MILK TESTING

A SIMPLE PRACTICAL HANDBOOK FOR

DAIRY FARMERS, ESTATE AGENTS, CREAMERY MANAGERS,

MILK DISTRIBUTERS AND CONSUMERS.

BY

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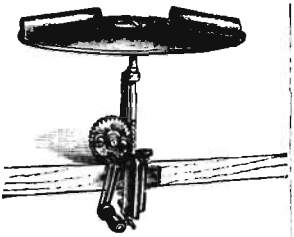

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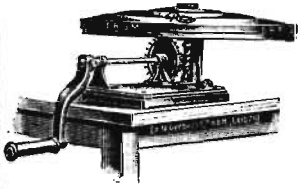

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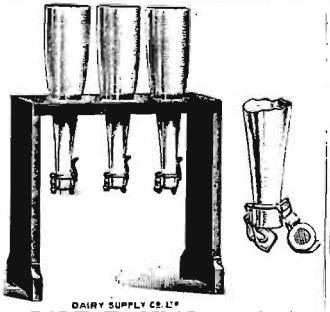

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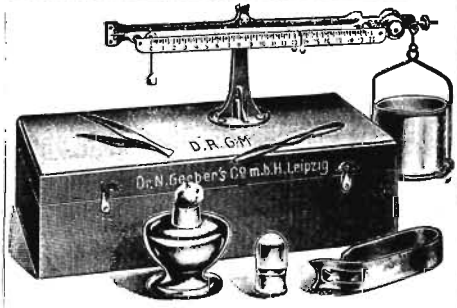

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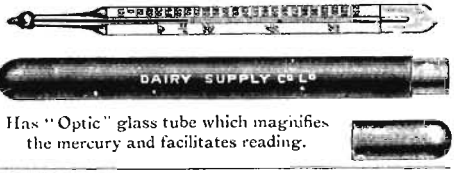

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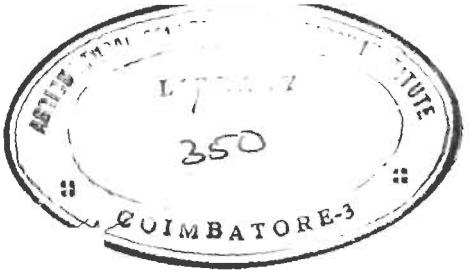


DEDICATION.

TO MY MOTHER AND MY AUNT ELEANOR.
TO THE FORMER
I AM INDEBTED FOR ANY TALENT I MAY POSSESS;
TO THE LATTER
FOR A LIFE-LONG INTEREST IN MY WELFARE.

PREFACE TO REVISED EDITION.

THE quick sale of the first edition of "Milk Testing" has proved most gratifying to the author, whose object in first publishing the work was to provide, at a popular price, a simple guide for busy practical people.

Although the book has been out of print several months, the author has preferred, rather than reprint it in its old form, to delay republication so as to find time to revise the text thoroughly and make additions where necessary in order to bring it completely up to date. To those who were unable to obtain a copy of the original edition, it is to be hoped some little compensation will be afforded by the improvements now introduced.

The subject of Milk Testing is daily gaining in importance, and the time is now come when every dairy farmer should, in his own interests, carry out tests. Various County Councils are sending out trained men to test the quantity and quality of milk yielded by the cows in the herd of any dairy farmer who cares to apply for such testing to be done.

This is excellent propaganda work towards getting the tests made known, but the best results can only be obtained where the farmer makes the tests systematically for himself. A keen desire to know the quantity and quality of the annual milk yield of each cow in his own herd, so as to be able to sum up its value, is essential to success in modern dairy farming.

C. W. WALKER-TISDALE.

Northallerton,

May, 1911.

Some Press Opinions on "Milk Testing."

ROYAL AGRICULTURAL SOCIETY'S JOURNAL.

"All cow-keeping farmers who depend upon milk-selling for a considerable proportion of their income must feel that the *quality* of milk is at this present time much more generally held to be of importance to the public than it was in the past. . . . To all who appreciate this truth we can thoroughly recommend this little book."

BATH AND WEST JOURNAL.

"This is a useful little work, concise and well illustrated. . . . It is a popular exposition of the kind of testing which can be done by those who are not analytical chemists, but yet possess sufficient manipulative skill to handle apparatus."

NATURE.

"The result is an admirable little volume, sound in regard to analytical methods, and direct in its appeal to the man for whom it is intended."

FARM AND HOME.

"We do not think there is a better guide to milk testing obtainable. It deals with all the details in a thorough manner, and provides for serious students a series of examination or test questions by means of which they can gauge the extent of their knowledge. . . . We cordially recommend the book."

SCOTTISH FARMER.

"With the help of this book, and the proper appliances as described therein, anybody can accurately test the milk which they, either as producers, middlemen, or consumers, handle. . . . If the time is not here already, it is not far distant when everyone will have to be able to test milk."

FARM AND GARDEN.

"All manner of tests are described, and the apparatus required is illustrated. Not only are we told how to test for butter-fat and other solids in milk, but also how to test dairy liquids for acids, and how to detect preservatives and colouring matter in milk. It is undoubtedly a handy and useful book for the practical man."

THE DAIRY.

"Busy practical people, who cannot wade through volumes of scientific treatises, nor devote time to working with elaborate and expensive apparatus, will find this book all that is really necessary to enable them to understand how to quickly and accurately test milk with the most reliable results."

FARMERS' GAZETTE.

"The little book is an admirable shillingsworth, and should be in the hands of all creamery managers, dairy instructors, and pupils. Considering its size it is wonderfully complete."

THE ESTATES GAZETTE.

"A simple, practical handbook which the author has prepared to assist busy people, milk producers, distributers and consumers, estate agents and others, who require simple, accurate and rapid means of testing milk, and it very amply fulfils its purpose. . . . Will be found most useful to those who have little time to spare and desire practical guidance in such matters."

DAILY TELEGRAPH.

"A very useful and practical handbook. . . . It gives full details as to the various methods, and has been prepared to assist busy people who require simple, accurate, and rapid means of testing milk. . . . The instructions given will be found very helpful in carrying out the work."

SCOTSMAN.

"Concise, clear, skilful, and eminently practical, it cannot but prove serviceable to dairy farmers, creamery managers, and consumers of milk who are interested to see that the milk supply is the best possible."

PREFACE TO FIRST EDITION.

This short treatise on Milk Testing is prepared specially for busy practical people who can devote but little time to such work, and yet to whom accurate tests are of the greatest importance. Only those tests by which accurate results can be obtained quickly are of service to the average practical person who can neither afford the expensive apparatus, acquire the knowledge and skill, nor devote the time necessary to the carrying out of elaborate analyses.

At the present stage of development of the dairy industry, testing is all-important to those connected with the production, purchase, and sale of milk, and any who ignore it must inevitably suffer in competition with those who make use of its principles and practice.

The dairy farmer is only enabled to build up a first-class, highly profitable milking herd by regularly weighing and measuring the milk of each cow and testing its quality, discarding (after a trial lasting for two seasons) all cows which fall short of a certain standard fixed according to his ambition.

Every farmer who sells milk (either wholesale or retail) should protect himself by making frequent tests to ascertain its composition, so that when complaints arrive, he knows and can state the exact quality of the milk as it left the farm. The dairyman should make regular tests and be assured that he is supplying his customers with a good article; and, if working on the lines of selling milk to men or the so-called "carriers" for distribution (taking back any not sold), such testing is imperative to prevent fraud.

Many customers advisedly test the milk supplied to them; but such must be warned not to accept as accurate results obtained by the use of milk testers (sold at about 1s.) marked to indicate the percentage of adulteration by added water. These testers are forms of the Lactometer, and from the remarks under this heading it will be seen are generally useless where adulteration has been practised.

Members of the public desirous of ascertaining the quality of milk supplied them should use the simple type of modern centrifugal tester, by means of which an accurate test may readily be made at a trifling cost.

The subject-matter of this small work originally appeared in *Farm and Home*; and it is by kind permission of the Editor of that paper that it is published in its present revised and amplified form. The author gratefully acknowledges the loan of illustrations from the catalogues of several firms (whose names appear in connection therewith), and, whilst holding a brief from none, has depicted all apparatus thought necessary to make the text clear.

C. W. W.-T.

Northallerton,

April, 1909.

MILK TESTING.

1.—THE COMPOSITION OF MILK.

One of the most striking advantages which have followed the advances of science is the possibility of detecting with certainty whether a food which is offered for sale is pure or whether it has undergone adulteration. Milk is especially liable to be adulterated, and the fact that its composition even if unadulterated is not uniform renders it very difficult, if the added substances are not too great, to say whether they are in the milk naturally or have been added intentionally. Milk varies enormously in its composition, in fact the constituents are never present in exactly the same proportion in any two samples. Thus in stating the composition of milk it is only safe to give figures representing the average quality of as many samples as possible. It is then safe to assume that unadulterated milk varies from the average composition only within certain limits, and it is by relying on this close approximation of any one sample to the average that it can be more or less confidently asserted, after the examination is complete, whether foreign substances have been added or not.

Everyone knows that milk is a more or less whitish fluid, which is produced by that class of animals called mammalia. It is produced sometimes before, but usually at and after, the time of the birth of young, and is for the purpose of feeding the offspring until it is able to forage for itself.

It essentially consists of five different constituents, as shown in the following table, which is the average obtained from a large number of samples :—

Water	87·55 per cent.
Fat	3·60 „
Casein and Albumin	3·50 „
Lactose (milk sugar)	4·60 „
Mineral Salts	·75 „
	100·00

Constituents of Milk.—Water.

The most striking fact here indicated is that nearly nine-tenths of milk is water only. Though this seems a very large proportion, yet it is exceeded in not a few other foods, especially in vegetables. Turnips, for instance, contain a far greater proportion of water than does milk.

Seeing, however, that the quantity in good milk is so great, the seriousness of adding more water—and such an addition does occasionally take place—is only too plain. The more water the milk contains the less the proportion of solid matter present, and it is in this loss that the real harm of watered milk consists. It is occasionally found that owing to badly-selected foods or the ill-health of the cow the quantity of water present may naturally increase, but this variation must be slight or the artificial addition of water will be suspected.

Total Solids and Solids non-fat.

The whole of the other constituents of the milk are named the Total solids, and these solids are usually divided into the fat portion and the non-fatty portion. By adding together all the figures excepting the water the total obtained is 12·45, which represents the total solids.

Leaving out the figures showing the water and fat, the rest added together give the solids non-fat or non-fatty solids, which amount to 8·85 per cent. So that in another form the composition of milk may be shown as follows :—

Water			87·55 per cent.
Total solids—			
Including Fat	3·60		
And Solids non-fat, as casein, sugar and salts or mineral matter	8·85	12·45	„
		100·00	

Butter Fat.

The fat of the milk is the essential constituent of butter, which can be obtained from either milk or cream, and hence it is called "butter fat," even though it may not be made into butter. It is in the form of small globules, which are only visible by the aid of the microscope.

These globules vary somewhat in size, the smallest having a diameter of 1-600th of a millimetre, while the largest may be six times as large as this, so that if one hundred were placed in a row touching one another they would stretch over a milli-

metre. They are largest in the milk from the Channel Islands breeds of cattle, and smallest in the case of Dutch and Ayrshires.

One disputed point among investigators is whether these globules have an envelope or containing skin of casein surrounding them or not. If such a skin be present it must be of very slight character, since the act of churning necessitates the breaking of these enveloping skins, if they exist, and the coalescing of the globules to form the solid particles of butter then takes place.

Volatile Acids.

Chemically, butter fat is of a somewhat complicated nature, and is really a mixture of several different fats. It consists of glycerine combined with certain fatty acids, some of which are insoluble and non-volatile acids, while others are soluble and volatile. It is the latter that serve to distinguish butter fat from other fats, since very few other fats contain them to any extent. They also serve because of their volatile character to give to butter the smell or aroma which is distinctive of it. The 3·5 per cent. of fat, or thereabouts, usually present in milk is made up, according to Blyth, of the following fats :—

The acids entering into the composition of these fats are insoluble and non-volatile : —	
Olein	1·477
Stearin	1·750
Palmitin	
Acids of these fats are soluble and volatile :—	
Butyrin	·270
Caproin	·003
Caprylin	
Caprin	

These fatty compounds have all different melting points. Olein, for example, when separated, is liquid at the ordinary temperature of the air. Stearin and palmitin, on the other hand, are solid at the ordinary temperature, and do not melt till about 130 deg. F. is reached.

If the proportion of olein increases, this will naturally tend to make the butter softer, since it is liquid at the ordinary temperature. And it is found that olein increases in the summer, when the cow's rations consist almost entirely of green foods, while in winter, when the dry foods increase, the quantity of olein formed diminishes, and the butter fat on this account alone tends to become harder.

Stearin exists largely in mutton fat, and it is because it is a solid at the ordinary temperature of the air that the mutton fat hardens on one's plate on cooling rather more readily than the warm liquid fat from most other kinds of meat.

Butter and Margarine.

The determination of the amount of volatile fatty acids is of the greatest service in detecting the fats in "falsified" butters which have not been obtained from milk. In pure butter, in fact, the quantity of these volatile fatty acids is about eight times as great as the quantity found in beef or mutton fat, or in cotton-seed or other oils, and about six times as great as the quantity found in cocoa butter.

Butter usually contains from 8 to 10 per cent. of volatile fatty acids, whereas margarine has present only from 1 to 3 per cent. Yet it should be added that the proportions of the volatile and non-volatile fatty acids are not always the same. The proportion of the volatile ones decreases as the milk yield becomes less; and the softness of the butter of newly-calved cows is attributed to the high proportion of the soluble fatty acids which are contained in the milk at that period.

The breed of the cow also affects the proportion of the two parts of the fat, and so does undoubtedly the individuality of the animal itself.

A variation in food has some effect on this proportion, but to what extent or in what direction has not yet been accurately determined.

The process by which the volatile and non-volatile fats are separated by the analyst is ingenious and simple of explanation. The fat is converted into a soap with a strong alkali, such as caustic potash. A dilute mineral acid, usually sulphuric, is then added. This decomposes the soap, and if a current of steam be passed through, the volatile acids are dissolved and carried off by the steam, and they can thus be collected and measured. The non-volatile acids remain behind quite separated from those which prove to be volatile under the test.

Albuminoids.—Casein.

We now consider another of the constituents of milk—the casein. This belongs to that class of substances called albuminoids, and they contain a large quantity of nitrogen. These nitro-

genous bodies are the essential flesh-forming portion of the foods we consume. Of them, cheese, which is formed chiefly from the casein of the milk, is one of the most useful.

Although in the above table casein is the only nitrogenous substance mentioned, it is maintained by some investigators this is only one of a very large number of nitrogenous substances which are found in milk.

Two others of importance have been named lactalbumin and globulin. Seeing, however, that the amount of casein present is at least four times as great as these two put together, and also that the casein itself only forms about 3 per cent. of the total constituents of milk, these two substances are often considered as included under the figures given for casein.

When milk becomes coagulated, either naturally by souring or by the use of rennet, it is the casein which is the part that forms the clot, though when this happens particles of fat are also held mechanically along with it.

The chemical composition of albuminoids, according to Wolff, is as follows :—

Carbon	52 to 54 per cent.
Hydrogen	7 ,,
Nitrogen	15 to 17 ,,
Oxygen	21 to 24 ,,
Sulphur	1 to 15 ,,

In addition to these five elements, phosphorus is nearly always found in traces.

With albuminoids it is usual, in whatever form and in whatever substances they may be found, to regard the nitrogen as being present to the amount of 16 per cent. It has become a working rule, in order to obtain at once the quantity of albuminoid present, for the analyst to find accurately the amount of nitrogen, and obtain the albuminoids by merely multiplying the quantity of nitrogen by $6\frac{1}{4}$. There is evidently here a possibility of a slight error, but it is found in actual practice to be usually so near accuracy that the time which would be spent in estimating each element separately is saved, unless the individual quantities of each are specially wanted.

One interesting form which casein takes is the skin which is noticed on milk after it has been heated, and which is usually known as *albumin*. It is found on investigating that this skin contains the same proportion of nitrogen as that present in the casein, but no phosphorus. It is the presence of sometimes as

much as 15 per cent. of albumin in the "first milk," colostrum or beestings, of a newly-calved cow that causes coagulation on heating to a temperature of 170 deg. F. or more.

Milk Sugar or Lactose.

The lactose, or milk sugar, which is usually present in milk to the extent of about 4½ per cent., belongs to that class of substances known as carbohydrates, on account of the elements which form them. In the milk it exists entirely dissolved. If it be obtained in the pure state it has the ordinary appearance of crystals—colourless and transparent. It is a substance which is not nearly so soluble in water as ordinary cane sugar, and although found in the milk of all mammals, it is not found elsewhere.

Under certain conditions it will undergo fermentation, forming lactic, or butyric, or alcoholic substances. Lactic acid is the body most commonly produced, the formation of which is essential to the ripening of cream and the production of cheese.

It is the presence of milk sugar that makes whey of such value as a pig food when mixed with meal or other matter; indeed, it is from whey that commercial milk sugar is prepared, whey being evaporated in vacuum pans, the residue consisting chiefly of milk sugar. This natural sugar of milk is not nearly so sweet as cane sugar, but is equally valuable in its nutritive properties.

Ash or Mineral Matter.

The mineral salts which form the ash are the same as those which are found present in animal tissues and in blood, though in the latter there is a larger amount of sodium, which is present as sodium chloride or common salt; while in milk the potash is in greater quantity.

Essentially the salts present are those of lime, of sodium, of potash, magnesium, and of iron, and these are combined, forming either the chlorides or the phosphates. It is generally maintained that one portion of the phosphate of lime present is in a state of suspension, and this is proved to be the case from the fact that if the milk is left for some weeks standing at rest, this phosphate is found deposited on the bottom of the vessel. It is, in any case, the only mineral salt which exists in a state of suspension in the milk.

2.—RELATIVE PURITY.

The subject of milk testing, if dealt with from all aspects, assumes considerable dimensions, and in a small treatise of this kind it is impossible to deal with it in any but the phases which chiefly concern the practical dairyman.

The bacteriological examination of milk, though so important, does not come within the sphere or scope of the milk retailer, and therefore the methods of cultivation and isolation of bacteria from milk will not be included.

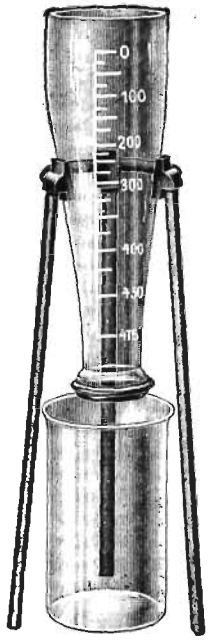
There are, however, some tests of a practical character dependent upon the principles of bacteriology which may be carried out by any dairyman who has not previously studied the subject of bacteriology. Of these, the Catalase and Reductase tests, which are of recent introduction, will be described briefly, as they are tests which largely determine the purity or cleanliness or healthiness of milk.

Testing Milk for Cleanliness.

The simplest method of testing milk to ascertain if it has been handled in a cleanly manner is by means of a **Dirt in Milk Tester,** which is a simple, practical method for ascertaining the amount of dirt or sediment in milk. In this test a definite quantity of milk is filtered through a small pad of cotton-wool.

A simple form of tester for this purpose consists of a glass bottle open at both ends. At the narrow or neck end of the bottle is fitted a cap containing a small piece of wire gauze, and on the gauze is placed a small cotton-wool disc. The cap is then either clasped or screwed on to the neck, and the milk to be tested—say one pint in quantity—is poured in at the wide or top end, so that it filters through the piece of cotton-wool, which retains the dirt or sediment present.

The test is best made when the milk is warmed to 100 deg. F. The cotton-wool disc containing the sediment may be dried on blotting-paper and preserved



DIRT IN MILK TESTER.

for reference. The amount of sediment collected on the cotton-wool will, of course, vary according to the care which has been taken in handling the milk prior to the test being made.

The Catalase Test.

Catalase is an enzyme or unorganised or chemical ferment which is commonly found in the protoplasm of living plants, animals, and in many kinds of bacteria.

This enzyme is capable of liberating oxygen from hydrogen peroxide. Catalase is to a limited extent present in normal milk, and on this property of liberating oxygen gas depends the so-called catalase test. The apparatus required for the test is a specially made test tube, into which fits a cork containing a long, narrow, graduated open tube.

To make the test 15 c.c. of milk are placed in the outer tube, together with 5 c.c. of a 1 per cent. solution of hydrogen peroxide. The inner tube is then inserted with the cork, and adjusted so that the milk rises up in it as far as the figure 0.

The whole apparatus is then put into a water bath regulated to a temperature of 77 deg. F., and left for two hours. As the gas is liberated the milk is forced up the inner tube, and the graduations show the number of c.c.'s of gas thus liberated.

In the case of normal milk the point marked on the inner tube should not be higher than 2·5; if higher than this, the presence of an abnormal amount of obnoxious bacteria—which have greatly increased the normal amount of catalase found in the milk—is evident, and such milk is condemned in proportion to the amount of gas liberated.

Reductase Test.

Milk contains reductase, an enzyme capable of reducing or taking away oxygen from a compound in which oxygen is present in a loosely combined form.

This enzyme, as present in milk, needs the presence of a reducing agent in order to assist the reduction.

Reduction is shown by the loss of colour from some colouring reagent when the milk is kept at a temperature of about 115 deg F.

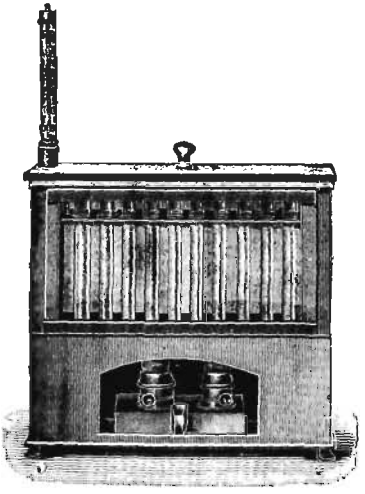
The apparatus commonly used for this test consists of a glass chamber in which the test tubes, which may be ordinary test tubes, or specially constructed tubes made with restricted necks to hold glass balls, are stood upright and are heated by means of a lamp.

To each test tube is added 10 c.c. of milk and ½ c.c. of colour solution, usually consisting of a mixture of methylene blue tincture and formalin in water. If the special tubes are not used, then a little paraffin should be poured on the top of the mixture of milk and colouring matter, to keep the sample air-tight. The tubes are then incubated or kept warm at the temperature before mentioned for about three hours.

Special Tube for Reductase Test.

Interpretation of Results.

If loss of colour occurs in less than an hour, this indicates bad milk; loss of colour in one to three hours shows passable milk according to the time taken for the colour to go—the longer, the better the milk. If more than three hours is taken, this indicates perfectly good milk. Of course, boiled milk shows no loss of colour at all with this test.



Reductase Test Apparatus.

It will be seen in this test, as in the catalase test, that a quick and ready means is afforded of detecting stale milk, but reduction will only take place after several hours when milk is normal in character. If it contains large numbers of bacteria, the reduction is hastened, and so the comparative purity of milk can be ascertained.

3.—SPECIFIC GRAVITY.

Milk is a mixture of liquid and solids of very varying degrees of density.

The fatty part of milk is lighter than the milk serum ; in fact, it is its lightness which causes this portion to rise to the surface as cream. The weight of any definite quantity of milk, therefore, will vary according as it contains more or less fat ; if the fat is present in greater proportion, it will weigh less as a whole than if it contained a smaller quantity.

For the purpose of comparing the weight of milk and other substances, water is taken as the standard, and it is taken at a fixed temperature, the comparison always being made with a certain volume of water at 39 deg. F., the point of its greatest weight or maximum density. The constant temperature is necessary, since a volume of water and of other substances is not the same at different temperatures, as expansion occurs on heating and contraction on cooling.

If at the standard temperature a substance is of exactly the same weight as water, volume for volume, its weight is taken as 1, and this number, which thus represents the relation of its weight to that of water, is called its specific gravity or relative weight. The latter term is the simpler and the older name for it, but the former is now generally used. If, then, a substance is heavier than water, its specific gravity will be more than 1 ; if lighter, it will be less than 1. In practice it is not found convenient to reduce the temperature of substances to 39 deg. F. before weighing them, so the common temperature of 60 deg. F. is adopted, being the one most easy for general working.

Specific Gravity of Various Substances.

The specific gravity of most woods is less than 1, seeing that they float on water, and are therefore lighter. Ash is ·76, beech is ·7, oak is ·83, and so on. The specific gravity of fats and oils is less than 1 ; olive oil is ·9, oil of turpentine is ·87, petroleum is ·84.

The specific gravity of whole milk varies to some extent, but should be between 1·028 and 1·034 ; on the average it will be found 1·032. The presence of the fatty matter in milk would tend to bring its specific gravity below 1 ; but the other con-

stituents which it contains outbalance this tendency, so that all considered it comes out slightly heavier than water, as indicated by its specific gravity. It is found to be a little higher a long time after milking than when freshly drawn, so that the weight of a gallon of milk will vary slightly from the mean weight of 10¾ lb., according as it is perfectly fresh or has stood some time, and again whether warm or cold. The temperature alone would account for this difference, but the presence immediately after milking of minute air-bubbles in the liquid also tends in the same direction.

The Lactometer. The common and simplest method of finding the specific gravity of milk is to use an instrument called the lactometer.

This consists of a closed glass tube with a bulb at the lower end containing small shot or quicksilver to weight it, so that it will remain upright when placed in a liquid. On the upper part, or stem, is marked a graduated scale. The weighting is so arranged that when the lactometer is placed bulb downwards in water it floats at such a level that the 0 of the scale is just level with the surface of the water. This 0 mark on the lactometer really represents the specific gravity of water, which is 1, as before mentioned.

If it be placed in a liquid lighter than water it will, of course, sink a little deeper, and if the scale be graduated the figures on it will indicate its specific gravity.

Hence it is clear that reading up the scale from the 0 (equivalent to 1·0) the numbers are less than one; while reading down they are greater than one—that is, the scale is an inverted one as compared with that on a barometer or a thermometer.

If placed in milk which has not been tampered with, it should sink until the liquid reaches a point between 28 and 34, which represents a specific gravity of 1·028 to 1·034.

THERMO-LACTO-METER.

This instrument combines a thermometer and lactometer, as seen by the two scales.

Influence of Adulteration on Specific Gravity.

If fat has been abstracted from the milk, that which is left will be the heavier, because of the absence of the lighter fat, and the lactometer will not sink so far, thus showing an increased specific gravity of the milk, and indicating that it has been tampered with.

If, on the other hand, water has been added to milk, since the water is not so heavy as milk, the new mixture will be lighter than the pure milk, the lactometer will sink deeper into it, and the indicator will read a number lower than that of pure milk, and so indicate that it is a lighter liquid. This would at first sight seem to be a very simple and a very effective method of testing; but the ingenuity of the man who desired to tamper with the milk was soon equal to outwitting this simple method. Seeing that taking away the fat makes the milk heavier, all that it is necessary to do in order to conceal the abstraction of the fat is to add something to the milk which is lighter than it, and so bring it back to its normal specific gravity.

Water is lighter than milk; it can be judiciously added so as to bring back the milk to the proper weight, and so delude the observer who relies merely on the lactometer. If an unscrupulous dealer receives very rich milk from the farmer, which milk will have a low specific gravity, he can take away cream, or add separated milk (which has a higher specific gravity than whole milk) to it in the right proportion, and the specific gravity as indicated by the lactometer may be made not to exceed the normal limit of 1·034 for whole milk.

In several cases where the so-called milk which has been found retailed in the poorest quarters of some of our large towns has been examined, the analysis has shown it to be nothing more than skim-milk coloured with annatto, and loaded with preservative substances, and even containing a foreign oil to replace the butter fat which has been extracted.

Unreliability of the Lactometer.

Yet this, when tested with the lactometer, has shown a specific gravity which lay between 1·028 and 1·034, thus indicating, not, indeed, the purity of the milk in this case, but the skill and ingenuity of the "manufacturer" of it; and pointing out further that if the lactometer were the only means we possessed by which the milk could be tested there would be little real difficulty in evading such a test.

Yet the lactometer has its use, and will continue to be of service, even though there exist clever and unscrupulous milk dealers who can evade its indications.

The lactometer itself is too well known to need any minute description, yet there are one or two points to be observed in using it if its indications are to be at all reliable.

Correcting for Temperature.

Seeing that the specific gravity of the milk varies with the temperature, it is necessary, if comparisons are to be made, that the lactometer should be used with the milk always at the same temperature. The most convenient is 60 deg. F. Tables, or a sliding scale, can be used which enable the correction to be made if the milk is not at this temperature, but in practice it is a simple matter to make the correction.

The correction for temperature is to *add* ·1 to the lactometer reading or ·0001 to the specific gravity for every 1 deg. F. above 60 deg. F., and *subtract* ·1 (or ·0001) for every 1 deg. F. below 60 deg. F.—*e.g.*, if lactometer reads 31·5, *i.e.*, 1·0315 at 65 deg. F., corrected to 60 deg. F. it would be 32 or 1·032.

An ingenious form of lactometer, called the Thermo-lactometer (see illustration), is made which contains at the lower weighted end a small thermometer. This enables the temperature to be found by the use of the one instrument only, and usually the standard temperature, 60 deg. F. (or 15 deg. C.), is distinguished by a red line, while the other degrees are marked in black.

Method of Using the Lactometer.

Besides the accurate observation of the temperature, care must be taken that the milk is thoroughly stirred before immersing the lactometer, in order that a complete mixing of the parts of varying density may be effected. Before reading the instrument it must be made certain that it floats freely in the liquid, and is not touching either the side or the bottom of the vessel in which the milk is contained. If the surface be covered with froth or bubbles these must be removed before the observation is made, and it is best where possible to get the eye at the same level as the surface of the milk, so that the figure may be read which is exactly reached by the liquid itself.

Specific Gravity Determined by Weighing.

If a chemical balance is available (this is only the case in the larger dairies), specific gravity may be determined rather more accurately by weighing than by the lactometer.

The following is an example of a determination by weighing :—

Take a small specific gravity bottle which is graduated to hold 25 grams of water when full.

Fill the bottle with milk and weigh.

Deduct the weight of the bottle, which gives the weight of the volume of milk.

Now, the exact amount of water held by the bottle is 25 grams ; therefore, if this is divided into the weight of the same volume of milk, the result is the specific gravity.

Weight of bottle + milk	=	40·821 grams
Weight of bottle	=	15·021 ,,
Weight of milk	=	25·800 ,,

25·800 ÷ 25 = 1·032 specific gravity of milk.

Specific Gravity Determined by the Westphal Balance.

In this the weight of a known volume of liquid is determined by noting the loss of weight which occurs through displacement. The Westphal Balance consists of a steelyard, and from one end of the beam is hung a glass plummet which is so adjusted that when hanging in air the pointer indicates zero. A weight, which is provided, when hooked on to the end, will cause the pointer to return to zero when the plummet is immersed in water at 60 deg. F. The beam on the balance is divided into 10 parts, indicated by notches, and riders weighing 1-10th, 1-100th, and 1-1,000th of the said weight before mentioned are supplied for use. To find the specific gravity of milk, immerse the plummet in milk at 60 deg. F. and place the riders on the notches until the pointer is at zero. The weights, therefore, and their respective positions on the arm of the balance indicate the specific gravity.

Thus : count 1 for the weight on the end, the first place of decimals from the notch on which the rider of equal weight is hung, the second place from the notch on which the 1-100th rider is hung, and so with the fourth. Thus milk of an average specific gravity of 1·032 would have weights and riders in the following positions on beam : 1 end weight, 1-10th rider on

third notch or hook, 1-100th rider on second notch, the place of the riders not required to be supplied by 0.

This method of determining specific gravity is adopted by a good many dairy companies, but it is not so accurate as the method of determining by weighing.

For the average dairyman the lactometer is the best and simplest method to adopt.

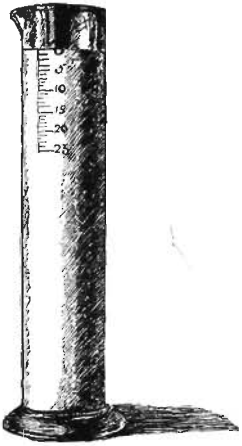
4.—THE CREAMOMETER.

Another simple instrument which is used for testing the composition of milk is the creamometer. As the name implies, it serves to measure the amount of fat as cream which is present in a measured quantity of milk. It consists of a tall glass vessel of uniform diameter, which is graduated downward from zero, which is at or near the top. It is made to hold 100 parts, so that on the graduated portion the cream may be read off in percentages.

To use the instrument it is filled with milk up to the level of the zero mark, and for comparison with other milk the temperature must be the same in all cases; 60 deg. F. is the usual temperature at which the milk is kept.

The milk is then left to stand a number of hours—twenty-four hours is a convenient period—which must, of course, be the same with all the samples to be compared.

At the end of this period the cream will have risen, and since its upper surface is level with the mark 0 on the scale, the figure opposite the lower edge of the layer of cream will indicate at once the thickness of the layer of cream which has risen.



THE CREAMOMETER.
From "Popular Science," Cassell & Co.

This quantity naturally varies with different samples. From a good milk 12 to 15 per cent. should be shown, but anything over 10 per cent. indicates that the milk, so far as its contained cream is concerned, is of fairly good quality.

Factors Influencing Creamometer Readings.

The want of reliability in this method of testing is due not to the misplaced ingenuity of persons who would adulterate the milk, but to the fact that it merely indicates the quantity only of the cream which rises, and gives no indication whatever of its quality or richness in fat.

A poor milk will sometimes throw up a bulky cream, and show if measured by the creamometer a good percentage, and yet this bulky cream may contain a very small amount of fat, and hence would produce but a comparatively small quantity of butter.

It frequently happens that if the fat globules of a particular sample are small they rise only very slowly, or some not at all, to the surface, so that the creamometer would show but a poor percentage of cream present ; yet if such milk were put through the separator it would yield quite as large a quantity as another sample, which, judged by the indication of the creamometer, seemed to be very much richer, merely from the fact that, the fat globules being larger, a much thicker layer of cream has formed in the time it was under observation.

In view of this peculiarity it will be realised that the kind of milk considered is a considerable factor in modifying the indications of the creamometer.

Milk from Channel Island Breeds.

In the case of milk from Jersey cows, owing to the much larger size of the fat globules, more fat will come to the surface in the form of cream than in the case of milk from Shorthorns ; indeed, so much is this the case that Jersey milk will frequently show 18 to 26 per cent. of cream by the lactometer.

Now, even if both milks contained the same proportion of fat as measured by the more accurate Gerber tester, the Jersey milk would show a much greater percentage of cream, the essential point of difference being that in the first milk taken the fat globules are much larger than in the second, and hence have a greater power to overcome the viscosity of the milk, and to show themselves as cream in a much shorter space of time.

Temperature is also an important factor to be considered in using the creamometer.

If the temperature be high the fat appears to shrink in volume, or, at least, it does not occupy so large a space as when the

cream is raised at a low temperature, since in the latter case it is much larger in bulk and also thinner.

For practical use on the farm a creamometer is much more serviceable in the case of mixed milk than it is in the case of milk from individual cows, where the differences may be due to peculiarities of the single cows, or to the eccentricities of the fat globules.

5.—VOLUMETRIC CHEMICAL ANALYSIS.

The methods used for determining the amount of fat in milk which are universal to-day are all in the main modifications or applications of the original method followed in the use of the lactocrite. Though this instrument, under that name, did not become very widely used, the principle of it is the same which underlies practically all the modern ones, whatever be the names under which they are known.

Centrifugal Force.

As in the separator, the force called into play is that known as centrifugal force. This force is exerted when any substance is rapidly swung round a centre, and tends to drive the swinging body as far from the centre as possible. If two bodies of different density be swung together, the heavier one is subject to the greater force, driving it outwards. If, for instance, two liquids be swung in the same bottle, the heavier liquid will always be driven to the end of the bottle which is farther away from the centre round which the revolution takes place ; while the lighter liquid will separate itself from the heavier one, and remain at the innermost end of the bottle. This is the principle on which depends the separation of the cream from the skim-milk in the separator, and it is also the principle which is used to separate the fat in any specimen of milk from the other constituents.

Liberating the Fat.

In order to give the fat a much easier opportunity of separating itself, the casein of the milk has to be dissolved. This is best effected by the use of sulphuric acid. When it is added, not

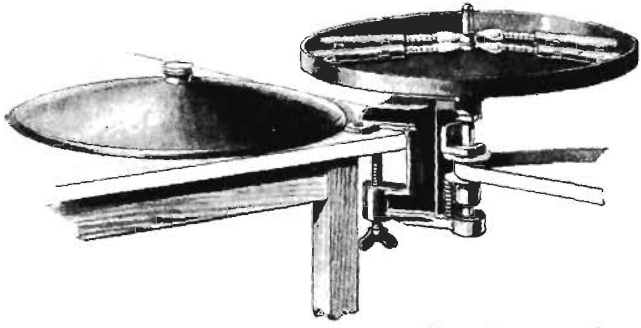
only is the casein dissolved, but a considerable rise in temperature takes place, the fatty matter becomes hot, and is therefore liquefied, and in this state separates still more easily. If a measured quantity of milk be taken, and a measured quantity of sulphuric acid be added, the amount of fat contained can be measured when it is separated, and this can easily then be expressed as a percentage at once.

The Babcock Method.

This method of separation was first utilised practically by Dr. Babcock, and it is still known as Babcock's method, and extensively used in America. In his method of testing, sulphuric acid of a certain strength—that is of specific gravity 1·83—is used, and the bottles, after being turned in the revolving machine for several minutes, are filled half-way up to the neck with hot water to bring the fat on to the graduated scale, they are whirled again for two or three minutes, and the fat by means of the graduation on the bottle can then be read off. Each large division represents 2 per cent. of fat, and each small one ·2 per cent.

The Gerber Method.

Dr. Gerber, a Swiss scientist, perfected this method and constructed a special apparatus, which is named the Butyrometer, and his name has become familiar in dairy circles in consequence of the test being so widely used.



STRAP-DRIVEN GERBER BUTYROMETER SHOWING TEST BOTTLES IN POSITION.

One slight modification was found necessary in order to avoid a drawback which is inevitable if the test is carried out in the way described above. It is found that in consequence of the

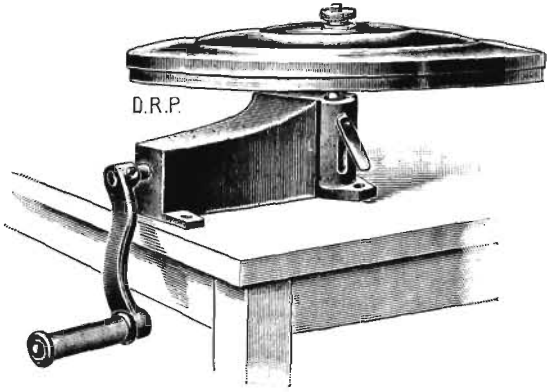
great heat produced by the addition of the sulphuric acid to the milk, some of the fat and milk sugar contained frequently becomes so charred that a black substance is formed, which collects in the neck of the test bottles and interferes with the exact observation of the experiment, thus rendering the result inaccurate.

But the addition of a small quantity of amyl alcohol is very effective in preventing this charring, and as the liquid fat then remains clear, the accuracy of the result may be depended upon.

The Gerber test is without question the one which now finds most favour in England and Germany, and there is good reason for this in the fact that it is one of the simplest and quickest methods which exist, and yet at the same time, if carried out with care, is capable of a high degree of accuracy.

Sampling the Milk.

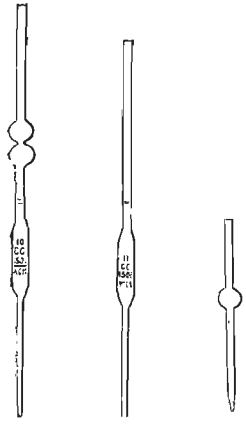
The careful sampling of the milk is of the utmost importance, and if it be not properly done the results obtained are quite



CRANK PATTERN TESTER.

useless as an indication of the general character of the whole quantity of milk from which the sample has been taken

The essential point before sampling is to ensure thorough mixing of the milk, whether this be the milk from one cow or from a number of cows. It is best effected by using a plunger, or if in small quantity pouring from pail to pail, and only when a complete mixing is made, and it is at the same time quite certain that the cream is well distributed throughout, should the sample be drawn for testing.



Acid, 10 c.c. Milk, 11 c.c. Amyl Alcohol, 1 c.c.

MEASURING PIPETTES FOR USE WITH GERBER TEST.

Apparatus for the Gerber Test.

For making the actual test the essential pieces of apparatus are pipettes or glass tubes of the following capacity, for measuring the milk, acid and alcohol employed:—

For the acid, one of 10 cubic centimetres (c.c.).

For the milk, one of 11 cubic centimetres.

For the amyl alcohol, one of 1 cubic centimetre.

and test bottles fitted with rubber stoppers.

Chemicals Used.

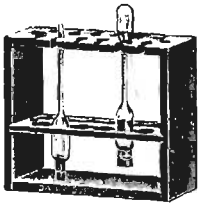
These are two in number only, and consist of sulphuric acid and amyl alcohol. The sulphuric acid is the pure acid of commerce, and should have a specific gravity of 1·82 to 1·825. This means a proportion of 90 per cent. of the actually pure acid with 10 per cent. of water. It is a substance which absorbs moisture from the air whenever possible, thus tending to become weaker. On this account it must always be kept in well-closed bottles or flasks; the stoppers should be either rubber or glass, since cork is rapidly attacked by the acid.

Measuring the Acid.

In making the test 10 c.c. of acid is drawn up into the pipette, which should have a safety bulb in order to prevent the possibility of any of the acid reaching the mouth. By slacking the pressure of the finger at the top of the pipette, air can gradually

be allowed to enter until the liquid within drops to the 10 c.c. mark, when a slightly increased pressure of the finger will stop the outflow, and this quantity of liquid is ready to be put into the test bottle.

The test bottle should already have been placed mouth uppermost in a stand, and the acid can then be allowed to run into it. Care should be taken that the acid does not wet the mouth or neck of the test bottle when filling. If the mouth of the test bottle is kept dry the rubber stopper will then hold the better, and there is likely to be less inaccuracy in the results, and accidents which may result from the stopper coming out will be avoided.



Stand for holding "Gerber" Test Bottles.

It is not necessary to blow out of the pipette the last drop which appears to stick at the bottom; allowance is made on the graduation of the pipette for this last drop to remain there. Hence, if it be blown into the test bottle a greater quantity than that measured will be introduced and another possibility of error in the result arises. The pipette should merely be tapped against the inside of the test bottle, and as much of the liquid contained got out of it as possible in this way

Adding the Milk.

The milk is now added to the test bottle, and great care should be taken in allowing it to enter the bottle. It is best done drop by drop, or if this be too slow a method it should be allowed to flow gently down the side of the bottle so as to come in contact slowly with the upper side of the sulphuric acid without there being any disturbance.

Amyl Alcohol.

The amyl alcohol should next be measured out in the pipette selected for it. It need not be sucked up, but if the pipette be immersed in the bottle containing it so as to allow the liquid to rise to the 1 c.c. mark, and the top then closed with the finger, it can be lifted out with the contained liquid and then transferred to the test bottle. There is again no need to blow out the last drop.

The measurement of the alcohol should be done with care so as to be accurate, as a slight error in the quantity may produce a very considerable error in the results worked out.

Order of Putting Ingredients into the Test Bottle.

This order of putting the three substances into the bottle can be changed, the sulphuric acid going in first, then the amyl alcohol, and lastly the milk. As the sulphuric acid is the heaviest, there is an advantage in letting that enter first, since the mixing of the liquids and the consequent heating of the vessel is avoided until all is prepared.

It is further desirable that the alcohol should not be allowed to be in contact with the acid before making the test for more than a few minutes, or a dark-coloured substance is produced which may interfere slightly with the accuracy of the test.

Making the Test.

The test bottle should now be corked effectively, care being taken that the corks are dry and without cracks. If the temperature has already risen to an uncomfortable degree it may be necessary to hold the tube by means of a cloth, instead of merely the hand being used. The rubber cork should be well pushed home, then the bottle should be shaken and inverted three or four times before putting it into the rotary machine.

The dissolving of the casein in the milk by the acid is rapid, and hence the rise in temperature. The bottles should not be put in the machine until all the curdy material is dissolved. In some few cases the bottle, when the ingredients used are very cold, may be left to stand for some minutes in water heated to a temperature of about 170 deg. F. This renders the chemical action of the sulphuric acid rapid and effective, and aids materially in the liberation of the fat.

Position of Test Bottles in the Machines.

The bottle is now put in the rotary machine, usually with others on the opposite side, so that the balance of the machine is maintained, though in one make of machine this is not necessary owing to a specially constructed centre-piece balancer.

It is, of course, put in with the wide stoppered end near the circumference and the narrow graduated end near the centre, since it is to this narrow end that the liberated fat, being lighter, will be forced.

Revolving the Machine.

The machine is revolved rapidly by giving six or eight strokes with the strap attached, or by winding a piece of cord round the spindle and setting off "top fashion." It is then allowed to run alone till it begins to slow at the end of a few minutes. In many types of machine a crank handle is fitted, and the operator turns the handle for the time specified.

If the milk under the test is one very poor in fat, it may be necessary to spin it again in order to ensure that all the fat shall be liberated.

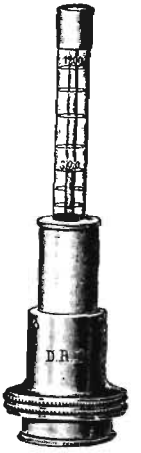
The bottles should be revolved for three minutes, and the speed attained should reach about 1,000 to 1,200 revolutions per minute.

Speed Indicator.

A speed indicator may be attached to the central screw on which is affixed the cover of any type of Gerber machine, and it will be found very useful to regulate the speed of the steam turbine and electrically driven machines.

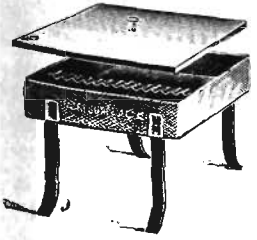
The indicator contains glycerine, and the effect of the centrifugal force upon it is to send the glycerine up into the glass tube, thus indicating by the height of the lines it reaches the number of revolutions per minute the machine is making.

The machine should always be stopped gradually, and no sudden jerk should be given to the movement. A simple method is to place a cloth with a slight pressure on the revolving lid; this will act as a brake and slowly bring the machine to rest.



Speed Indicator.

Removing the Test Bottles.



Water Bath in which Test Bottles are heated.

On removing the test bottle from the machine the fat will be found all collected in the thinner end.

If it be suspected that the separation is not complete, the tube should be placed in hot water at a temperature of about 170 deg. F., and the revolution process gone through again. This repetition is, however, rarely necessary if care has been taken in the first case, and if the weather is warm.

In winter, however, the fall in temperature of the test bottle is often so great as to necessitate immersing it in hot water before the column of fat can be read off. The fat visible in the tube is usually of a pale yellowish colour ; slight variations in the tint are sometimes produced by changes in the feeding of the cows.

Reading the Test.

Test Bottle in position for reading the Fat.

In order to read the amount of fat present in the tube, the column of fat, if not already there, must be brought on the graduated scale, which is marked in a suitable position on the tubular part of the bottle.

The position of the column of fat can be adjusted by pressing in or slightly withdrawing the indiarubber stopper.

Graduation of the Test Bottles.

When the lower end of the fat column has been got level with one of the long gradation marks, it is a simple matter to read off the amount of fat present between that mark and the one on a level with the upper end of the fat column. The length of the divisions is so calculated that the space between each number represents 1 per cent. of the fat in the milk. Each of these lengths is divided into ten, so that the smaller divisions each indicate ·1 per cent.

Hence, if, for example, the column of fat fills up three of the larger divisions and five of the smaller ones, this indicates that the percentage of fat present is 3·5.

In above illustration the section on the right-hand side, indicated by arrow, shows the position of the bore of the graduated tube with the shape of the glass.

The result of this special construction is to give a magnifying effect which makes the contents of the tube appear as if they occupied the full width of the glass neck. This facilitates clear reading, as shown in the illustration.

Possible Errors in Readings.

It is desirable that the reading should be made without allowing the temperature of the liquid to drop. This may easily make a difference of ·05 per cent. in the calculation.

Another possibility of error in the reading arises from the fact that the upper end of the column of fat is not level but has a curved surface—the meniscus. The reading should be made on the mark which is level with the lowest part of this meniscus, and not with the upper part.

Averaging.

With the same sample at least two separate readings should be made, and the average of the two taken. If the second test can be read by a second person, the possibility of error due to the personal equation is much lessened.

If the test of a particular sample of milk is being made, the whole process should be gone over at least twice, and if the results are at all widely different, a third should be made. The result of this third test should confirm one or other of the former readings, or if the figures are very close for all three tests, an average may be taken, which result will be more reliable than if only one test had been made.

Testing in Cold Weather.

It may happen—and frequently does in cold weather—that when the bottles are examined after the whirling, the fat is not clear or not liquid enough for a correct reading to be made. If this be found to be the case, the bottle must be placed in water at a temperature of about 170 deg. F. for a few minutes, and then whirled for another minute to bring to the top any further fatty globules which have remained in the liquid in consequence of the lower temperature at which it was first performed.

Testing Sour Milk.

In case it is required to test, by means of the Gerber method, a sample of milk which is sour or coagulated, it will be first necessary to partially dissolve the curd and reduce it to an homogeneous mass. This is best done by adding a mixture of ammonia and glycerine in small quantity, which will, if vigorously shaken with the milk, reduce the clots and make the sample fit for testing in the course of a short time. The mixture of ammonia and glycerine can be made by mixing two parts of the strongest ammonia with one part of glycerine. Of course, any strong alkali, such as caustic soda, will answer the purpose,

and is best added in solid form. It is important to remember, in testing a prepared sample of this kind, to remove the rubber stopper immediately after first shaking the milk with the sulphuric acid. This permits the escape of gas, which might otherwise force out the cork and cause the contents of the bottle to be spilt, with possibly disastrous results.

Cleaning the Apparatus.

On the completion of the test, and the noting of the results, the tubes should be emptied at once into a vessel which is not attacked by acid, or on to earth or gravel outside the dairy ; then they should be rinsed, first with warm water and afterwards with hot.

The rubber corks used should be dropped into water which has been alkalised by the addition of soda, so that the acid which they have been in contact with may be neutralised ; they should then be washed in cold water and allowed to dry in the air, never in the sunshine or in any artificial heat, for if this is done they soon become unfit for use.

The reading of the test bottle is a simple matter, though many people not possessed of keen sight have not found it always so easy as might be imagined.

A decided improvement has been effected in the Gerber test bottle recently, which will specially suit those who may have experienced difficulties with the readings.

The new bottles have a flat, graduated neck instead of a round one, hence reading off fat is greatly facilitated.

A keen eye can now detect even so low an amount as ·03 per cent. of fat in a Gerber bottle, this being practically one-third of one of the small divisions, or ·1 per cent.

The use of a magnifying-glass makes the reading of the tests easier in all cases.

Operations of the Gerber Test Illustrated.

Fig. 1.—Measuring the liquid by means of pipette. The liquid is drawn up into the pipette by suction, and as soon as it is above the indicating line the end of the first finger is placed firmly on the top to prevent the liquid running out. The exact amount of liquid in the pipette is regulated by the admission of air by the finger.

Fig. 2.—Emptying the pipetteful of liquid into the test bottle. The end of the pipette should be inserted well into the test bottle so as not to wet the neck, which makes it difficult for the stopper to be retained.

Fig. 3.—Shaking the stoppered test bottle to mix the ingredients before testing.

Fig. 4.—Inverting the test tube to allow the acid retained in the neck to become thoroughly mixed.

Fig. 5.—Placing the test bottle in the brass holders of the rotating machine prior to rotating for three minutes at a speed of 800 to 1,000 revolutions per minute.

Fig. 6.—Adjusting the stopper so as to be able to read the column of fat in the test bottle. The correct position of angle of test bottle to the eye is shown in this illustration.

(This illustration is given by kind consent of the Dairy Supply Company, London.)

Gerber Test and Gravimetric Analysis.

The following are results obtained separately by the Gerber test and gravimetric analysis :—

% of Fat.	
By Gerber Test.	By Chemical Analysis.
3·45 per cent.	3·48 per cent.
3·8 ,,	3·75 ,,
3·8 ,,	3·71 ,,
3·8 ,,	3·70 ,,
3·65 ,,	3·52 ,,
3·2 ,,	3·26 ,,
3·3 ,,	3·45 ,,
4·1 ,,	4·11 ,,

The gravimetric analyses were made by one of our best-known dairy analysts, samples of the same milk having been previously tested by the Gerber method elsewhere. Allowing for experimental error, the results shown above are seen to correspond very closely.

Testing Separated Milk.

Precision Tube for Testing Separated Milk.

For testing separated milk, buttermilk or whey—liquids which contain comparatively little fat, the special test bottle with tapered, narrow-bore neck is recommended. In such test bottles, 1 per cent. of fat occupies a considerable length of the tube, hence the subdivisions, ·1 percentages, are large and most easily read.

In testing separated milk, it is most important, in order to bring all the fat to the surface, to heat the test bottles and rotate two or three separate times in the machine, keeping up the temperature all the time.

The special tube mentioned may be used for whole milk where special accuracy of the decimal percentages is required.

Testing without Sulphuric Acid.

Other chemicals are now sometimes used in place of sulphuric acid with fairly satisfactory results.

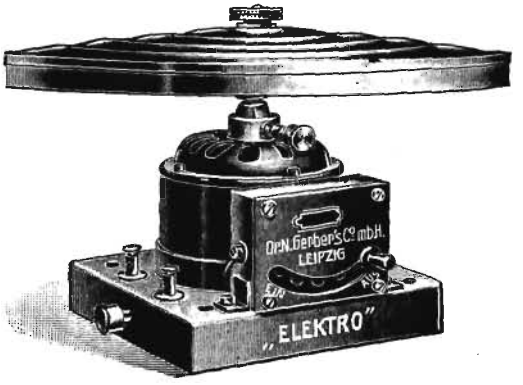
Objections to the use of sulphuric acid, otherwise known as "oil of vitriol," are raised on account of its burning nature and the bad effects which may follow if it is carelessly used.

The "Sal" or "non-acid method," in which caustic soda is largely used to replace sulphuric acid, necessitates always heating the tests, and the writer has not found the results so quick or quite so accurate as where employing sulphuric acid.

Certainly there is no danger with the chemicals used in the "Sal" method which accompanies the handling of sulphuric acid, but with ordinary care no *ill-effects from* the latter need ever occur.

In the more recently devised "Neusal" process a special solution is used, containing an alcoholic reagent, which means that only one chemical has to be measured and used in conjunction with a "Neusal" powder.

The larger centrifugalising machines, or those capable of holding up to thirty-two test bottles at a time, are made with a small steam turbine, which supplies the motive power, or in some instances electricity is used for driving the tester.

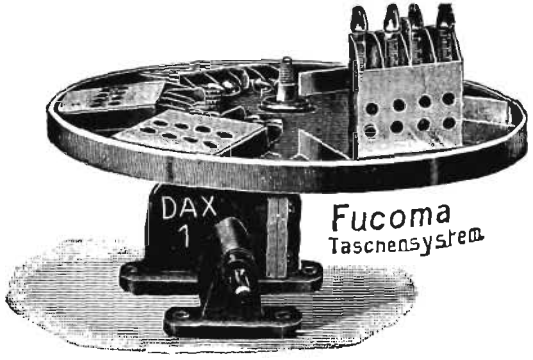


TESTER DRIVEN BY ELECTRICITY.

A New Pocket System of Testing has recently been introduced, which consists of the usual Gerber method, but all the apparatus is on a reduced scale

The test bottles and pipettes are made half the usual size, the pipettes holding, respectively, sulphuric acid 5 c.c., milk $5\frac{1}{2}$ c.c., and amyl alcohol $\frac{1}{2}$ c.c., thus only half the usual quantities of the different liquids are employed.

The system commends itself to the use of those who have already had experience in testing, and who are able to manipulate small quantities accurately. It would seem to be very suitable for those who travel from farm to farm testing the milk of cows of different herds.



FUCOMA POCKET TESTER.

(Frank Bryan & Co., London.)

6.—SPECIAL MEASURING AND OTHER APPARATUS.

In addition to the common form of measuring instruments—the pipettes, previously described—there are a number of what may be termed special forms of measuring apparatus. They have been devised with the idea of making the measurement of the liquids quicker, safer and easier, and how these three requirements have been met may be seen by considering the instruments themselves.

Many people object to sucking up sulphuric acid in a pipette, even if that pipette is fitted with a couple of safety bulbs to prevent the acid coming near the mouth.

When this is the case, the difficulty is overcome by measuring the acid by means of a small measuring glass, into which the acid is simply poured.

Automatic Acid Pipette.

This, in the illustration, is shown in position for use when the lower end is immersed in acid. The sloping tube on the right is placed in the mouth and the acid is drawn up until it comes up into one of the bulbs, when the finger is immediately pressed down on the glass rod surrounded by the coiled wire or spring. This forces the glass tube, or continuation of the rod, which is V-shaped at the end, into the lower part of the oval bulb of the pipette, and so closes the orifice by which the acid might escape.

Automatic Acid Pipette.

Now, whilst the pipette is being held a small quantity of acid will run out, although the orifice is closed, and the amount remaining will be exactly 10 c.c.

This is managed by means of a small hole let into the spring rod just at the mark on the pipette which indicates 10 c.c. All the acid taken into the pipette above this point, therefore, escapes by means of the hole and runs away down the tube. This tube, it will be understood, although hollow and capable

of carrying away any liquid above the 10 c.c. mark, by means of its V-shaped end, prevents the exact amount required—*i.e.*, 10 c.c.—from escaping until the finger releases the spring.

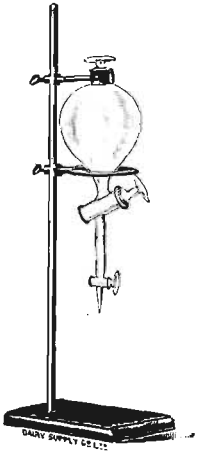
Making Tests at the Creamery.

Where a very large number of samples have to be tested, as at creameries supplied with milk by as many as 600 different persons. means must be found of making the tests quickly, and at the same time adhering to accuracy.

To measure off the ingredients for 600 tests is by no means light work, and yet each supplier's milk has to be tested, if the milk is paid for according to its quality.

Automatic Acid Measure.

The automatic acid measure (as shown in illustration) is extremely handy for measuring off the acid for a large number of tests. It is fixed in a stand, and the upper bulbular portion is filled with acid. This container is fitted with a ground-glass stopper, by which the air is kept from coming in contact with the acid. Owing to the fact that sulphuric acid absorbs moisture from the air, it is apt to lose strength, so the precautions must be taken to prevent this.



Automatic Acid Measure.

To use the measure the top tap is opened and the portion between it and the lower tap—that which holds exactly 10 c.c.—is allowed to fill. The tap is then given a half-turn, so that a second opening bored through it comes into contact with the air, the opening to the air being at the end of the tap, and at the left-hand side of diagram. The lower tap may now be opened and the contents of the 10 c.c. chamber discharged into a test bottle held underneath.

The lower tap being shut off, the upper one is given a half-turn so as to allow the second opening in it to communicate with the upper and lower chamber of the apparatus, and so the measuring goes on.

In many large dairies ordinary burettes are used for measuring both the acid and the alcohol, and they prove of great use.

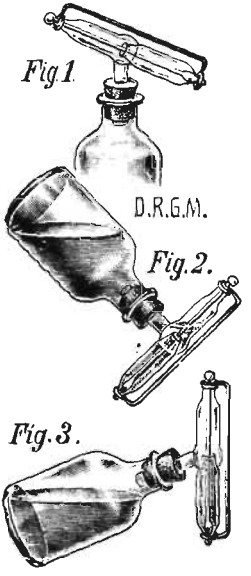
Tilt Measure.

The normal position of this measure is shown in Fig. 1.

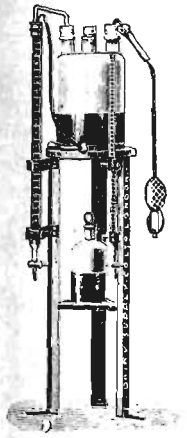
No. 2 shows the position in which the apparatus is held to fill the measuring chamber.

Fig. 3 shows the position when the measuring chamber is vertical that allows the excess of acid to return to the bottle.

Having got the measuring chamber full of acid, the spout is placed on the mouth of the test bottle, when the contents will be automatically released and flow into the test bottle.



Veith's Apparatus.



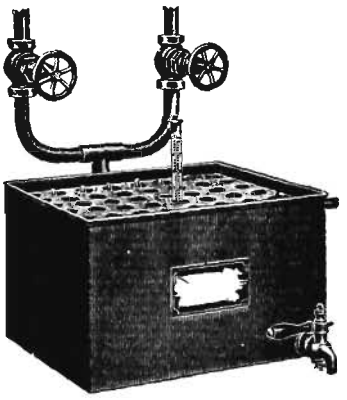
Veith's Automatic Acid and Alcohol Measure.

Dr. Veith's patent automatic acid and alcohol measure consists of a couple of burettes attached to large receivers containing acid and alcohol.

The great advantage of this apparatus as compared with the burettes used alone is that the burettes may be filled by merely pressing a bulb instead of by pouring in acid and alcohol in the ordinary way from stock bottles.

All joints of the apparatus are made air-tight by the use of rubber corks, so that when air is forced in by squeezing the bulbs the liquids are caused to syphon over into the burettes.

The burettes so soon as they are emptied of their contents are, therefore, very readily filled again.



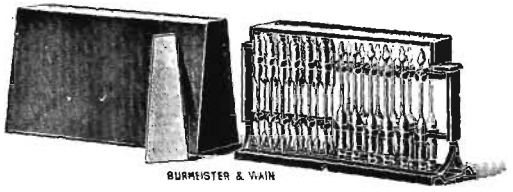
Copper Heating Bath for Test Bottles.

Testing on a Large Scale.

Many pieces of apparatus are used to save time in the shaking and heating of the test bottles where a large number of tests are made.

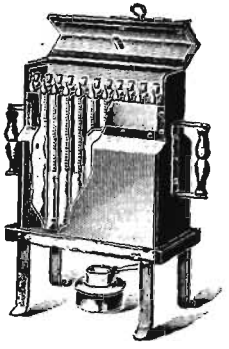
Illustrated is a copper heating bath which, as will be seen, can be filled quickly with water at the right temperature by means of the steam and water connections.

The steam can be left escaping into the bath to maintain the temperature, whilst the overflow pipe depicted on the right will prevent it becoming too full.



"Perfect" Shaking Stand.

By means of a shaking stand a large number of full test bottles may be shaken at a time; whilst a combined filling, heating, and shaking stand (hot air) can be obtained.



"Universal" Filling, Heating, and Shaking Stand. (Heated by Hot Air.)

Automatic Pipette for Milk.

The fact that cream rises so readily upon milk makes it very essential that the quantity required for the test should be measured off directly after the mixing of the sample is completed. To those who at all times find the use of an ordinary pipette neither pleasant nor easy, the automatic pipette will recommend itself, though it is comparatively little used in practice.

Description.

It differs from the automatic acid pipette before described in that the surplus amount of the liquid taken into it is discharged not through an inner hollow tube, but by openings at the sides. In the illustration one of these openings (there are two altogether—one at each side) may be seen very clearly between the upper and lower bulbs of the pipette.

Automatic Milk Pipette.

Using the Pipette.

In using the pipette, it is immersed in the milk so that the openings just mentioned can no longer be seen. This allows the lower bulb and part of the upper one to become filled with milk. In the upper bulb will be noticed a glass rod, to the lower end of which is fixed a rubber cork, the whole acting as a kind of piston. The finger is placed on the top of the rod above the spring and pressed down so that the cork at the lower end is forced on to the upper pointed end of the pipette.

With the finger still pressing on the rod, the pipette may be removed from the milk, when the surplus amount (that is, all over 11 c.c. which is now contained in the lower bulb) will run out at the sides. The 11 c.c. may be delivered into the test bottle by simply removing the pressure of the finger from the piston-rod.

7.—COMPOSITE TESTING.

This is the name given to the system of testing adopted at creameries, cheese factories, and dairies to which milk is supplied in large quantities, and where payment is made for it not according to the quantity supplied but according to quality.

The quality is estimated solely by the amount of butterfat contained in the milk, and since in the manufacture of butter nothing but the fat is of any service, this method of testing is eminently the right one from the butter manufacturer's standpoint.

Disposal of Separated Milk.

As to the separated milk which is left when the milk has passed through the separator, its disposal is arranged for in one of two ways.

Either it is retained by the butter-maker, and used for condensing or for pig-feeding, when a small allowance is made for it, or more commonly it is returned to the farmer direct, by whom it is used as food for his stock.

Seeing that the rate of payment made to the farmer depends on the fat contained, it is absolutely essential that the testing of the milk should be made with the greatest accuracy. A slight error in the percentage obtained in testing may easily make a considerable difference in the actual payment made to the farmer for the milk he has supplied.

Accurate Testing.

To ensure absolute accuracy, the sample taken each morning and evening should always be an amount proportional to the quantity of milk supplied. If, for example, the farmer delivers 450 lb. of milk in the morning and 300 lb. in the afternoon, the quantity of the sample taken in the morning should be half as much again as that in the sample taken in the afternoon.

Thus if the sample taken in the morning were 45 c.c. of milk, then that in the evening would have to be 30 c.c., and this ratio could be kept up all through the week, taking 1 c.c. for every 10 lb. supplied.

The samples taken are put in the same bottle, a preservative is added, and the same procedure is repeated each day, morning and evening, throughout the week. At the end of the week, or other period arranged, the sample is analysed by the rapid fat-determining process previously described.

Reason for Proportionate Sampling.

The necessity of having the sample proportionate in quantity to the actual amount supplied is evident when it is considered that the milk varies in quality, the evening's milk being nearly always the richer.

The evening sample should, therefore, form just the same part of the quantity tested as the evening's milk is of the quantity supplied. If this is always secured the method is evidently fair both to the supplier and to the receiver.

It is not necessary to adopt the proportion mentioned above—1 c.c. for every 10 lb. of milk—any system of measurement will do, but when once decided on it must be continued unchanged throughout one set of samples.

One ounce of sample to every 50 gallons of milk supplied is found to be a very simple proportion, but whichever is adopted the necessity for accurate measurement is very evident.

Preserving Composite Samples.

In order that the milk may be sweet at the end of the week when the test is made, it is necessary that a preservative should be added.

The preservatives used are mostly of a poisonous nature; the most common being bichromate of potash. Only a very few crystals of this substance are needed, which transmits a bright yellow colour to the milk, hence there is no likelihood of the preserved milk being mistaken for ordinary.

Another preservative which is not infrequently used is corrosive sublimate or bichloride of mercury, and though so far as preserving the milk is concerned this serves its purpose admirably, it is not to be recommended, as it is one of the most deadly of poisons, and milk containing it if accidently consumed would prove fatal.

Tablets consisting of a mixture of bichromate of potash and corrosive sublimate are now much in favour; they contain just enough preservative for a sample, hence no measurement is

necessary. The bright yellow colour imparted by the bichromate of potash acts as a warning of the more deadly poison present, which by itself does not alter the appearance of the milk.

Formalin or Formic Aldehyde serves excellently as a preservative; about half a cubic centimetre usually suffices for each stock bottle, and its special advantage is its non-poisonous nature. In fact, this preservative, which is discussed later, has been recommended for use in butter, milk, and other articles of daily consumption, a proceeding upon the propriety or advantage of which we will not here enter.

Examples of Composite Tests.

The working of the test can best be indicated by taking practical examples.

Instance: Mr. A. supplies during the week 400 gallons, the test of the collected samples at the end of the week showing an average of 3·5 per cent. of fat. If we assume that a gallon of milk weighs 10·3 lb., the 400 gallons would weigh 4,120 lb. The amount of fat in this would be 3·5 × 41 = 144·2 lb. of fat. This, valued at 1s. per lb., comes out at £7 4s. 2d., or about 4·32d. per gallon of milk, the separated milk being returned free. This price obtained for the milk raises the question of the relative advantage of selling it thus for butter-making, or for consumption as milk, but this is a matter outside the scope of the present subject.

Composite Test of One Cow's Milk.

A closer idea of the practical working of the test is shown by the following figures.

The milk of a large Shorthorn cow was analysed twice daily for a week, and the total lb. of fat per day worked out, and at the same time a proportionate sample was taken out and a test made at the end of the week.

The figures obtained were:—

	Lb. of milk daily.	Lb. of fat.
Monday	.. 44·92	1·48
Tuesday	.. 50·37	1·88
Wednesday	.. 46·62	1·55
Thursday	.. 45·87	1·60
Friday	.. 48·25	1·45
Saturday	.. 46·12	1·73
Total	.. 282·15	9·69

This gives an average for the day of 47·025 lb. of milk and 1·615 lb. of fat, which amounts to 3·43 per cent.

The composite test of the combined samples at the end of the week showed 3·45 per cent. of fat. Thus practically the two results coincide, and when it is realised that by the composite method only one test was needed, while in the other case a test had to be made every day, or if morning and evening milk were tested separately, two tests a day, it is clear that the composite method gives a great saving of time without losing anything in the matter of accuracy.

Composite Tests of Mixed Milk.

To take another example, that of milk delivered at a dairy from one farm, two composite samples of which were taken, one of the morning and one of the evening milk. The result of the separate daily testing as compared with the one at the end of the week was :—

Date.	Morning milk. Per cent. fat.	Evening milk. Per cent. fat.
August 15	3·2	4·5
,, 16	3·6	4·4
,, 17	3·3	4·1
,, 18	3·2	4·2
,, 19	3·5	4·5
,, 20	3·7	4·1
Total ..	20·5	25·8
	Average, 20·5 ÷ 6 = 3·41 per cent.	Average, 25·8 ÷ 6 = 4·3 per cent.
	The composite test showed 3·4 per cent.	The composite test showed 4·4 per cent.

The Churn Test.

The churn test is an essentially practical method of estimating the quality of the milk, and appeals to the type of mind that is less easily convinced by methods which, however accurate and scientific, do not appear to give the final result in so vigorous and complete a fashion.

The churn test is carried out by simply churning the cream obtained from a given quantity of milk and weighing the actual amount of butter obtained.

In the butter tests as carried out at many of our shows, it is the churn test, in which each cow's milk is carefully weighed, then separated, and subsequently churned, that is generally employed.

Yet even this method, practical and effective though it seems as a test, is not necessarily accurately indicative of the fat contained in either the milk or the cream, and a considerable amount of care must be observed before such a method of testing can be relied on as justifying the condemnation of an animal as a bad butter-yielder.

The more accurate and rapid fat-determining process should be used in conjunction with it in order to have the result absolutely conclusive and reliable.

8.—THE PRACTICAL UTILITY OF TESTS FOR FARMERS.

There can hardly be any question as to the practical utility of milk tests to the farmer, yet it is desirable to indicate some advantages quite clearly.

By a regular and recorded testing of the milk of each cow he is enabled to see which animals give the best results.

Some, it will be found, yield a large volume of milk poor in quality by reason of deficiency in fat, while others yield large quantities of rich milk, and others again yield but small quantities of very rich milk.

In only too many cases cows utilise the food given them in putting on flesh instead of converting it into milk.

By discovering thus the characteristics of each animal he is able to weed out from the herd those which are either below the standard or which do not serve the exact purpose that he has in view.

If milk selling is the object in view, the purpose of the farmer should be to produce a large quantity of milk of good quality. In any business the man who puts on the market a first-class reliable article can gain a reputation for quality which will enable him to succeed and obtain good prices where another, marketing an inferior article, will fail.

This is eminently the case with milk, for high-class, clean, rich milk is less subject to the cutting competition with which low-grade milk is at present faced.

If butter-making is the object in view, the actual quantity of milk supplied is of much less importance than where it is sold, seeing that the yielding capacity of the milk is estimated

entirely by the amount of fat it contains, and not by its mere bulk nor its richness in solids other than fat.

A knowledge of the richness of the milk of each individual cow is of the greatest value to the farmer who undertakes butter-making, for it is practically ruinous to have in the herd cows which give an abundant supply of milk poor in fat, and such should be eliminated from the butter-making herd.

In making such a test of each individual cow the analysis of the milk should be made both night and morning separately on several occasions, preferably on one particular day each week for the whole of the lactation period, and then an average should be taken at the end of the period before condemning the animal as a producer of milk of but poor quality. This should be done because of the extreme variability in the quality of the milk, sometimes owing to the slightest causes.

Causes of Variation.

We have known, for instance, the milk of an individual cow much reduced in quantity by a very cold night, the fat percentage being much lessened at the same time. There are many other factors acting on the nervous system which have a similar effect, and others which cannot be directly marked, the only proof of their existence being indicated by the odd variations in the quantity and fat percentage which the milk sometimes shows.

There are, of course, some well-known causes, such as the period of lactation, which will be taken into consideration by every man before he acts upon the evidence afforded by the testing of the milk.

One definite cause of the poorness in solids, and especially fat, which is often apparent in the milk, is the deficiency of the food in albuminoids. When this is the case, however, it is a long time in showing itself, because though an animal may be receiving a diet which is insufficient in these compounds, it does not for a time let the milk suffer in consequence, but uses up its own body material and fat to produce what is needed, and without which there would be a deficiency of quality generally of the milk.

Yet there are innumerable animals producing milk poor in fat due to their own individuality, and no alteration can be produced by any change whatever in the feeding.

The evening milk is with all cows usually richer in fat than the morning milk. The variation between the two may amount to ·2, ·3, ·5, or even 1 per cent. The occasions on which the

morning milk shows a higher percentage of fat have not yet been satisfactorily explained.

Variation in Morning and Evening Milk.

The following figures from the records of a lengthy series of tests will show the variations which occur in the amount of fat present in the milk :—

Shorthorn Cows.	Morning's Milk.		Evening's Milk.	
	Yield.	Per cent of Fat.	Yield.	Per cent. of Fat.
	lb. oz.		lb. oz.	
No. 1	31 6	2·7	20 2	4·0
,, ...	29 8	2·5	22 0	4·0
No. 2	15 8	3·15	10 4	4·2
,, ...	14 5	3·8	9 0	3·4

Cow No. 1 was a very heavy milker, and during her year's milking period gave considerably over 1,300 gallons. Her morning milk generally showed a deficiency in fat, being considerably under 3 per cent., though in a few cases when it was tested it rose to 3, and on one occasion to 3·1 per cent. The lowest percentage recorded was 1·9. The evening milk was always rich, and on one occasion rose to the somewhat unusual percentage for the class of cow of 4·45.

In the case of cow No. 2 there is a reversal of affairs, the morning milk in one set of tests being the richer, which is not according to the general rule.

During the whole of the tests there was no variation in the food given to either of the cows which would in any way account for these variations in the fat percentage of the milk produced, and the causes will have to be set down as the mere individual peculiarities of the cows, or due to circumstances concerning which further investigation is necessary before definite conclusions can be drawn.

In innumerable instances of abnormally poor morning milk, the cause appears to be the long period which elapses between the evening and morning milkings.

In some cases observed, the period between the milkings has been 16 and 8 hours respectively, the milking having been done at 12 o'clock midday and 4 in the morning, for convenience of sale. The more even the periods between the milkings, the less likelihood will there be of the milk falling below standard.

9.—DETERMINATION OF MILK SOLIDS.

When describing the lactometer and discussing its use, it was stated to be of no value whatever, when used by itself, for the purpose of detecting adulterated samples of milk. Although this is the case, it does not, however, follow that the lactometer may not be of service if used in conjunction with other tests. The lactometer, indeed, is of the utmost value if used in conjunction with the Gerber tester, as will very soon be seen.

Board of Agriculture Regulations.

Attention has before been drawn to the Board of Agriculture regulations concerning the quality of milk for sale, which may be summarised as follows: Where a sample of milk, offered for sale as whole milk, contains less than 3 per cent. of milk fat, or less than 8·5 per cent. of milk solids other than milk fat, it is presumed, for the purposes of the Sale of Food and Drugs Acts, until the contrary is proved, that the milk is not genuine.

A further clause, dealing with skimmed or separated milk, states that genuine skimmed or separated milk should contain not less than 9 per cent. of milk solids.

The two terms used by analysts which it is important to understand for the proper interpretation of the above regulations are "total solids" and "solids non-fat."

Estimation of Milk Solids by Evaporation.

It will be remembered from the analyses given on pages 11 and 12 that milk is a watery fluid containing a number of substances, part of which are floating about or in suspension, and part in solution.

If a quantity of milk be taken in any vessel, and heated for a time, so that all the water is driven off in the form of steam, there will remain behind a deposit of solid matter which is known technically as "total solids," and consists of fat, casein, sugar, and mineral matter.

The estimation of total solids is a very simple matter, though a chemical balance is essential to carry it out accurately. It is

usually performed as follows: A small white perfectly dry porcelain dish is weighed. To obtain the dish in this dry state it is first heated over a Bunsen burner, or dried in a hot-water oven, and then placed in a desiccator to cool. The desiccator is a piece of apparatus in which the air is kept perfectly dry by means of calcium chloride, a substance which is very absorbent of water.

About five grams of milk (the particular quantity taken does not matter, though it should be somewhere about this amount) is next weighed into the dish, and then two or three drops of glacial acetic acid are added to coagulate it.

The reason for coagulating the milk is to allow the quicker escape of water from it, as if in the form of a curd, the usual skim which forms when milk is heated, and prevents evaporation, is avoided. The basin is now set on a water-bath for evaporation to take place.

Heating on the Water Bath.

A water-bath merely consists of a vessel containing water which may be kept boiling and giving off steam, so that the contents of basins, &c., which are placed on openings in the lid, may be kept at a temperature of about 212 deg. F. If the water-bath is kept boiling the greater part of the water of the milk will be driven off, and a deposit of solid matter will remain behind. It would not now be safe to weigh the basin to see the loss of water, for the basin, having stood on the water-bath, will itself have absorbed some moisture, so that an inaccurate result would be obtained. The basin, therefore, with its contents, is placed in a water-oven for an hour or two, so that here the final drying of the milk and of the basin is effected.

A water-oven consists of an oven with a water-jacket, the water in which is kept boiling all the time.

On removal of the basin from the oven it is placed in the desiccator for a short time, so that it may become cooled before weighing.

The difference in the weight of the milk before and after evaporation represents the amount of water which has been lost, which may be calculated out into a percentage. Or the water lost from 5 grams of milk if deducted from 5 leaves the amount of solids or "total solids" yielded, which may be calculated out into a percentage.

Calculating the Percentage.

Taking a series of figures, the way in which the calculation is made is readily seen :—

Weight of dish plus milk	27·205 grams
Weight of dish	22·205 ,,
Quantity of milk taken	5·000 ,,
Weight of dish plus milk *before* evaporation	27·205 ,,
Weight of dish plus milk *after* evaporation	22·835 ,,
Loss of water from 5 grams of milk..	4·370

Then, if 5 grams of milk lose 4·370 grams of water, the remainder, ·630 grams, represents the milk solids. Hence, if 5 grams of milk contain ·630 grams of total solids, then 100 grams of milk contain $\frac{\cdot 630 \times 100}{5} = 12 \cdot 6$ or 12·6 per cent. of total solids, which would represent the composition of an average sample of morning milk.

Now, although this is an accurate way of determining the solids of milk, yet it is one which cannot find much favour with the average practical dairyman, who would consider the time necessary to perform the test as debarring its serious consideration—indeed, the mere fact of having to carry out weighings is not in its favour for everyday dairy use. As will be imagined, an analyst or laboratory worker thinks nothing of such a test as this, and can easily have a dozen or two samples going at the same time, evaporation either being carried on for a certain set time or until there is no further loss in weight.

Separating the Solids.

If a basin containing the total solids be taken, and the solid matter is carefully broken up and washed with several lots of ether, a further loss in weight will take place.

The loss this time is not due to water, as that has already been got rid of, but is caused by something which the ether has dissolved. Ether readily dissolves fat, hence the loss is that of fat. There will still be remaining the other constituents of milk. To enumerate, there are casein, sugar and mineral matter, and it is these collectively which are termed "solids non-fat," or "non-fatty solids." They are, of course, all the constituents of milk with the exception of the fat and water.

To any but the large dairy companies, who can afford to keep their own analysts, a number of the different processes used in the analysis of milk and its products are impossible. However, methods have, fortunately, been devised by which dairy farmers and dairymen may get analytical results by simple means, and herein comes the use of the lactometer.

Estimation of Solids by Calculation.

By the aid of the lactometer and the Gerber tester used in conjunction with it, sufficient data are obtained to calculate to a nicety the percentage of solids. It has been found by a great deal of experience that such calculated results are only just inferior in accuracy to gravimetric analysis. A very simple formula, which we have used for many years with satisfactory results, is :—

$$\text{Per cent. Solids non-Fat} = \frac{\text{Lactometer reading at } 60^\circ \text{ F.} + \text{per cent. Fat.}}{4}$$

It is necessary, of course, to note the lactometer reading very carefully and correct the reading to the temperature of 60 deg. F., in addition to getting the percentage of fat accurately.

If the lactometer reading used in the calculation is one which has not been corrected to 60 deg. F., the margin for inaccuracy is greatly widened. If the milk be at any other temperature than 60 deg. F. when the reading is taken, correction to 60 deg. F. should be made in the following manner :—

For every 1° F. *above* 60° F. *add* ·1 to the lactometer reading.
For every 1° F. *below* 60° F. *subtract* ·1 from the lactometer reading.

This is to allow for the expansion or contraction of the liquid above or below 60 deg. F.

An Example.

To take an example which may be worked out by formula. A sample of milk registers a lactometer reading of 31·5 when standing at a temperature of 65 deg. F. The fat is 3·5 per cent., what is the percentage of solids non-fat ?

31·5 + ·5 = 32, the lactometer reading corrected to 60° F.

$$\text{Per cent. solids non-fat} = \frac{32 + 3{\cdot}5}{4}$$

Per cent. solids non-fat = 8·88 per cent.

This, if added to the per cent. of fat, gives the percentage of "total solids"; for example, 3·5 + 8·88 = 12·38. The idea upon which this formula is based is that every 1 per cent. of fat present in the milk lowers the lactometer reading 4 degrees.

Other Formulæ.

Quite a large number of formulæ have been invented for calculation of the total solids direct, one of Droop Richmond's in common use being :—

$$T=\frac{G}{4}+\frac{6F}{5}+\cdot 12.$$

T=per cent. total solids.
G=specific gravity or lactometer reading corrected to 60° F.
F=per cent. fat.

If the following example be worked out it will show the application of the formula. Suppose a sample of milk to show a specific gravity of 1·031 and 4 per cent. of fat.

$$T=\frac{31}{4}+\frac{6\times 4}{5}+\cdot 12.$$

$$T=12\cdot 67.$$

For those who do not care to do any calculations whatever there are scales and tables of different kinds which may be used.

Use of Sliding Scale.

One of the best of these is Droop Richmond's sliding scale, which is made in the form of a ruler with a sliding centre slip. At the left-hand top side is a scale of temperature, while on the top side of the movable slip is a scale of lactometer readings, ranging from 22 to 37.

Now, when the lactometer reading of a sample of milk has been taken, and the temperature noted, the corrected reading to 60 deg. F. may be found by placing the lactometer reading obtained in a line with 60 deg. F., when the corrected reading will be shown in line with the temperature at which the reading was taken—*e.g.*, actual reading 32 at 65 deg. F.; if 32 be placed in a line with 60 deg. F., opposite 65 deg. F. will be shown 32·65, the corrected reading. (It will be noted that the figure here used for correcting differs slightly from that before mentioned.) On the top right-hand part of the scale are found percentages of fat marked out, while running the whole length of the bottom of the ruler is a scale giving percentages of total solids.

On the right-hand bottom side of the sliding piece is another scale of lactometer readings, or specific gravities.

Richmond's Milk Scale.

Having found the corrected lactometer reading, the sliding piece is moved until the arrow on it points to the percentage of fat present in the sample of milk.

If now the specific gravity reading be noted on the right-hand scale of the sliding piece, opposite to this reading will be found the percentage of total solids on the solids scale.

Suppose a sample, of which the corrected specific gravity is 32·65, shows a fat percentage of 3·5.

Then by placing the arrow (on the right of the specific gravity figures) against 3·5 on the column marked fat it will be seen that the specific gravity 32·65 is in line with 12·55 on the total solids scale.

Thus 12·55 (per cent.) represents the total solids in the sample.

The formula upon which this scale is worked out is :—

$$T = \cdot 25\ G + 1 \cdot 2\ F + \cdot 14.$$

10.—DETERMINATION OF ACID IN DAIRY LIQUIDS.

It is necessary in both butter and cheese-making to be able to say accurately when the acidity in the cream or the curd has reached a certain degree. This in the older methods was largely a matter of guesswork or experience.

From the taste and smell, and by noting the appearance of milk, cream, and curd, after considerable practice a rough but approximate guess could be made of the amount of acid present in each case, and thus it was decided if milk were ready for rennetting, cream for churning, or curd for grinding.

This method, though commonly satisfactory, lacks accuracy, and is quite unsuited to persons who have not had considerable experience.

The modern method, more accurate, and much less liable to error, and, further, not dependent on any individual's experience of milk or its products whatever, is naturally becoming more and more largely adopted because of these evident advantages.

To the milk dealer, knowing what percentage of acid there is present in milk, it tells him approximately how long it will keep and be safe for selling, or should he desire to pasteurise milk about which there may be some doubt, the percentage of acid present will indicate whether it will stand the process or not.

The Acidimeter—Principles of its Use.

The general principle of the method first introduced into dairy practice by Professor J. F. Lloyd, F.I.C., is as follows: A few drops of a substance called phenol phthalein, which is colourless when in acid, is added to the liquid whose acidity is to be found. So long as the liquid remains acid the phenol phthalein remains colourless, but the moment that the liquid becomes alkaline the colour changes to pink, and this change of colour serves as an accurate indication of the moment when the acid has been neutralised.

The strength or degree of the acidity is measured by finding how many cubic centimetres of an alkali of known strength it is necessary to add before the colour turns pink.

If many cubic centimetres of the alkali are necessary to produce this change the acidity must be evidently greater; if, on the other hand, little alkali is needed before the pink colour is produced, then the acidity is evidently small in quantity.

Apparatus Required.

A burette to contain the alkaline solution, fixed in a stand. An alkaline solution (caustic soda is the one nearly always used) of a known strength. The phenol phthalein, or indicating liquid, a pipette or tube with volume indications marked on its sides (one which holds 10 c.c. is most useful), a small porcelain dish, and a glass stirring-rod.

The whole of this apparatus, with sufficient liquid for use for a considerable time, can be purchased for a few shillings.

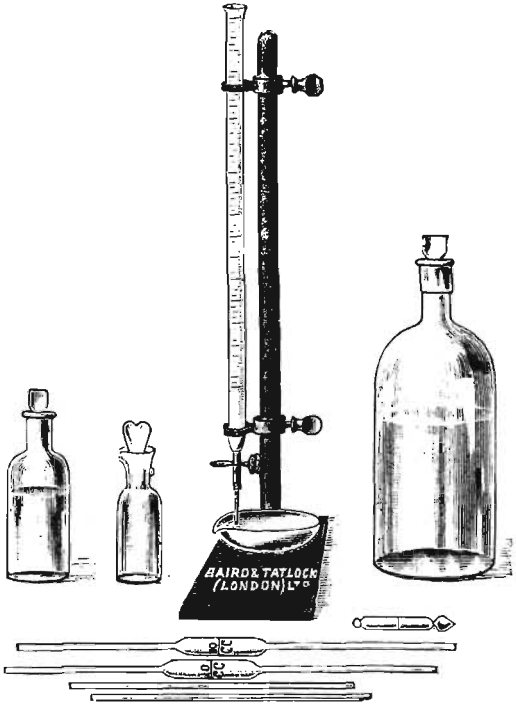
As a matter of convenience, the strength of the caustic soda used is such that the use of 1 c.c. indicates the presence of ·01 (1-100th) of a gram of lactic acid in 10 c.c. of the liquid tested. If twice this amount is needed before the colour changes, then twice the amount—*i.e.*, ·02 of a gram of lactic acid—is present in the 10 c.c. of the liquid which are taken to be tested.

The quantity of alkaline solution necessary will, therefore, serve as an accurate indication of the amount of lactic acid present in the liquid, of which 10 c.c. have been taken.

It is clear that the whole value of the test as an accurate means of finding the acidity depends on the correctness of the alkaline solution. This is prepared by dissolving 4·5 grams of 98 per cent. pure caustic soda in a litre of distilled water. Any firm of chemists will supply it, and the accuracy of the strength of the solution can then be relied on, or those with a little knowledge of analytical chemistry may prepare it for themselves.

Method of Using the Acidimeter.

The actual testing of a sample would then be carried out as follows: 10 c.c. of the sample should be accurately measured. To this three or four drops of the phenol phthalein liquid are then added. A measured quantity of the caustic soda solution is placed in the burette, and it is allowed to fall, drop by drop, from the burette into the sample.

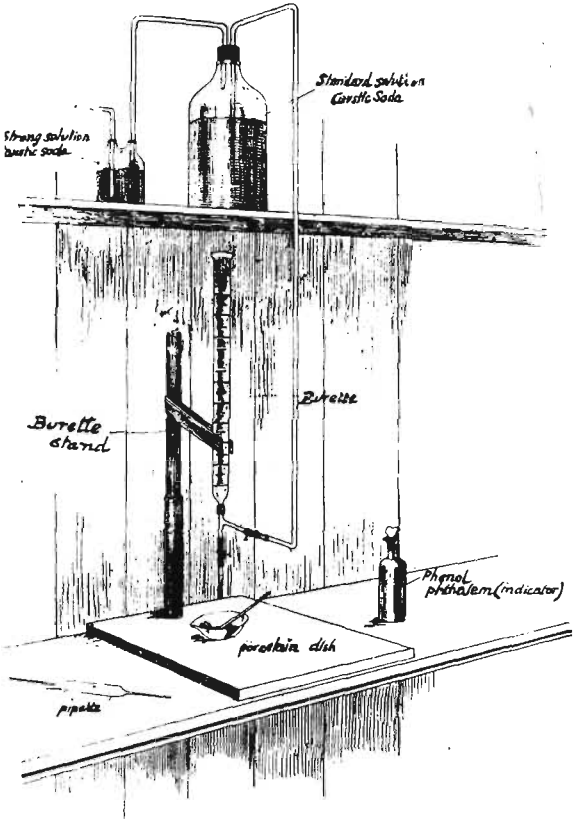


DAIRY ACIDIMETER, SHOWING BURETTE AND BASIN, PIPETTES, AND DROP BOTTLE CONTAINING PHENOL PHTHALEIN.
(Baird & Tatlock, London.)

Critical watch must be kept, and the sample must be well stirred. The moment the pink tinge is apparent the addition of soda solution must stop, and the number of cubic centimetres

of this solution which have been added must be read off on the burette.

If, as frequently happens with cream ready for churning, it is



ACIDIMETER FOR TESTING THE AMOUNT OF ACID IN MILK, CREAM AND WHEY, FITTED FOR USE IN A DAIRY FACTORY.

The above shows the arrangement where the acidimeter is in constant daily use. The burette is filled up as required from the stock bottle on the shelf by opening the stop-cock on the cross tube on the right

found, that 5·5 c.c. of the caustic soda has been used to neutralise the acidity in the sample, this shows the presence of ·01 × 5·5 grams of lactic acid in the 10 c.c. of the liquid tested.

Hence in 100 c.c. of the sample there would be 10 times this amount—that is, ·01 × 5·5 × 10. This is ·55 on the 100 of the sample, hence the acidity is ·55 per cent.

This calculation is, in practice, simplified by merely taking one-tenth of the amount of soda solution used ; and the number thus obtained represents at once the percentage of acid present in the sample.

It is this simplicity in obtaining the percentage which has led to the method being so readily adopted. If the quantities taken are all measured accurately the percentage of acid present can be read off at a glance, and it may always be allowed that each cubic centimetre of soda used represents ·1 per cent. of acid present in the liquid tested.

Acidities in Cheddar Cheese-making.

The following are results showing the common acidities obtained in Cheddar cheese-making : the acidity of mixed milk on starting, ·20–·21 per cent. of lactic acid ; the whey on cutting the curd, ·15 per cent. ; on drawing from the curd, ·19–·2 per cent. ; from the curd when ready for grinding, ·8 per cent. ; that coming from the curd when put to press, ·9 per cent. The advantages in accuracy and surety which follow when the variations in the acidity of the whey and curd can be so narrowly watched and so clearly mapped out in this manner are so evident as to need no other recommendation.

The cheesemaker knows accurately the state of the curd at any and every moment, and can detect and correct any variation which would have an injurious effect upon the character of the cheese produced.

11.—THE USE OF PRESERVATIVES.

The use of food preservatives is an all-important subject, affecting, as it does, practically the well-being of a nation. The revelations in connection with the meat-canning industry of America have brought home to the public the stern necessity of inquiring into the source and subsequent treatment of our food supply.

People who formerly were content to consume foods without question as to their purity are now becoming really particular, as witness the tremendous decline in the use of tinned goods during the scare caused by the disgusting facts made known about certain tinned and many prepared foods.

Now that the subject of pure food for the million is raised, the question as to whether or not preservatives may be used with impunity should be at once and for ever settled.

A large number of eminent medical men, scientists, and experimenters have for a very long time endeavoured to persuade the public that the preservatives which are contained in a number of the perishable foodstuffs are positively prejudicial and distinctly injurious to the health of the human being.

The best of arguments have been put forward to endeavour to get the public to demand foods free from preservatives, and with what result ?—considerable laxity on the part of the public in raising a finger to protect themselves.

Perhaps few realise to what danger they are exposed in consuming drugged foods ; anyway, it is only necessary to point out a few of the many eatables which are in common daily consumption to realise that the danger is more than a mere passing one.

Some Foods in which Preservatives are Commonly Found.

Let us enumerate the foods which are to be found charged with one of the commonest preservatives used—namely, a mixture of borax and boric acid.

Bacon and hams are cured with it, the preservative being used in addition to the salt and saltpetre commonly employed. Its use is not absolutely necessary, and this is only one of those instances in which the modern tendency to do things quickly (and improperly) leads to the sacrifice of much of that which is best.

Actually we get American bacon nowadays "cured" (?) during the sea voyage. The pigs, after being cut up, are packed in boxes with preservative and salt, or preservative alone, arriving in England to be delivered to the grocer, who unpacks the "bacon" (?), washes, and then dries it preparatory to selling. The boric acid with which this bacon is charged is said by a specialist in skin diseases to be the cause of an annoying skin irritation from which many people suffer.

The mere fact of curing meat in any way renders it less digestible, but when, in addition to an actual food substance such as salt, chemicals like those mentioned above are used, the digestibility is still further lessened to a very considerable degree.

One would expect to get a piece of fresh meat from one's butcher that had not been treated, but no! this is not absolutely certain. Most butchers and dealers in fish and game are true friends of preservatives, and do not fail to use them lavishly when occasion may demand.

A favourite form in which to use the borax type of preservative is to mix it in powder form with flour, and then by means of a dredger dust it over meat, game, poultry, etc.; fish is soaked in a solution of preservative, which is the commonest mode, bringing about the preservation of a food which would in a short time be totally unfit for eating.

Again, pork-pies, sausages, and such foods are not free from preservatives, whilst, coming nearer to the subject of our text, milk, cream, and butter are commonly found loaded up with preservatives of different kinds, chiefly those of the borax type.

Preservatives in Tinned Foods.

Not only do fresh foods contain preservatives, but they may even be found in tinned articles, which, if properly prepared, need never contain them.

As an instance of importance to the dairy industry, it may be mentioned that inferior brands of condensed milk have been shown to contain boric acid.

Now, having named a number of the fresh foods commonly preserved (there are many others not included), which in all cases ought to be free from the addition of any preservative whatsoever, it will be clear that in their common daily foods people consume a lot more chemical substances than ought to be the case.

When the question of the physical deterioration of the nation is being inquired into as it is nowadays, purity of the food supply should be one of the first points to receive attention.

A Curse of Modern Civilisation.

Undoubtedly, drugged foods are nothing less than a curse of modern civilisation. The all-prevailing dyspepsia and indigestion from which so many persons now suffer is without doubt, to a great extent, caused directly by the consumption of chemically preserved foods.

Further than this, it has recently been stated by an eminent physician that in his opinion the now common disease, appendicitis, is primarily caused by foods containing preservatives, which produce indigestion at first in a mild form, which later becomes chronic, and as a final result appendicitis is produced.

Be this as it may—it is much more likely to be true than not—appendicitis, which was barely known a number of years ago, is undoubtedly the result of digestive troubles, and what is more likely to produce them than drugged foods ?

Injurious Nature of Preservatives.

Whatever may be said to the contrary by those who are directly or indirectly interested in the sale of preservatives, and of such persons there are a very large number on account of the tremendous profits obtained by the sale of such substances as boric acid and borax under different fancy names, preservatives have, as has been shown by Dr. Wiley, of the U.S. Department of Agriculture, a most detrimental effect on the human being.

For the results of experiments in which human beings were fed with preserved foods, and the effects which the chemicals produced, we refer readers to Dr. Wiley's report.

How can we be sure of obtaining pure foods, so far as the absence of preservatives allows them to be so termed ?

Nothing but a popular outcry against preservatives will result in the abolition of their use, and the sooner this outcry comes the better.

If the average housewife would demand milk, butter, or other food free from preservative when making her purchase, the seller is really bound to declare if he cannot supply it. A grocer who guarantees butter free from preservative, which is found not to be so, is selling the article under false pretences, and is liable to prosecution for so doing.

No individual trader would like to have to confess that he could not supply a substance free from preservative, and to have to say, "You must go elsewhere," and yet this is really the position of the majority of dealers in certain classes of food at the present time. Fortunately for them, customers are not very fastidious, and do not commonly request preservative-free food, and yet there are a large number of dairies building up a reputation by selling only non-doctored material.

As showing some of the abhorrence of the medical profession to preserved food, the following instance will be interesting. A number of Harley Street medical specialists actually pay 4d. per pound more for their butter by reason of obtaining it through the post from a dairy making a speciality of not using preservatives, and in addition recommend many of their patients to do the same.

The Legal Aspect.

Turning to the legal aspect as to the use of prescrvatives, a Departmental Committee was appointed by the Local Government Board a few years ago to inquire into the use of preservatives and colouring matters used in the preservation and colouring of food.

This committee, after carefully considering the evidence put forward by experts who submitted information which dealt with the matter from all points of view, finally reported :—

Departmental Committee's Recommendations.

(*a*) That the use of formaldehyde, or formalin, or preparations thereof, in foods or drinks be absolutely prohibited, and that salicylic acid be not used in a greater proportion than 1 gr. per pint in liquid food and 1 gr. per pound in solid food. Its presence in all cases to be declared.

(*b*) That the use of any preservative or colouring matter whatever in milk offered for sale in the United Kingdom be constituted an offence under the Sale of Food and Drugs Act.

(*c*) That the only preservative which it shall be lawful to

use in cream be boric acid, or mixtures of boric acid and borax, and in amount not exceeding 0·25 per cent. expressed as boric acid. The amount of such preservative to be notified by a label upon the vessel.

(*d*) That the only preservative permitted to be used in butter and margarine be boric acid and mixtures of boric acid and borax, to be used in proportions not exceeding 0·5 per cent. expressed as boric acid.

(*e*) That in the case of all dietetic preparations intended for the use of invalids or infants chemical preservatives of all kinds be prohibited.

(*f*) That the use of copper salts in the so-called greening of preserved foods be prohibited.

(*g*) That means be provided, either by the establishment of a separate Court of Reference or by the imposition of more direct obligation on the Local Government Board, to exercise supervision over the use of preservatives and colouring matter in foods, and to prepare schedules of such as may be considered inimical to the public health.

Although this report was issued several years ago, no Parliamentary action has yet been taken in the matter, though the effect has been to cause a somewhat decreased use of preservatives in milk and cream.

Deaths of Infants.

Recommendation (*e*) is of very special importance, for while a strong person may take for a time, with impunity, foods in which preservatives have been used, the effect on infants and invalids is very harmful. It has often occurred to us that while medical men have been pointing out the enormous number of deaths of infants each year, especially during the hot weather, they have not suggested that the poisoning substances may be the preservatives present in milk.

Considering that the medical profession is so against the use of preservatives, medical officers of health, in addition to attacking the farmer for not being more careful in producing clean, wholesome milk, should direct their attention to those who "fake" the milk after it leaves the farm.

Summer diarrhœa in infants is commonly set down to the excessive number of bacteria present in milk during the hot

weather. This may be correct, but it should also be remembered that in hot weather many dairymen put an increased quantity of preservatives in milk in order to give it further keeping qualities, and while the bacteria may induce the disease, why should not the boric acid assist in producing the irritative and poisonous effects ?

Heavy Doses of Preservatives.

The quantity of preservatives often put into milk is frequently astonishing.

In a case in which a family suffered from the poisoning effects caused by preservatives, Dr. Robinson, the medical officer for East Kent, pointed out that the milk which caused the trouble had been dosed first by the farmer, secondly by the dairyman, and thirdly by the cook at the house where the trouble occurred. Each, of course, had assumed the milk to be fresh and free from preservative, and so the milk got a triple dose.

Dairy farmers do not use preservatives as a rule, and are strongly recommended not to do so. Effective cooling of milk before it is sent off by rail is all that is necessary. Of course, it is nice to be quite sure that the milk will keep sound in hot weather, and for this reason, no doubt, a number of farmers have asked for the best preservative to use, but in all cases we recommend none.

That which should be put a stop to altogether for the benefit of the public and the dairy industry, must not be encouraged among producers upon whom the nation depends for its food supply.

Inducing Foreign Competition.

If farmers take to preserving milk, they are opening out yet one other source of foreign competition. It should be remembered that the foreigner may send milk to this country if allowed to preserve it, and especially is he likely to do so if the English law permits him to preserve milk in such a cheap way as by adding preservative to it.

The home article, which can be proclaimed pure, therefore, may stand against milk and butter coming from abroad which may have to be doctored to keep it sound while on the journey here.

Local Authorities and the Use of Preservatives.

A circular issued to local authorities throughout the country by the Local Government Board (under the Food and Drugs Act) points out that as a result of the Departmental Committee's inquiry in 1900 the addition of preservatives to milk is considered unnecessary, and that it is recommended that no preservative should be allowed in milk.

Further, it is added that a number of dairymen do successfully carry on their business without the aid of preservatives, even in the hottest of weather, so that really the effect of preservatives is to protect those engaged in the milk traffic " against the immediate results of neglect of scrupulous cleanliness ; as under the influence of these preservatives milk may be exposed without sensible injury to conditions which otherwise would render it unsaleable. It may remain sweet to the taste and smell, and yet have incorporated disease germs of various kinds, whereof the activity may be suspended for a time by the action of the preservative, but may be resumed before the milk is digested."

The circular advises local authorities to obtain in reports from public analysts all possible information in connection with the use of preservatives in foods submitted to them for analysis. As to the administrative action to be taken where preservatives are found in milk, the circular suggests that Councils should notify to traders that action will be taken.

Foods Declared to Contain Preservatives.

It is pointed out that some difficulty arises where the vendor declares that preservatives are used, and the suggestion is made that careful note should be made of the quantity specified as being used and contrasted with the results of analyses. If the quantity be considered excessive, it may be presumed that the article has been rendered injurious to health, and proceedings may be taken.

Finally, " as regards formalin and boron preservatives, however, the Board are advised that the presence in milk of formalin to an amount which is ascertained by examination within three days of collecting the sample to exceed 1 part in 40,000 (1 part in 100,000 of formic aldehyde) raises a strong presumption that the article has been rendered injurious to health, and that the purchaser has been prejudiced, in the above sense ; and also that similar presumption is raised where boron preservatives are present in milk to an amount exceeding 57 parts

of boric acid per 100,000, or 40 gr. of boric acid per gallon. It appears desirable that the addition of preservatives to skim milk, separated milk, and condensed milk should be watched and controlled on similar lines."

We need not discuss the items in this circular, which from the public point of view may be regarded as a fair protection, though *the amount of preservative specified as not to be exceeded* seems to be far too great.

The results of this circular, as seen in daily practice, have been to induce those who before employed large quantities of preservative to use a lighter hand in the matter, and in many cases dairymen have given up using them altogether.

On the publication of the Local Government Board's circular, one firm dealing largely in preservatives immediately offered for sale a preservative guaranteed to contain no boron or boric acid, and claimed to be undetectable by chemical analysis. This preservative proved to be sodium fluoride and of very little use as a preservative.

Simple Tests for Detecting Preservatives.

There are several simple tests that may be employed for the detection of preservatives in milk, cream and butter. These tests are qualitative—that is to say, they show the presence, but not the quantity present, of any preservative; the quantitative tests, or those which show the quantity, being of a difficult and complicated nature.

The most important and extensively used preservatives in the dairy trade are boric acid, borax, and formalin, while among those of but little importance, owing to their slight use, may be mentioned salicylic and benzoic acids, sulphites and fluorides.

*The commercial preservatives sold under various high-*sounding names practically all consist of boron compounds, usually in the form of boric acid and borax. These last-named substances are employed either singly, together, or with the addition of small quantities of carbonate of soda, salt, saltpetre, and sometimes also sugar.

It is possible for boric acid to find its way into the milk if contained in cakes and other artificial foods eaten by the cow. Where this is the case, however, only faint traces will be found, whereas in the case of milk to which boric acid and borax have been added to preserve it, a comparatively large amount will be present.

Boron Preservatives.

Boron is an element not found in a free state in nature, but as boric acid (H_3BO_3) in the waters of hot lagoons in Tuscany. Tincal, a borate of sodium, is found in lake-basins in America and several parts of Asia, while calcium borate also occurs naturally.

Boric acid is a moderately soluble acid, and has but a slight taste. Borax is an alkaline salt.

A very useful characteristic of boron compounds is that they impart a green colour to a non-luminous flame, hence burning is one of the means by which they may be detected.

To Detect the Presence of Borax and Boric or Boracic Acid.

(1) *Flame Test.*—Evaporate a little milk to dryness in a small porcelain dish and then burn it to ash by making it red-hot. Add a little dilute sulphuric acid and some alcohol (methylated spirits will do) and apply a light. The presence of boracic acid causes the production of a flame with a green-coloured edge.

The water pressed from butter may be treated in a similar manner when it is desired to test butter for preservative.

(2) *Turmeric Test.*—Slightly acidify the ash of milk by adding a few drops of hydrochloric acid, immerse a piece of turmeric paper, and then carefully dry it at a gentle heat. The paper acquires a reddish-brown colouration. If boracic acid or borax is present, this is turned to greenish black on the addition of a little sodium carbonate to the paper.

If it is required to distinguish between borax and boracic acid, though these substances are hardly ever found to be present singly in foods, some ash of milk should be dissolved in water. If boracic acid is present it will answer to the turmeric test, but borax will give no reaction.

The addition of hydrochloric acid converts the borax into metaboric acid, which responds to the turmeric test, and this is the reason for its use.

(3) *Modified Turmeric Test.*—Take a porcelain dish and in it place two or three drops of milk, two drops of strong hydrochloric acid, and two drops of saturated tincture of turmeric. Dry this mixture by warming, and add a drop of ammonia solution from the end of a glass rod. If borax is present, a slaty blue colour changing to green is produced.

(4) *Glycerine Test*, which detects the presence of either borax or boracic acid, is performed as follows : Take some milk and add to it a few drops of phenol phthalein and then some dilute caustic soda till the milk acquires a delicate pink tinge. (This part of the test is the same as using the acidimeter.) Then add an equal quantity of a mixture made up of equal parts of water and glycerine. If the milk contains no preservative, no change occurs, but if borax or boracic acid be present, the pink colour changes to white.

In all cases, control or duplicate tests should be made with milk known to be pure, and the results compared.

Very commonly the milk delivered at a creamery, or that purchased by the dairyman, already contains preservative. A preliminary test may be made for preservative by ascertaining the acidity of the milk by means of the acidimeter.

Some preservative mixtures increase the acidity of the milk. Milk that has been preserved may show a high percentage of acid, and yet not smell or taste sour, as would milk containing a similar percentage of acid but containing no preservative. On the other hand, preservatives may show no free acid at all, and in this case the acidity of the milk would remain unchanged.

Formalin.

This consists of a 40 per cent. solution of formic aldehyde, and is still used to some extent as a preservative ; it may be detected by the following tests :—

Hehner's Test is said to detect the presence of 1 part of formalin in 200,000 parts of milk. Take some milk in an ordinary test tube and dilute with an equal volume of water. Pour strong sulphuric acid of 92 per cent. strength (or that used for the Gerber tester, having a specific gravity of 1·82, will do) down the side of the tube. A violet ring is formed at the junction of the two liquids if formalin is present.

If no formalin is present, a greenish tinge is first seen, which soon disappears, and the milk becomes pinkish brown.

This test is improved and the colour more quickly detected if two or three drops of ferric chloride are added before the acid.

Amidol Test (Manget and Marion).—Take a little warm milk in a porcelain basin and throw on to the surface a little amidol or amido-phenol (commonly used in photography). If formalin is present, the milk assumes a strong *yellow* colour. Milk containing no formalin gives a salmon-pink colour.

Salicylic Acid.

This, an expensive preservative, is now more commonly used for preserving jam than for milk and butter. It may be detected in milk, or in the water from butter, by the addition of ferric chloride, which produces a violet colouration.

Test for Salicylic Acid.—If present in small quantity only in milk, its presence is best shown by the following method : Take some milk and add to it a few drops of sulphuric acid, then shake it up with ether. Evaporate the ether solution and add to the residue alcohol and a little ferric chloride. A deep violet colour is produced if salicylic acid is present.

12.—THE COLOURING OF MILK.

This is a practice common in the milk trade at the present time, especially in London and many large towns, though, as will be seen from the Departmental Committee's report on page 66, it is condemned entirely. It is done primarily to make milk appear richer, as the richest milk—that from Jersey and Guernsey cows—has nearly always a deep yellow colour.

Milk of a yellow colour is really demanded by a large section of the population of large towns, who consider it poor and inferior in quality if it is very white, as it appears in its natural state in winter. Thus the dairyman is frequently compelled to colour milk in order to keep his customers.

Another reason, perhaps, why colouring is used in the milk trade is because refrigerated milk, such as most dairymen in large towns deliver, has, by reason of the refrigerating process, lost to a great extent its power to throw up cream. The customer usually judges the quality of the milk by its capacity for throwing up cream, and if it does not do this freely considers it inferior. Adding colouring matter makes milk look rich and full of cream—in fact, the milk and cream are then of the same colour, and if this is the case the consumer is unable to judge the creaming powers of any particular sample.

Milk is coloured for cheesemaking purposes, as well as for sale as milk, and produces the bright yellow cheese such as is in

demand in many markets. In both cases colouring is really an unnecessary proceeding, but as it is demanded by the public, who prefer to judge by eye rather than palate, is practised to please them, though, unfortunately, it is also sometimes used as a mask to make an inferior or adulterated article look rich and good.

Colouring Matter Used in Milk.

The colouring matters added to milk come under two headings: (1) Preparations of annatto; (2) aniline dyes. The former are harmless vegetable preparations, but aniline dyes, which are prepared from coal-tar, are of a dangerous, poisonous character. Annatto is made from the seeds of the plant known as Bixa orellana.

Butter Colouring is a preparation of the colouring matter from the seeds dissolved in oil, and is suitable colouring for cream only.

Cheese Colouring, which is used for colouring milk, consists of the colouring matter dissolved in water. It may also be used in cream for colouring butter, but will colour the butter-milk as well as the butter, which annatto in oil does not do.

Annatto colouring is harmless in character, but aniline dyes should never be permitted in milk, cream or butter.

Detection of Colouring Matter in Milk.

To the keen observer, there is a vast difference in the clarity of appearance of artificially coloured milk and Jersey or milk of naturally high colour, but in all cases this difference is not apparent.

The simplest test of all is to put some milk warmed to 90 deg. or 100 deg. F. in a glass, and allow it to stand for a few hours. If artificially coloured, although cream will have risen to the surface, the lower portion will still be coloured. In natural milk, the cream only is of a yellow colour, and the milk underneath assumes a bluish appearance.

Aniline or coal-tar dyes of the Azo group may be detected by their turning pink on the addition of a mineral acid such as strong sulphuric acid.

Distinguishing between Annatto and Aniline Colouring in Milk.

To ascertain which type of colouring matter is present, warm some milk and add a small quantity of acid to coagulate it,

and then filter. Annatto is insoluble in acids and is retained in the curd, whereas aniline dyes are soluble.

Thus if the coagulated mass remaining on the filter paper is yellow, and the filtrate or liquid running through is colourless or similar to ordinary whey, this indicates the presence of annatto. If aniline dye is present, the filtrate will be coloured.

Householder's Test.

Take a portion of milk in a white porcelain saucer or cup, and dissolve in it sodium bicarbonate in sufficient quantity to make it taste soapy, or in other words turn it alkaline. Then immerse the lower part of a strip of blotting or filter paper in the milk and leave it there for a few hours. If artificial colouring matter is present, it will be transferred to the blotting paper, which will become stained yellowish brown.

Modified Test for Detecting Annatto.

Take some milk in a test tube and add some strong alkali such as caustic soda to it, which will dissolve the colouring matter. Next add some stannous chloride, which will give a pink colouration if annatto is present (annatto is always coloured bright pink with stannous chloride).

In making colour tests, it is always well to have duplicate tests made with milk known not to be artificially coloured, with which to make comparison.

13.—THE PASTEURISATION OF MILK.

Since the modern methods of butter-making have been in vogue the improvement of the machinery in use has been considerable. Now every year an advance is noticed in the type of apparatus used, as well as the introduction of a number of quite new machines.

Generally speaking, for the best apparatus, designed both for the use of private dairies as well as creameries, we have to go to Denmark and Sweden. These two countries have specialised in the dairy industry to such an extent that their dairy machinery, which is designed on scientific principles, is sought

after by users in all parts of the world—indeed, there is no country in which dairying is carried on where machinery from Denmark has not been introduced.

Special attention has been given by the Danes to the manufacture of separators and pasteurisers, and considering the present usefulness of some pasteurisers which were designed nearly ten years ago, the care bestowed both upon the design and construction of these machines can well be imagined.

In quite the early stages in the development of the dairy industry Denmark recognised the value of the pasteurisation of milk; hence we have seen a gradual change in the design of pasteurising apparatus, each year some improvements being embodied until nowadays the apparatus used is practically all that can be desired.

Pasteurising Temperature.

Some years ago an Act was passed in Denmark making it compulsory for creameries to pasteurise all milk and cream to a temperature of not less than 85 deg. C. (185 deg. F.).

Pasteurisation, defined, may be said to consist of the heating of milk to a certain temperature for a definite time, both time and temperature being sufficient to kill all the living bacteria in the milk, though it would have no effect upon their spores or seeds.

As the temperature adopted depends upon the time during which it is intended to heat the milk, it is important to consider these two points together.

Killing the Tubercle Bacillus.

If, say, the temperature of 140 deg. F. be decided upon, it will be necessary to keep the milk at this temperature for half an hour to secure the thorough destruction of any disease germs, such as tubercle bacilli, which may be present.

It has been shown by certain investigators that this is the lowest temperature and time that will ensure the destruction of tubercle bacilli, and then it is a most important point that the heating should be carried out in contact with air. If the heating be performed in a closed vessel where the air has not free access, the envelope or capsule which surrounds the tubercle bacillus is not broken, hence the organism resists the heating, and is saved from destruction.

On the other hand, if such a high temperature as 185 deg. F., which is used in Denmark for pasteurisation, is the one selected, the "continuous flow" type of pasteurising apparatus may be employed. In such pasteurising machines the milk enters at the bottom of the machine, and in its course of about two minutes or less is passed out at the top, having been heated up to 185 deg. F. during its passage through the machine.

This pasteurisation is satisfactory, and has advantages, the chief of which is that the temperature being maintained only for a short space of time, less injury will be done to the milk, less cooked flavour being imparted to it.

Pasteurisation in the Milk Trade.

The pasteurisation of milk for sale is exceedingly common, and many large firms of repute pasteurise all milk before it is delivered to customers.

It is pasteurised and at once cooled to a low temperature (about 40 deg. F.) by means of a refrigerating plant, so that there is practically no alteration in the flavour of the milk.

Where pure unpasteurised milk can be procured, it is preferable *to that which has been pasteurised, as pasteurisation makes* milk safe by reason of the germ destruction which it brings about, and dairymen who practise it may get careless as to the cleanliness of the milk and source of supply.

It is of the greatest importance that the milk supply should come from healthy cows, and that the milk be kept as clean and pure as possible, and if it is effectually cooled this obviates to a large extent the necessity for pasteurisation to enhance its keeping properties.

Now, considering the law relating to the pasteurisation of milk at creameries which was brought into force in Denmark in order to protect the public health, and at the same time prevent the spread (through the agency of milk) of tuberculosis among the live stock of the country, it is essential to have some tests by which inspectors may verify if the heating has been properly carried out.

Obviously a low temperature maintained for only a short space of time is not of much use in ensuring the destruction of germs, so that if at creameries, as is commonly the case, the pasteurisation is carried out in a careless manner, it is of little, if any, value in safeguarding the public from tubercle germs

which may be present in the milk, and are not destroyed unless properly heated.

Tests for Pasteurised or Scalded Milk.

The tests which have been devised for the detection of insufficiently heated milk, cream, etc., are very numerous, and are dependent upon the formation of different colours, on the addition of the reagents, in raw or only partly scalded milks.

The theory concerning the formation of colour in raw milk is that it is in some way connected with the enzyme catalase or natural chemical ferment present in milk, or wherever living cells are found. The ferment has the power of decomposing hydrogen peroxide (H_2O_2) to water and oxygen, and it is in connection with this change that colours are formed in different substances.

Hydrogen peroxide (H_2O_2) is one of those substances which possess an amount of oxygen which it will readily yield up; it is well known on this account for bleaching action, and being practically water with an atom of oxygen tacked on, it is very commonly used as a preparation for bleaching.

If heating be carried so far as to destroy the ferment, the formation of colour does not take place. It follows, therefore, that according to the amount of colour formed, the temperature to which the milk has been heated can be judged approximately.

Further than this, it is possible to ascertain if mixtures have been made of part new and part pasteurised milk, and the approximate portions present in the mixture.

Those who use the tests about to be described are advised always to work with controls in doubtful cases—that is to say, if you are testing a sample of milk, and you want to be absolutely certain that it has been heated to a particular temperature, no more or no less, a sample of raw milk should be taken and heated to the temperature fixed upon, and a test made with it, and the results compared.

In the latter case you have a certainty, and if the other sample, of which you know but little, gives a similar degree of colour, you may safely assume that it has been heated in a like manner to the control.

The different tests vary but slightly in their use; the colour formed, however, varies with the temperature a good deal in the case of the different reagents.

The test commonly preferred is the gum guaiacum test.

Gum Guaiacum Test.—The reagent required for this test is a concentrated solution of gum guaiacum in methylated spirit or acetone. It is made by grinding up the gum, mixing with the spirit, and then filtering the solution obtained.

Take the milk to be tested (in all the tests it should be just warm), add two or three drops of hydrogen peroxide, and then pour in some of the gum guaiacum solution. In the course of about half a minute or so a brilliant green colour will be produced in the case of raw milk, but no colour appears if the milk has been properly pasteurised.

Starch and Potassium Iodide Test.—This is one of the earliest of the tests devised, and is simple and good; one of the drawbacks is the fact that the reagent used (the starch and potassium iodide) does not keep very well, and needs to be freshly made up occasionally.

To prepare the reagent, take some starch, mix thoroughly with a little cold water, then dilute it considerably, and add a few crystals of potassium iodide, after which boil the whole for a few minutes, and, when cool, it is ready for use.

To make the test, take the milk to be examined, add to it a few drops of hydrogen peroxide, and then some of the reagent. In the case of raw milk, a dark blue colour is formed, whereas in pasteurised milk a slate-green colour only appears.

Storch's Test.—This test was devised by the Danish dairy expert, Professor Storch, and the reagent used is a 2 per cent. solution of paraphenylenediamine. A sample of milk is taken and a drop of hydrogen peroxide added, then two drops of the reagent. The mixture is shaken, and if a dark violet colour appears at once the milk has not been heated up to 176 deg. F.

Butter may be examined to see if made from properly pasteurised cream by carefully melting some in a tube put into water at a temperature of 140 deg. F. or under.

The liquid butter fat is poured off and the remaining portion diluted with an equal quantity of water, and the test applied as in the case of milk.

Ortol Test (Saul).—The reagent used is a 1 per cent. solution of orthomethylaminophenol sulphate, but, when purchased, all that need be asked for at the chemist's is photographic ortol. To make the test, take 10 c.c. of milk, 1 c.c. of the reagent, and one drop of hydrogen peroxide.

A deep red colour appears in thirty seconds in the case of raw milk; an excess of hydrogen peroxide must not be used, as it bleaches the colour, though the presence of preservatives in the milk does not affect it. No colour is formed when the milk has been heated up to 176 deg. F.

Guaiacol Test (*Dupuoy*).—In this case the reagent is a 1 per cent. solution of crystallised guaiacol, which should be kept in a yellow glass bottle. Add to milk an equal quantity of the reagent and one drop of hydrogen peroxide.

In the case of raw milk, a pomegranate colour is produced, but in milk heated up to 176 deg. F. no colour is formed.

From the foregoing, readers may select a test for distinguishing between raw and heated milks, and, with a little practice, they will soon be able to ascertain the degree to which milk has been heated.

EXAMINATION OR TEST QUESTIONS.

The extent of one's knowledge of any subject can be gauged largely by attempting to answer questions upon it.

For the benefit of students and others, a number of questions are set on the different sections of this book.

For ready reference the sections in which the answers will be found are given above the questions.

SECTION I.

1. What is milk? Name its constituents, and state to what extent each exists in milk of average quality.
2. What do you understand by the terms "Total Solids" and "Solids non-Fat"?
3. What is butter-fat, and in what form does it exist in milk?
4. Of what does butter-fat consist? State what it may be considered chemically.
5. Does the breed and food of the cow have any effect upon the proportion of fat found in milk?
6. In what way does margarine differ from butter?

7. How do you account for butter made from newly calved cow's milk being softer than that made from cows stale in milk ?

8. State the method by which the volatile and non-volatile fatty acids are separated.

9. What do you understand by the term "Albuminoids," and what are their uses in milk ? State their composition.

0. What is milk sugar ? What are its uses, and how is it prepared commercially ?

1. Of what does the ash of milk consist ?

SECTION 2.

2. What simple test is there for ascertaining the cleanliness of a sample ?

3. What do you know of a colour test for the relative purity of milk samples ?

SECTION 3.

4. Describe the lactometer, and state the points to be observed in its use.

5. What information does knowing the Specific Gravity afford ? Is the lactometer a reliable test ? Give reasons for your answer.

6. At what temperature do you take the specific gravity ? If milk is not at that temperature, in what way could you procure a correct reading ?

7. If 15 per cent. of water is added to whole milk of average quality (Sp. Gr. 1·032), what would be the specific gravity of the resulting mixture ?

SECTION 4.

8. Describe the creamometer and enumerate the points to be observed in using it.

9. Is the creamometer test a true guide to the quality of the milk or not ? Give full reasons for your reply.

SECTION 5.

20. Give a brief description of the Gerber Tester.

21. In testing by the "Gerber" method, why is it necessary that the chemicals used should be of a certain strength? Why does the fat appear in the graduated neck of the test bottle?

22. Why is it essential to mix the milk thoroughly before testing it by the "Gerber" method?

23. State how the percentage of fat is indicated in the test bottles. What would be the result if the machine revolved for a longer or shorter period than three minutes?

24. State the advantages and disadvantages of testing with and without sulphuric acid ("Sal" or non-acid method) respectively.

25. How would you prepare a sample of sour milk that it is needful to test?

SECTION 6.

26. State the methods of using:—an automatic acid pipette, an automatic milk pipette.

27. Give a short description of the principle of operating Veith's automatic acid and alcohol measure.

SECTION 7.

28. What is meant by composite milk testing? What is the reason for the proportionate sampling in composite testing?

29. How would you sample milk for testing?

30. In collecting each day's milk for testing at the end of the week, how would you preserve it so that it may remain sweet?

SECTION 8.

31. In what way are milk records and tests advantageous to the farmer?

32. What are the chief causes of variation of the quality and quantity of milk from individual cows?

SECTION 9.

33. What are the legal standards of quality for milk and separated milk ?

34. Give a description of the evaporation test for the total solids in milk ?

35. Give the formula for estimating the percentage of total solids and non-fatty solids in milk when the specific gravity and per cent. of fat in the milk are known.

36. If a sample of milk contains 3·5 per cent. fat, and the lactometer reading is 31 at 70 deg. F., how, by means of the Richmond Scale, could you ascertain the percentage of solids non-fat ?

SECTION 10.

37. Describe the acidimeter and state the principles of its use.

38. What percentage of acid would you expect to find in milk newly drawn from the cow ?

39. State the practical value to the milkseller, buttermaker, and cheesemaker of being able to determine the percentage of acid in milk.

40. State the acidity developed at the various stages in Cheddar cheese making.

SECTION 11.

41. What do you understand by the term preservative ? Name the preservatives which are commonly found in perishable foodstuffs.

42. What reasons lead you to believe that the use of preservatives in foods is harmful ?

43. What are the Departmental Committee's Recommendations with regard to the use of preservatives and colouring matter in foods ?

44. What action does the Local Government Board advise local authorities to take with regard to the use of preservatives ?

45. What are boron preservatives, and how are they used in foods ?

46. Give the different tests for detecting the presence of borax and boracic acid in milk and its products.

47. What is formalin and how can its presence in milk be detected ?

48. How can you ascertain if milk or butter contains salicylic acid ?

SECTION 12.

49. What are the reasons for colouring milk for sale, and is the practice to be advised or condemned ?

50. How can butter colouring be distinguished from cheese colouring ? And of what does the substance annatto consist ?

51. State the test by which annatto and aniline colouring may be detected in milk.

SECTION 13.

52. What do you understand by the term pasteurisation ? State all its advantages and disadvantages.

53. How is it possible to detect if milk has been scalded when to the taste the milk remains the same ?

54. Describe Storch's test for pasteurised milk.

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