FERMENTED MILK

Thesis for Degree M. Agr.

F. O. FOSTER

1913

F E R M E N T E D M I L K

T H E S I S

F O R D E G R E E

M A S T E R O F A G R I C U L T U R E

F. O. F O S T E R.

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FERMENTED MILK.

A study of the subject from a practical business standpoint.

Three important questions answered.

1. Is the manufacture and sale of fermented milk a profitable undertaking for firms engaged in the distribution of market milk?

2. Can the process of manufacture be controlled so as to overcome the objections that have been raised against it?

3. Has Bacillus Bulgaricus any advantage over the common lactic acid cultures?

INTRODUCTION.

Many articles both technical and popular have been written on this subject during the last eight years. The most of the articles published consider the subject from the medical standpoint, or the use of the product on a small scale. It is the purpose of this study to show the practical application of it and its value to agriculture.

Circular 171 of the Bureau of Animal Industry, U. S. Department of Agriculture, entitled "Fermented Milks", gives the most complete bibliography and summary of the work done on the subject that has been published to date.

Some additional articles of interest in this connection are:

1. Douglass: "The Bacillus of Long Life", National Food Magazine, Mar. 1911.

2. Dunn: "On the use of living lactic acid bacilli to combat intestinal fermentation in infancy", Archives of Pediatrics, Apr. 1907.

3. Kendall: "Lactic Acid Bacilli: What they are and what they are supposed to do", Archives of Pediatrics, Aug. 1910.

The subject is divided by common application into two parts:

A. Fermented skim milk as a substitute for buttermilk.

B. Special fermented milk.

A.

FERMENTED SKIM MILK.

Skim milk - buttermilk or Culture Process Buttermilk.

The use of skim milk fermented with lactic acid bacteria as a substitute for buttermilk.

Statement of existing conditions.

Much buttermilk sold to-day in the large cities is not fit for human food. The demand for buttermilk greatly exceeds the supply of good buttermilk, and it is common practice among milk dealers to churn all sour milk and cream, and milk and cream returned from the routes which is too old or otherwise unfit to send out again, and to sell it as and for buttermilk.

Sometimes this is ripened over night with a pure culture starter to improve the flavor and secure uniform consistency. Frequently skim milk is mixed with it and all ripened together.

Much of this milk, especially in hot weather, is in an advanced stage of decomposition, as indicated by foul odors, gas bubbles and separation of whey before it is dumped into the vat for ripening previous to churning.

The attitude of some managers and superintendents on the subject is shown by the following: In one instance when I objected to churning and putting out as buttermilk the rotten milk that was being dumped, the reply of the superintendent was, "There is a chance for you to show your skill in making a salable product out of it. We have not enough to supply the demand, and as long as people will pay 5¢ a quart for it, we can not afford to throw it away".

Frequently there is mixed with this milk after it is churned, the buttermilk obtained from churning cream gathered from the farms for buttermaking purposes. This is usually old, sour and bad flavored.

In the summer time the cream is often foaming out of the cans on arrival at the plant, due to contamination with yeasts and bacteria and not being kept cold. The acidity is so high that many firms use lime water to reduce it. In the winter when weather conditions are more favorable the cream is kept longer on the farm and is in nearly as bad condition when received. The following data from a record kept by me at the plant of the Polk Sanitary Milk Co., during December, 1912, and January, 1913, shows a common condition.

December 1912 Total cream shippers 165

Number sending but one can during the month 29
(These were probably new shippers or trial shipments)

Number sending cream once a week 64

Number sending cream oftener than once a week 18

Number sending more than a week apart 54

Forty-one of the fifty-four had shipments 10 to 17 days apart.

January 1913 Total cream shippers 158

Number sending but once during the month 33

Number sending oftener than once a week 14
(Four of these sent twice a week, ten sent 4 to 6 days apart.)

Number sending once a week 35

Number sending more than a week apart 76

Of these, 61 sent 8 to 12 days apart, and 15 sent 13 to 17 days apart. Forty-nine had shipments from 10 to 17 days apart.

There are three main reasons for this condition:

1. Economy.

The farmers keep but few cows and it takes several days to get a full can of cream. The cost of sending a can partly full is as great as that of sending a full can. To save time in hauling to the station, and to save freight charges they ship only when they get a can full.

2. Competition.

Three large firms are buying from the same territory. If one firm tries to enforce quality regulations the farmer will ship to one of the other firms.

3. Ignorance and carelessness on the part of the farmer.

Some farmers do not know or will not believe that their cream is bad. Others do not care so long as they get the same price.

A recent report of the U. S. Dept. of Agriculture states that 82 1/2% of the butter made in the U. S. is of inferior quality because of bad cream.

The buttermilk obtained under these conditions, although being better than that from decomposing milk, be-

cause of the fact that the cream is Pasteurized, is not what we like to consider a pure food.

Through personal experience in Baltimore, Detroit and Indianapolis, and through observation in some other cities, I know the condition of the buttermilk business, above described, to be quite general. The following copy of a letter from a dealer in Philadelphia confirms the statement for that city.

Harbison's Dairies
2015 Dreer Street

Philadelphia, Feb. 5, 1913.

Mr. F. A. Foster,

Dear Sir,

Regarding the subject of interest to you concerning the sale of buttermilk in Philadelphia and the price thereon.

Allow me to state after speaking to several large dealers in this city that they could not give any figures in any way of value to you.

The chief trouble they admit is that part is skim-buttermilk, some sour milk-buttermilk and in many cases a mixture of the above sold at 5¢ a qt.

The majority of the dealers sell buttermilk as a side line to use up surplus and do not pretend to have any special quality of buttermilk.

Hoping this will be satisfactory, I remain

Yours respectfully,

(Signed) Robt. J. Harbison, Jr.

Cream is purchased for buttermaking at a price based on the market quotations for butter, which allows for profit in manufacture without considering any returns for the buttermilk. Moreover many firms sell the buttermilk for stock food. The value of the buttermilk therefore need not stand in the way of a change to the skim milk kind.

The Milk Supply.

It is necessary for milk distributors to secure milk from enough producers to supply the demand during the portion of the year when the milk supply is at its lowest point. There is always a time during the early part of the summer, and occasionally at other times, when the supply greatly exceeds the demands of the consumers.

This surplus milk has to be skimmed and the cream made into butter, sometimes at a loss because of the fact that the price paid for milk is above the value of the cream for butter making purposes. Part of the skim milk may be made into cottage cheese, but as a supply can not be gaurnteed regularly it is difficult to find a market for large quantities for short periods only.

In addition to this skim milk from surplus milk, there is frequently a surplus of skim milk left from skimming milk to get cream for the cream trade.

I have seen in Detroit in 1909 and 1910, and in

Indianapolis in 1911, thousands of gallons of fresh sweet skim milk ran down the sewer. This surplus has amounted to several hundred gallons a day for several weeks.

It is of great economic importance to save this waste of good food material. If the substitution of fermented skim milk in the place of buttermilk is possible, much of this surplus milk can be utilized. A better quality of buttermilk will also increase the consumption of that article, and at the same time be a benefit to the public health.

Fermented Skim Milk Practical.

The use of fermented skim milk in the place of buttermilk is not a new idea, but many firms are using it only to supplement the supply of the other kind, and are not making it in a systematic manner, consequently the product is not uniform and is often unsatisfactory.

The following case shows how the system may be changed not only without loss to the dealer but greatly to his advantage.

Prior to March 1st, 1911, the Polk Sanitary Milk Co. of Indianapolis were using for buttermilk, milk that was sour when received, sour milk returned from the routes, and surplus skim milk. This was ripened sometimes with a pure culture starter and sometimes with starter from the previous batch. It was then cooled, churned and bottled, and sold at 4¢ per quart. It was not of uniform

quality and surely the part of it made from old sour milk was not a healthful food.

During March the system was changed. The sour milk was sent to the country for hog feed, and a uniform quality of culture process buttermilk was made from Pasteurized and fermented skim milk. It was advertised as such and a steady increase in demand resulted. On April 1st the price was raised to 5¢ per quart. Contrary to expectations there was no falling off in sales but a continued increase.

No attempt was made to deceive the consumer. No claim was made that it was regular buttermilk. It was advertised and sold as being made from fresh Pasteurized skim milk, hence was superior to buttermilk made from old gathered cream, which was the only kind available in any quantity. Other claims made for this product were that it was practically the same as buttermilk in chemical composition and food value, and more uniform in flavor and composition.

The trade on this grew to about 500 gallons a day in the summer and 300 gallons a day in the winter.

Proof that the consumers preferred the skim milk product was had when one day the buttermilk from a fair churning of Pasteurized gathered cream was sent out. Numerous complaints came in. "The buttermilk was not as good as usual", "It was thin", It was part water", "It did not taste right", etc.

The benefits to the dealer in this case were:

Increased sales.

A higher price.

A saving of much milk that was being wasted.

Better satisfied customers.

Good will and recommendations of the physicians and health officers.

The consumers got a purer food.

Method of Manufacture.

Much of the milk brought to the Indianapolis market is from Jersey cows and is rich in total solids. When this milk is fermented the resulting product is very thick. People were used to thin buttermilk and complained about the consistency. In order to satisfy this idea in the public mind, we found it necessary to dilute the skim milk before fermenting it. After nine days experimenting with dilutions, gradually working down and getting expressions regarding it from the consumers, we established the rate of five parts skim milk to one part water, which has been adhered to and given satisfaction for two years. At this dilution it is still somewhat thicker than the buttermilk from the regular churning and contains about the same amount of solids. In the case of cream, the separator bowl is flushed with water, the cream cans rinsed with water, (sometimes at the farm and again at the city plant), and the vats rinsed with water, and by the time the buttermilk is drawn from the churn, it may contain as much water as was

added to the skim milk.

Analysis of buttermilk Mar. 21, 1913, gave the following results: The samples were taken from the regular daily make and represent the average run.

From gathered cream churning:

.4% fat, 7.8% total solids, .59% acid.

From diluted condensed skim fermented:

.8% fat, 7.56% total solids, .635% acid.

A recent report from Germany states that it was held in the courts that a reasonable amount of water was permissable in buttermilk, and that no convictions for adulteration could be secured even when the added water ran as high as 25%.

However we are not advocating adulteration. It is solely a matter of catering to the demands of the consumer. We tried to give them the undiluted article and they objected to it.

In working up a new trade for skim milk buttermilk it might be possible to educate the consumer to take it undiluted. That was done with a special fermented milk very successfully. We praised its consistency with remarks like, "See how rich and creamy it is", "See how it paints the glass", etc. People expected it to be thick and complained when it was not so.

The addition of salt to the mixture of milk and water at the rate of one pound to 500 gallons was found to be beneficial to the flavor.

The entire process of manufacture is carried on satisfactorily in one Pasteurizing and ripening vat, which is connected with steam, cold water and brine or ice water. The milk is put into the vat and the water and salt added. The mixture is then heated to 180 degrees or higher, cooled to 70 to 80 degrees, 2 to 5% of pure culture starter added, and allowed to stand 12 to 15 hours or until about .8% of acid has developed.

The batch is then cooled to 50 degrees or lower, agitated at the same time to thoroughly break the curd, strained through a wire mesh or perforated metal strainer to remove any lumps of curd remaining unbroken, bottled and kept cold until delivered.

Vigorous churning or rapid agitation should be avoided during the latter part of the cooling or after the product is cold. If a pump is used to transfer the buttermilk to a bottle filler, it should run at a slow speed. These precautions are necessary to avoid foaming, which gives trouble in filling, causes a mass of foamy curd to gather in the necks of the bottles, and causes pockets of whey to separate as the air bubbles work out.

When it is desired to use the buttermilk obtained from churning the Pasteurized cream - and it frequently happens that some of it is fit to use, especially when the cream is graded - the skim milk should be fermented undiluted and after being cooled, the other buttermilk

may be mixed with it at the rate of one part of buttermilk to three or four parts of fermented skim milk. This will give a product of about the same consistency and not differing from the usual run enough to cause trouble.

A trade worked up for the product must be supplied throughout the year, and at times when the milk is needed for the regular milk trade something must be done to retain the buttermilk business.

To meet this difficulty, trials were first made with milk flour or dried skim milk. Other firms had reported fairly satisfactory results, and the supply house claimed they could not get enough flour to supply the demand. My trials were only partially successful.

The product had a strong flavor of cooked milk, and the curd was not as good as that from skim milk. The flour was not completely soluble and an undissolved portion was always left in the bottom of the vat. The flour was not uniform, one barrel being stronger flavored, harder to dissolve and apparently made from milk that was nearly sour.

The better grades of flour could be used with fair results in preparing starter, but the product was not satisfactory to sell as buttermilk.

Condensed skim milk was next tried. This was obtained from Chicago, Ill. and Newark, Ohio. It was claimed to be made from fresh skim milk concentrated four volumes into

one. The Chicago product proved quite uniform at that density. At first the Newark product was very variable, ranging from 2 1/2 to 1 to 4 1/2 to 1, and every shipment had to be tested and the dilution calculated. Later after considerable correspondence and adjusting of methods at the condensery the product was obtained of uniform density.

This condensed skim milk diluted to its original volume when to be mixed with other buttermilk, or to a specific gravity of 1.030 when used alone, made a buttermilk which could not be distinguished from that made from fresh skim milk. Upwards of 250 gallons of this buttermilk were bottled and sold daily for several months during the fall and winter of 1912 & 1913 without complaint.

This diluted condensed milk was Pasteurized and fermented in exactly the same manner as the fresh skim. It not only held the trade during the shortage in the supply of milk, but was handled at a good profit. At the same time the firms condensing it were making a profit, and the farmers in their territory had a market for their milk, although being too far from a large market to send the milk in in its natural state.

During the last year there was sold in Indianapolis at the lowest estimate 150,000 gallons of culture process buttermilk for a sum exceeding $25,000. If the other cities in the United States, having a population above 100,000, were to consume it at the same rate per capita, the amount sold in these larger cities yearly would exceed 12,000,000 gallons with a selling value of $2,000,000.

B.

Special Fermented Milk.

The use of Bacillus Bulgaricus.

Culture Studies.

Bacillus Bulgaricus.

The writings of Professor Elie Metchnikoff advocating the use of lactic acid cultures, or soured milk, as a means of controlling fermentations in the digestive tract and preventing auto-intoxication* have had more influence on the minds of physicians than is generally supposed.

Physicians in both Europe and America took up the subject and the medical journals contain numerous articles giving reports of trials and recommending methods of use. As a result most physicians are familiar with the practice and will make use of and recommend it frequently where a reliable product is obtainable.

The Bacillus Bulgaricus, isolated by Gregeroff from sour milk from Bulgaria, was the lactic acid producing organism recommended by Metchnikoff, and is the one generally advocated. The claims made for B. Bulgaricus are: It produces much greater quantities of lactic acid than the common lactic cultures. Its optimum temperature is about the temperature of the body. It will grow readily in the intestines, and becoming established in the lower intestines, will inhibit the growth of undesirable organisms or cause a more favorable fermentation.

It is not attempted in this study to prove the claims from a medical standpoint further than to note that favor-

* Poisoning of the body by substances resulting from the processes incidental to its life.------Herschell.

able results were almost invariably obtained by physicians in using the product. Whether the same results would have been obtained with a product fermented by the common lactic cultures can not be stated.

The fact that the Bulgarian or Metchnikoff Bacillus has such a prominent place in the minds of the physicians and has received so much publicity through popular magazine articles, gives a product containing it a great advantage in placing it on the market.

Milk fermented with this organism alone is not palatable. It is very viscous or slimy in consistency and has a strong acid taste. After a few trials of the culture, when I first began making fermented milk in 1910, I rejected it and went back to my old "Starter".

A year later, on taking up the work for the Polk Sanitary Milk Co. they said, "Because of its advertising value and the physicians demand for it, we must put the Bulgarian culture into it, if only in small quantities". So I started an investigation to determine:

1. What cultures would associate with the Bulgarian culture to produce the best results.
2. How much Bulgarian culture could be used and make a palatable product which would sell for a beverage as well as for a medicine.
3. Could these cultures be grown in association and the milk fermented with a combined culture, or would they do better separately, the products being mixed after fermenting.

4. What temperatures were most favorable in either case.
5. The best method of manufacture to secure a uniform product from day to day.
6. How rich the milk should be to give a desirable flavor.
7. Was there any benefit in adding yeast to the cultures of bacteria.

Trial of Cultures.

As this thesis was not planned at that time, only general daily notes and conclusions were recorded. The complete data of each trial is not at hand.

No attempt was made to trace out the characteristics of each culture with a view to establishing the identity of the species or variety. Each culture was plated to determine whether it was a pure culture of lactic acid producing bacteria, and was carried along and kept in a vigorous condition by daily transfers into sterilized milk.

The tests were made under practical working conditions, to determine which would give the best flavor and consistency. The milk used was taken from the daily run of mixed nights and mornings milk, and was Pasteurized in quart milk bottles in the laboratory. One or more cultures were also set each day in two gallon cans in order to have larger quantities for testing, judging and experimenting with mixtures.

Cultures used.

Name or source	In what form purchased
Ericsson's Butter culture	In milk
Hansen's Lactic Ferment	Powder
Douglass Butter Culture	Liquid
Keith's Lactic Acid Culture	"
M A C Lactic Culture	Milk
Keith's Bacillus Bulgaricus	Liquid
Bulgara Culture (Walker-Gordon Lab.Balto.)	Milk
Bulgarian Culture (Perry L. Hobbs, Cleveland)	Milk

The last two were combination cultures from which I isolated the organisms and used them the same as single cultures.

I also isolated some lactic acid bacteria from the regular milk supply but did not succeed in getting any as satisfactory as those purchased.

The above named cultures showed no contamination and all developed readily when transferred to sterilized milk.

Each common lactic culture was grown alone and in defferent proportions when mixed. The time of development and effect on the product was noted.

After about ten weeks of experimenting the following conclusions were drawn:

Time.

The product was no better when developed in a few hours with a high per cent of inoculation, than when a longer time was taken with a lower per cent of inoculation. As it is convenient in practice to let the milk ferment over night, fifteen hours was adopted as a convenient standard and the per cent of inoculation adjusted to bring the fermentation to the right stage in that time.

Temperature.

The temperatures tried ranged from 70 to 100 degrees. The most favorable temperatures for fermenting milk with common lactic cultures was 70 to 80 degrees. For the combined cultures 75 to 85 degrees was most satisfactory. For the Bulgarian cultures alone, 90 to 100 degrees gave best results, the higher temperature being preferred.

Inoculation.

The per cent of inoculation was varied from 1/4% to 10% with differences in the temperature and time, and also with changes in the vigor of the culture.

About .95% of acid was preferred by the majority of consumers after the product was established on the market, although the acidity decided on in the laboratory trials was .8 to .9%.

One to 1 1/2% inoculation at 70 to 75 degrees developed the right acidity in the laboratory trials. Later it was found necessary to raise both the rate of inoculation and the temperature, 6% inoculation at 80 degrees being the other extreme.

The following table giving the averages for sixteen months, was taken from a daily record and shows the variation in temperatures and rate of inoculation found necessary in practice to secure the proper development of the product.

Month 1911	Quantity made daily	per cent inoculation	B to L A	Temperature degrees F.	Time Hrs.	Acidity %
April	Lab. trials	1	1 to 7	70	15	.8 to.86
May	170 gal.	2	1 to 6	75 to 80	14-17	
June	165 - 185	3	1 - 5	75	14	
July	160 - 190	3 to 5	1 - 7	75 - 80	16	
Aug.	160 - 190	5 - 7	1 - 5	77 - 80	15	
Sept.	140	5	1 - 6	80	15	
Oct.	90	4 - 5	1 - 6	77 - 80	15	
Nov.	120(3 a week)	5	1 - 6	80	15	
Dec.	120 "	5	1 - 6	80	15	
1912 Jan.	120 "	5	1 - 6	80	15	
Feb.	120 "	4 - 5	1 - 6	75 - 80	15	.95 - 1
Mar.	120 (EOD)*	5	1 - 6	78 - 80	15	
Apr.	120 "	6	1 - 6	80	15	1
May 1-21	160 "	6	1 - 7	80	15	.95
May 22-30	110 daily	6	1 - 7	80	15	
June	130 - 140	5	1 - 6	80	15	.95

* Every other day.

During the remainder of 1912 the quantity ran a little less than in 1911, the average per cent of inoculation was 5. The combination varied from 1 - 6 to 1 - 4, and the temperature from 75 to 80 degrees.

In case of shortage or accident it is possible to greatly hasten the process of manufacture. On one occasion I made a 100 gallon batch in six hours, by using fifteen per cent inoculation and setting at 85 degrees.

Association or Combination of Cultures.

In the first laboratory trials, the best results were obtained when one part of Bulgarian culture was used to five or six parts of common lactic culture. The culture increased in vigor and the rate was cut to 1 - 7. Later the proportion was increased and during the winter of 1912 & 1913 one part to four was used. Greater amounts of Bulgaricus gave a strong acid flavor and too great viscosity.

Some differences in flavor developed in the common lactic cultures and in this trial Ericsson's and Hansen's gave the most palatable product.

The addition of Bulgaricus in quantities not greater than noted above rather improved the flavor than otherwise. A pleasant "bite"or "twang" was secured that was absent when Bulgaricus was not used.

No difference could be seen in the finished product, whether the milk was fermented over night with the combined cultures or the milk divided, the parts fermented with separate cultures and mixed after fermenting.

The practice adopted after the preliminary work was to inoculate the milk at night with the two cultures, the cultures being grown separately up to this point. After nearly two years following that method, the method of dividing the milk, fermenting the parts separately, and mixing it after fermenting was used for several months with equally good results.

Combination Cultures.

Trials of cultures bought in combination all proved unsatisfactory. They contained an excess of Bulgaricus. When the organisms were isolated and used in the right proportions they produced good results.

As an example, the following was noted regarding a culture obtained from the Walker-Gordon Laboratory, Baltimore, Md.

In several trials using from 1/4 to 3% inoculation, and setting at 80 to 95 degrees, there was too strong a flavor of the Bulgarian culture.

Two ounces in one quart curdled in three hours at 95 degrees. One per cent inoculation at 80 degrees developed 1.52% acid in 15 hours. 1/4% at 90 gave too much acid in 15 hours.

Microscopic examinations of combined cultures showed the Bulgarian Bacillus in numbers about equal to the associate organism.

Combined Cultures Possible.

Trials were made with cultures combined in the laboratory which carried successfully for seven to ten days.

A combined culture prepared as for shipment was held two days at room temperature (70 to 80 degrees). It curdled in less than 24 hours. At the end of two days microscopic examination showed Bulgaricus present in relation to other lactics about one to four or five.

Another one ounce culture, inoculated 1 to 6, curdled in 20 hours, was left five days at 70 to 80 degrees, then transferred to 3/4 quart of sterilized milk. The milk curdled in less than 24 hours and the microscope showed Bulgaricus present in considerable numbers, but in a smaller proportion than the culture used.

Other trials were made in which the cultures carried in satisfactory proportions for 6 to 7 days.

A culture inoculated 1 to 6, mailed and returned for better address, was left at room temperature for two days, then put in a refrigerator at 55 degrees for 5 days. This culture placed in 3/4 pint of milk developed a good curd in 15 hours, but no Bulgaricus could be found by plating or microscopic examination.

A culture inoculated 1 to 6 was transferred daily and carried for 17 days at 70 to 80 degrees. No Bulgaricus could be found at the end of that time.

A culture was sent to La Crosse, Wis. on Aug. 9th, and carried as a starter until Oct. 12th. By my request a sample of the starter was then returned which proved to be practically a pure culture of the common lactics. The Bacillus Bulgaricus had died out.

I sent combined cultures to Dubuque, Ia. weekly from Aug. 1911 to Feb. 1913, 75 cultures in all, with but one complaint: To St. Paul, Minn. weekly two summers and bi-weekly one winter with no complaints; To Los Angeles weekly for several months, and to various other places for short periods and at irregular intervals.

The only difficulty met with was in shipping to Spokane, Wash. The cultures were five days on the road and did not develop properly at first. By inoculating with a very small per cent at about 50 degrees, they went through all right during the winter. As warm weather came on more trouble arose and separate cultures were sent.

Conclusion: If combined cultures are used they should be inoculated in the right proportion and a fresh culture secured weekly.

Uniformity of Product.

Herschell has written*, "The commercial supply of soured milk can not possibly succeed as an industrial enterprise, and as a matter of fact, in Paris the majority of firms which have embarked in the business have now practically abandoned it, as they have found their sales decrease day by day. The main reason of this was that they found it impossible to deliver to their customers a milk which resembled that supplied upon the previous day". And further on in the same work, "We must absolutely interdict the use of commercial soured milk supplied by dairy companies and private individuals for gain". Again in his conclusion, "Do not under any circumstances order a <u>commercial</u> preparation of soured milk".

Dairy conditions must have been very bad in London when Herschell wrote the above, for in one place he states, "First of all there is the difficulty of procuring, at any rate in London, a milk which contains absolutely no preservative of any kind whatever".

In our cities at the present time preservative in the milk is a rare occurrence. It is at most times an easy matter to get milk in good condition, so that with modern machinery and methods of Pasteurization it is possible to manufacture a product practically free from undesireable organisms, or nearly a pure culture of lactic acid bacteria.

* Soured milk, 1909 P31.

Given pure cultures and good milk, the successful production of a beverage depends upon careful attention to details in the process of manufacture.

The separation of whey in the finished product is the most frequent cause of complaint. This may be due to bacterial development from bad milk, improperly Pasteurized milk or contaminated cultures. It may be caused by handling the product too warm, or by a rapid agitation or pumping which causes foaming when the product is cold.

The latter conclusion is drawn from the following: During March 1911, milk was fermented in a vat, cooled, pumped into a churn and churned 1/2 hour which produced much foam. In this product the whey separated quite badly. A new vat was then used which broke the curd sufficiently without churning, the foaming was reduced and very little whey separated.

In May 1911, we started pumping fermented milk with a pump running rather fast. It produced much foam and subsequent separation of whey. The speed of the pump was lowered, avoiding the foam and the trouble ceased.

November 12, 1912 a new tank was installed for special fermented milk. The agitator was geared to run fast, which produced much foam and whey separated. Another gear was put on giving two speeds. The high speed was used for breaking the curd and partly cooling the batch, then the low speed

used to finish the cooling. This produced no foam and there was no further trouble about separation of whey.

Methods of Pasteurizing Milk.

The regular method adopted was to heat the milk to 180 to 200 degrees, hold it at that temperature for 1/2 to one hour, and cool to the setting temperature. Several tests of this milk after Pasteurizing gave a count of two and three colonies per plate when diluted 1 to 100.

The lowest temperature ever allowed was 180 degrees and cooled without holding.

At times the milk was received in poor condition. Often the count ran above 25,000,000 bacteria per cc. B. Subtilis was very numerous at some seasons.

In extreme cases special methods were resorted to. I have heated milk to 195 degrees for three hours and made an excellent product.

For two months I practiced heating to 190 - 195 degrees for two to three hours with good results.

Again for four months I Pasteurized at 190 to 200 degrees for 1/2 to 1 hour, cooled to 90 degrees, let stand six hours and repasteurized at 190 for 1/2 hour.

A scorched flavor is largely overcome by the production of acid, and adds a not unpleasant taste to the product. 195 degrees for three hours gave too strong a scorched flavor and changed the color slightly.

In cold weather where the milk was received in good condition in the forenoon, it was found satisfactory to heat to 150 degrees for 1/2 hour, cool to 50 degrees and heat again only to the setting temperature late in the afternoon.

Richness of Milk.

Upon the richness of the milk depended to a great extent the market price of the product. It was desirable to put on the market a beverage that would be sold at a profit at the popular price of 5 cents.

In some cities whole milk was being used and the product sold at ten cents a bottle (1/2 pints or 1/3 quarts), but a large trade could not be worked up at that price.

It was to be sold as a beverage and health drink, not as whole milk, hence there was no particular reason for leaving in all of the expensive butter fat.

At the same time it should be rich enough to have a pleasant flavor and be considered as a beverage in a class above buttermilk.

After trying milk varying in richness by 1/2 per cents from skimmed milk to four per cent, it was decided that two per cent fat, or equal parts of whole milk and skim milk, met all of the requirements.

The use of Yeast.

An effort was made to improve the flavor of fermented milk by the use of yeast. Kefir and Koumiss, two products that have been made in small quantities for many years, and for which methods of making are given in many dairy books, both contain yeast in association with lactic bacteria.

Two samples of Fer-mil-lac (the most widely known fermented milk now on the market) which I examined, contained a yeast in very small quantity.

Some articles on fermented milk advocated the use of yeast, and while no product that I had examined was superior in any way to the product that I was making without yeast, I did not wish to overlook any opportunity for improvement. I tried cultures of yeast from the following sources:

Yeast isolated from Fer-mil-lac.

Yeast isolated from Kefir Grains.

Fleischmann's yeast.

Bottom yeast from the Indianapolis Brewing Co.

Yeast isolated from a sample of starter from Spokane, Wash.

Yeast from a Kraut culture imported from Germany by the J. T. Polk Canning Co.

Trials were made with and without the addition of sugar, glucose and dextrose; at various temperatures, and with various per cents of inoculation.

In no case was there any improvement over a product made at the same time without the yeast. In most cases an undesirable yeasty odor and taste was left in the finished product. If the inoculation was small enough or the fermentation carried on at temperatures to prevent this, no difference could be noted between the products made with and without the yeast.

Reliability of Cultures.

Nearly all cultures purchased in milk or other liquid media, were pure and in a vigorous condition.

Most tablet preparations were very unsatisfactory.

Following are the results of some of the trials:

Lactone - Parke, Davis & Co.; Tablets purchased at drug stores. Several trials were made during two years, and in most cases gas and bad flavors developed and the microscope showed foreign organisms present. A few plated out pure and developed a good curd, but in these cases the flavor was not as good as that in some other cultures.

Bacillus Bulgaricus - Parke, Davis & Co.; Tablets obtained directly from the laboratory in Detroit. A pure culture and very good.

Fermenlactyl - A foreign culture obtained from a drug store. Supposed to be a combination of B. Bulgaricus and a common lactic. Contained no Bulgaricus but many B. Subtilis.

Yogurt - From Good Health Publishing Co., Battle Creek. Obtained direct. Tablets loose in a paper box. Supposed to be a Bulgarian combination. No B. Bulgaricus or other lactics present. B. Subtilis and a yeast numerous.

The following is an example of the condition of the tablet trade: In January 1913, I called at a prominent down town drug store in Indianapolis and asked for lactic cultures. They were out of Lactone tablets, but offered me two kinds of foreign tablets. One bottle was dated Jan. 1912, (a year old). The other was dated Sept. 1912, good for four months.

At the next drug store I found some fresh Lactone tablets, which happened to be pure.

Culture Studies.

The effect of temperature on the growth of B. Bul.

Bottles of milk that had been Pasteurized twice were inoculated with a vigorous culture of Bacillus Bulgaricus at the rate of 1 cc to 1/2 pint, and set at three different temperatures, viz., Room at 72 degrees, Electric incubator at 92 degrees, (was set at 85 and rose in a few hours to 92), and Gas incubator at 100 degrees. The acidity was tested at 17, 41 and 65 hours.

72 degrees	17 hrs.	not curdled	.2% acid
	41 "	" "	.32% "
92 degrees	17 "	" "	.22% "
	41 "	curdled (under 30 hrs.)	1.42% "
	65 "		1.93% "

100 degrees	17 hrs.	curdled	1.24% acid
	41 "		2.15% "
	65 "		2.59% "

The viscosity was greatest in the culture at 92 degrees.

A culture from Hansen's Lactic ferment was used at the same time at 72 and 92 degrees.

72 degrees	17 hrs.	curdled	.93% acid
	41 "		1.08% "
92 degrees	17 "	"	.95% "

Vitality in cold.

12-30-1911, P. D. Co. Bul. after standing 13 days in the refrigerator, developed readily in 20 hours at 37 degrees C. with 1/2% inoculation.

1-10-1912, Walker-Gordon Bul. after 23 days in the refrigerator developed in 24 hours at 37 degrees C. with 1/2% inoculation.

Number of Bacilli in Milk.

11-21-1912, A vigorous culture contained 114,000,000 per cc.

8-3-1911, Fermented milk, 170 gallons, set with 5% started (Bul. 1 to LA 7) 16 1/2 hours at 78 degrees, contained 8,000,000 Bul. per cc.

10-10-1911, Milk Pasteurized three times, set 15 hours at 78 degrees with Bul. 1 to LA 6, made an extra good pro-

duct with smooth and thick consistency. Gelatine plates at 20-25 degrees showed 500,000,000 lactics per cc. Whey agar plates at 37 degrees showed 4,000,000 Bul. per cc. 12-15-1911, Fermented milk, 150 gallons, Bul. 1 to LA 7, inoculation 5%, set 15 hours at 82 degrees. Product contained 6,000,000 Bul. and 500,000,000 lactics per cc.

Microscopic examination not a sure method of judging purity of culture.

B. Bulgaricus varies in size under different conditions of growth, sometimes appearing as long slender rods, at other times much shorter and thicker. It usually is much longer than any other bacillus likely to get into the milk, and microscopic examination will show when other organisms are present in any large numbers.

Herschell says, "Always make use of a pure laboratory culture which has been standardized and examined microscopically for contaminating organisms."

When B. Bul. is in the form of short rods it would be difficult to be sure whether others were present or not.

On Feb. 16, 1913, my culture did not act right, but the microscope showed nothing but long rods. A whey agar plate, however, showed the next morning a dense spreading surface colony. An examination of this showed an organism of size and shape not differentiated by the microscope from B. Bulgaricus.

Colony Formation.

Heinemann & Hefferan* describe B. Bul., cononies on whey-agar as "minute and almost indistinguishable to the eye from streptococcus colonies."

In no case did my cultures develop in this manner. They were always filamentous, and always many times larger than streptococcus colonies. There was much variation when grown at different temperatures, or in different media. Sometimes the colonies were dense masses of threads, at other times thin, and in a few cases they appeared as a thin veil on the surface not visible to the naked eye, but plainly seen when magnified 60 diameters.

On Jan. 11, 1912, I noted: Whey agar plates, 2 days at 35 - 36 degrees. Keith's Bulgaricus, dense colony, long slender bacillus, milk culture viscous.
P. D. Co. Bulgaricus, very thin colony, long slender bacillus, milk culture viscous.
Walker-Gordon Bulgaricus, thin colony, shorter thicker bacillus, milk culture not viscous.

Any of the cultures could be made viscous or not, almost at will, by changing the temperature of the incubator. Temperatures above 100 degrees F. and allowing high acidity to develop were unfavorable to the retention of the viscosity.

* A Study of B. Bulgaricus, U. of Chicago, 1909.

A viscous culture seemed to be always vigorous, and was desirable in the product to give a smooth body and help prevent the separation of whey.

Analysis of Fer-mil-lac.

Sample from St. Louis, the home of the product. (Firms in some other cities are making Fer-mil-lac under directions of the St. Louis Dairy Co., and paying the St. Louis company a royalty for using their methods and cultures.)

The sample examined tested 3% fat and 1.03% acid. Slides stained with carbol-fuchsin showed numerous common lactics, but no Bulgaricus could be found on four slides. (The product I was making with Bul. 1 to LA 6 would show several Bul. on each slide.)

Several plates of Fer-mil-lac on whey agar failed to show any Bulgaricus, but milk inoculated with Fer-mil-lac and incubated two days at 100 degrees F. developed Bulgaricus in considerable numbers.

Two plates showed colonies of yeast, and the sample of Fer-mil-lac after it got old had a yeasty odor.

Kefir.

Some kefir grains were ourchased and used both alone and in association with B. Bulgaricus. In every trial the product was inferior to that made with the regular lactic cultures.

Hops.

Imported and domestic hops were obtained from a brewing company and given a limited trial, but no improvement in flavor was secured.

The question arose in my mind, "If it is permissable to use yeast to produce an alcoholic fermentation in milk, why not mix a small amount of some liquor with the fermented milk and get the flavor without the yeast?"

Fermented milk containing beer at the rate of 1 teaspoonful per 1/2 pint was pronounced very good. A larger quantity had enough beer flavor to make the persons trying it suspicious. None of this was put on the market, and it was not considered practicable even if it did improve the flavor.

Conclusions Regarding Cultures.

Cultures in liquid media are most reliable.

Nearly all liquid cultures tried were pure.

Tablets frequently do not contain living bacteria of the kind desired, and many times undesirable forms are present.

Liquid cultures containing combinations of B. Bul. and common lactics, may not have the bacteria present in the right proportions to give best results.

Combination cultures are difficult to carry and keep the proportions right. A fresh culture should be secured weekly.

Better results can be obtained by carrying the cultures separately, each at its optimum temperature.

Conclusions.

Fermented milk can be made a profitable side issue on the market milk industry in large cities.

It utilizes the surplus milk, much of which frequently goes to waste at some seasons.

Fermented milk is a more healthful and purer food than most of the buttermilk now being sold.

Fermented milk can be made satisfactorily from condensed milk, which enables the dealer to maintain the trade during the part of the year when the milk supply is short.

The process of manufacture can be controlled so as to give a uniform product meeting the requirements of the physicians.

The Bulgarian Bacillus can not be used alone and produce a popular beverage.

The Bulgarian Bacillus, in association with a common lactic, has advantages over the common starters, by producing a better flavor and consistency, and through its advertising value in selling the product.