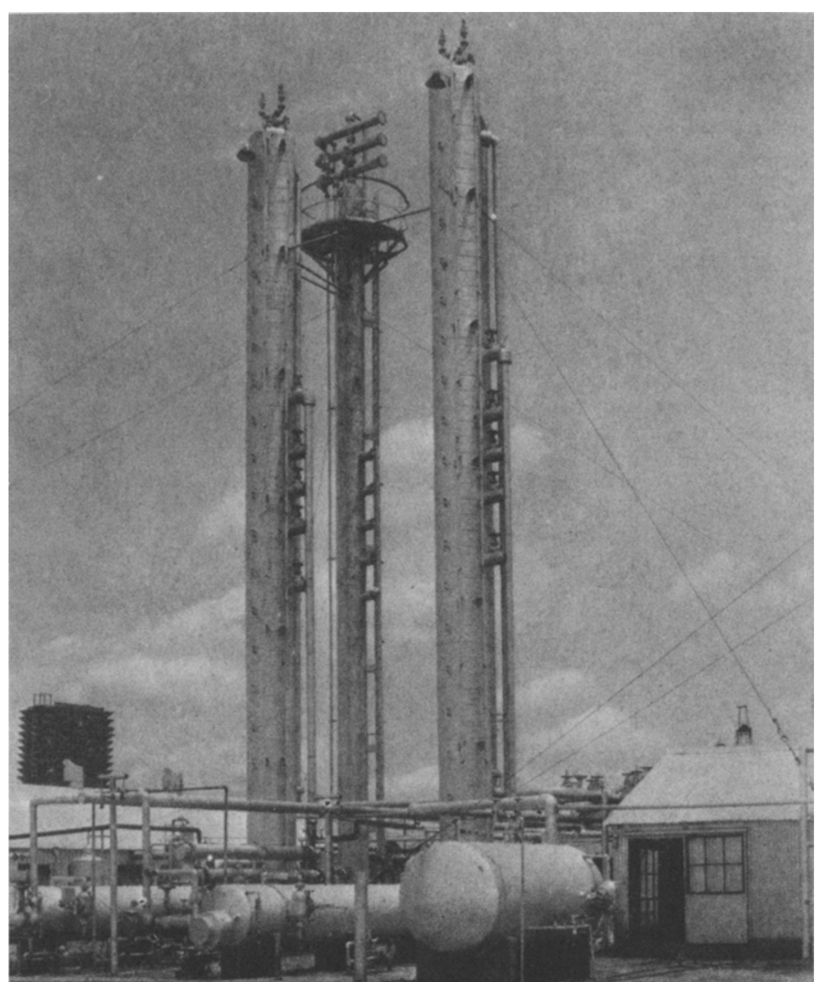
The emulsion is then pumped through the crystallizing device. This device consists of two similar vertical tubes, in series, each surrounded by a jacket containing liquid ammonia. In the tubes are agitator shafts of such a size that there is only about one quarter inch clearance between the shafts and the tube walls. These shafts have attached to them a series of knives, which ride by centrifugal force, against the tube walls. The agitator is rapidly revolved and the knives then serve to scrape the product from the wall and offer fresh contact for the transfer of heat. By this exposure of a relatively small amount of emulsion to a large refrigerating area, the heat is very quickly extracted from the emulsion, and the product is chilled below the point at which it would solidify. In a typical instance, the emulsion going into the machine has a temperature of 105° F. Coming out of the first tube it will have a temperature of 75° F. and coming from the second tube the temperature is 48° F. This is well below the solidifying point of the product, but due to the agitation, it does not solidify, but comes from the second chilling tube as a supercooled thick liquid. At this point when agitation is stopped, the product will set up firm in about two to five seconds. This second chilling tube, therefore, discharges into a larger, horizontal tube, equipped with a hot water jacket, which causes the material in it to move forward bodily, without agitation, and during the passage through here the product solidifies or takes its set. During this time the heat of crystallization causes the temperature to rise some ten or twelve degrees Fahrenheit.

As it reaches the end of this horizontal tube, referred to as the B Unit, the product is forced through a forming nozzle and emerges in the form of a slab, of such dimensions that it may be cut into prints for wrapping. The wrapping machine may be any conventional type, familiar to all who manufacture margarine. The only thing here that might be of interest is the cutting device. This consists of a frame having five wires stretched across it. The slab of margarine travels on rollers up to a stop on its conveyor. Then this wire frame, which is synchronized with the wrapping machine proper, is automatically forced across the slab cutting it into prints. These prints at the same time are pushed over onto a parallel conveyor which feeds the wrapping machine. As soon as they are out of the way, the slab moves forward again to the stop and the operation is repeated.

This system has most of the advantages looked for in a continuous process. It is totally enclosed and under pressure from the time the emulsion is made until the prints are formed. No losses of milk or salt occur, so all the flavor originally incorporated remains in it, and the analysis for salt and moisture should run closer than by any other system, with which we are familiar. All the parts coming in contact with the product can be made of nickel or stainless steel, to eliminate metallic contamination. It can be readily cleaned and sterilized with hot water and steam. The time element is reduced to a matter of minutes, and the labor required for operating it is certainly not excessive.

However, when we began to obtain actual operating experience with this equipment many difficulties became apparent and had to be overcome. The pump that delivered the emulsion to the machine, since it had to force the product all the way through to the forming nozzle at the outlet end, had to operate against a considerable pressure. At first we used gear pumps, and even though we used two in series, they soon began to wear, so that after some months their operating capacity dropped off from 3,500 pounds per hour to 2,000 pounds per hour or less. Speeding them up gave only temporary relief, and it became apparent that rotary pumps were not the proper type. We, therefore, obtained positive displacement piston pumps which were not subject to this disadvantage, and these have so far proven quite satisfactory.

Further, we realized that the flavor of the margarine made by this system was lacking in character. We were adding more ripened milk than formerly, and yet the milk flavor was not as pronounced as in margarine made by the old method. We decided that this was due to over emulsification. The agitator shafts were running at a high speed, and the knives in their limited clearance, were dispersing the milk into a very finely divided state. This was evident from the smooth, silky texture of the product and from microscopical examination. It seemed to us that this over emulsification was "smothering" the milk flavor and aroma. We were strengthened in this belief by the fact that the salt flavor also was smothered. Where three per cent salt formerly had tasted about right, it became necessary now to use over four per cent to obtain the same apparent saltiness. We could not reduce the speed of the agitators, so we decided to try to reduce the amount of agitation by by-passing the milk past the first tube and in-



**Some of the multiple-plate fractionating columns at the special naphtha plant of Skelly Oil Company, Lyman, Oklahoma. Skellysolve is made at this plant, which is located in the famous Burbank oil field, where there is a large supply of exceptionally pure natural gas.**

troduce it between the tubes, which would naturally cut the amount of agitation in half. To do this we used a 5 cylinder piston pump. Four of the cylinders pumped oil into the first chilling tube, while the fifth cylinder, calibrated to supply a little less than 20% milk-salt solution, discharged into the pipe joining the second tube to the first one. This gave a very encouraging improvement in flavor, so we then decided to go still further and by-pass both crystallizing tubes with the milk and salt. If this were done it would be necessary to get the milk and salt mixed in with the supercooled oil in some manner, and to do this a continuous blender was developed by the Vogt people. This blender, holding about six pounds of product, was inserted between the discharge of the second chilling tube and the horizontal setting-up tube, or B-Unit, and then the discharge from the milk-salt pump cylinder brought into the line just ahead of this blender. By setting the blender at a proper speed, the milk and salt were properly incorporated, and still allowed the full flavor and aroma to be obtained from the margarine.

I have described the preparation of the emulsion for this process. Obviously, when the milk is introduced separately, this step is eliminated. The four cylinders on the oil side of the piston pump can be connected to separate oil supplies, and we can now, on a limited range of formulae, pump oil directly from storage to the chilling tubes. This, of course, simplifies the operation and reduces the cost of manufacture correspondingly.

We have also installed, in the discharge line from the milk pump, a direct expansion milk cooler. This increases the capacity of the chilling tube, and reduces the load on the agitator shafts in those tubes.

This system of margarine manufacture is new, and as is the case with most new processes, there remain operating difficulties which need to be worked out. Perhaps the greatest of these is the fact that the crystallizer cannot be easily stopped and started. It is more or less synchronized with the wrapping machine, and when stoppages or jams occur in the wrapper, the slabs continue to come out of the forming nozzle, and must be laid aside. The wrapper is purposely geared a little faster than the crystallizer so that it can catch up on these slabs.

We realize that improvements can be made, but when we compare its advantages with the many disadvantages of other systems, we feel that it represents an undoubted step forward in the manufacture of margarine.

These and all the many other technical advances that have been made and are being made, constantly improving the quality of the product, are resulting in increasing consumption of margarine, and this increase will continue. Competent authorities point out that there are millions of families in the United States who do not have anything like an adequate amount of table fats, and because of its desirable flavor and moderate cost, margarine offers the greatest hope of supplying the deficiency.

This growing demand, together with a constantly increasing trend towards domestic vegetable oils, offers an opportunity and a responsibility to the oil chemist. We must strive for still further advances in processing technique, so that the present oils may be made most suitable for margarine purposes; and particularly we must seek to find ways for bringing into the edible field some of the oils that now cannot be used or which find only a limited use in that field.

# REPORT OF COMMITTEE ON INDICATORS

The study of the Committee of Indicators this season has brought forth no positive results. A considerable number of indicators were examined, both with regard to their theoretic desirability and their practical value and behavior in actual tests. In all tests the comparisons were made against Phenolphthalein as the standard. Special attention was given three (3) indicators: Thymol Phthalein, Methyl Blue, and Thymol Blue discussed by Mr. Shuey in his paper last spring.

Conclusions reached through tests are as follows:

THYMOL PHTHALEIN—does not have a sharp end point, gives slightly higher values on high acids and seems generally undesirable.

METHYL BLUE—on very high acids gives in the majority of cases higher values than Phenolphthalein, has a high $CO_2$ absorption and is thus not dependable. THYMOL BLUE—is perhaps the best of the three, however its color on acid solutions is not strong so that on very dark oils the end point is only a change from the natural color of the oil to the dark blue of the indicator, a change in many cases neither distinct nor adequate. A number of other indicators studied were even less desirable.

By far the most serious objection to all the indicators studied was their lack of uniformity. The committee members obtained one or more samples of each of the dyes and attempted as far as possible, to obtain them from different sources. It was quickly apparent that different lots of the same indicator varied widely, so much so in fact that this factor alone would preclude the adoption of any of them. This point was taken up with the manufacturers who informed us that at the present time it was almost impossible to manufacture these dyes uniformly and that they could hold no hope of our finding one that would be entirely dependable regardless of "lot" or source of supply.

The suggestion was made, however, that it might be possible to submit samples of different "lots" of any indicator found desirable, to a committee of the Society for testing; any "lot" thus found satisfactory to be purchased by the Society and dispensed by the Secretary. Such a procedure would insure uniformity and eliminate almost entirely present objections. It would of course carry with it certain obvious undesirable features.

One indicator suggested by the committee too late for thorough study was an Aniline Blue manufactured by Dr. G. Grubler and imported and distributed in the United States by Akatos, Inc., of New York City. It has been used in several laboratories with good results. The sample tested by the chairman seemed to fill entirely our requirements. The color change from a strong blue in ac to a red is that thought most desirable by the committee for an indicator used with dark oils. The end point is sharp, changing completely on the darkest oil with .05 to .1 cc. of quarter-normal lye. The F.F.A. values of dark oils up to almost thirty per cent (30%) acid were