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MILK – ITS COMPOSITION AND USES IN THE BAKERY

By Washington Platt, Manager, Technical Service Department, Merrell-Soule Co., Syracuse, N.Y.

In studying any raw material, the baker wants definite facts which will teach him:

1. How to buy it to best advantage.
2. How to use it to best advantage.
3. How it will affect his baked products.

To illustrate this in the case of milk—a baker finds that liquid whole milk sells for 38 cents a gallon, sweetened condensed milk whole for 14 cents a pound, and powdered whole milk for 35 cents a pound. Which should he buy? How can he tell high grade milk from poor milk? What points should he look for? What tests should he make?

After he has bought his milk, how should he use it in the bake shop so as to have the least labor and the best results? Finally, when he puts milk into his baked goods, how will it affect the cost, color, volume, richness, nutritive value and flavor of the goods?

To be able to give an intelligent answer to such questions, requires a knowledge of the production, composition and characteristics of various milk products. From this broad fundamental knowledge, information can be drawn to secure the answer to any particular question.

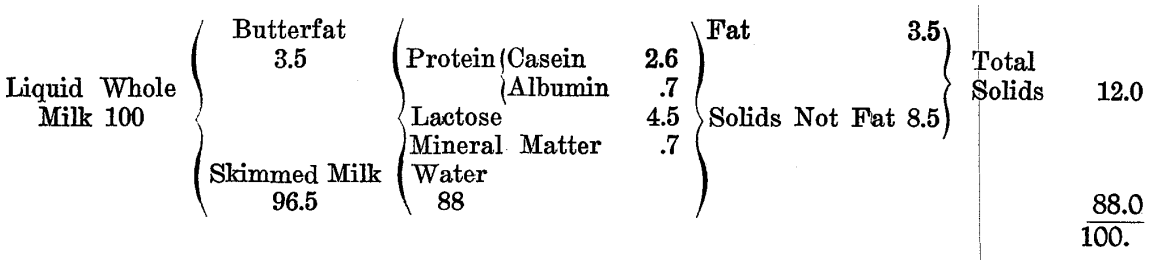
COMPOSITION OF MILK

To understand the composition of milk, let us suppose a quart of milk is standing in front of us. After a time the cream would rise to the top. If this were churned, Butterfat could be separated. After separating the cream completely, skimmed milk remains. If this is allowed to sour, it curdles, i.e. separates into curds and whey. The curd is composed of CASEIN.

Suppose that we now boil the whey. A white product much like egg white will separate for the same reason that the white of an egg coagulates on boiling. This is ALBUMIN. Albumin and Casein make up the protein of the milk.

TABLE I

AVERAGE COMPOSITION OF LIQUID WHOLE MILK
Expressed in Percentage



The remaining part of the milk can be evaporated down to a syrupy mass the WATER. If this is now cooled, crystals of milk sugar or LACTOSE will crystallize out.

If these should be removed and the resulting product burned to an ash, only MINERAL MATTER will be left.

Milk contains small amounts of other ingredients, the most important of which are the *VITAMINES.*

The proportions of the ingredients named above are shown in Table I.

It is convenient to put the casein and albumin together, under the head of proteins and to consider the composition of milk in round numbers as follows:

Average Composition Liquid Whole Milk:

Butterfat	3½%
Protein (Casein plus Albumin)	3¼%
Lactose	4½%
Mineral Matter	¾%
Water	88.0%
	100.0%

Let us now examine each of these ingredients in detail, as we shall thereby gain a good knowledge of the properties and uses of milk.

WATER

On looking at the above, we are struck with the fact that milk is mostly water. Each gallon of milk contains only one pound of solids together with $7y_2$ pounds of water,

Milk containing so much water is heavy to transport and spoils easily. It is this fact which has led to the recent rapid growth of the condensed and powdered milk industries where part or all of the water is removed.

BUTTER FAT

The butterfat in milk has always attracted more attention than any other ingredient. This is partly due to the fact that butterfat is comparatively easy to separate from the rest of the milk. On ordinary standing, cream tends to rise, though this separation is only partial. Modern centrifugal separators will remove the cream more completely giving a skim milk containing only about 1/10% of butterfat. On churning the cream, the fat separates, forming butter and leaving behind buttermilk.

The reason that fat separates so comparatively easily is that it is not dissolved in the milk, but exists as an emulsion; that is, it floats in the milk in the form of minute drops or globules of fat. These being lighter than water, tend to rise. These fat globules can be easily seen with the aid of a microscope.

When milk or cream or other liquid containing fat is passed through a homogenizer, the fat particles are broken up into globules even more minute. These may become so fine that the cream will not rise in the milk. The fat may be all there, but it is so finely divided that it fails to come to the top.

The amount of butter naturally present in milk varies more than any other ingredient. This depends principally upon the breed of the cow, but partly upon the time of the year and the feed. Normal limits are 3% to 5%. There is no federal legal standard, though many states and some cities have a standard of their own. Examples of these standards are given in the Table II. Whenever milk is handled in quantities, the proportion of butter fat is usually adjusted to some definite standard by the removal or addition of cream.

Butterfat is a highly digestible fat which melts at 86° F. It has dissolved in it a yellow coloring matter which gives the yellow tint to milk and cream. This coloring matter depends upon the feed of the cow, being much higher in the summer than in winter. Butterfat has a delicious flavor, superior to that of any other fat or oil. Mankind has learned to appreciate this rich flavor highly. There is no way to confer high quality on ice cream, confectionery or baked products, like the use of plenty of butterfat in the formula.

Butter itself contains only about 81% of pure butterfat, the remainder consists of 16% water (the legal standard) 2% salt and 1% curd. The composition is easily seen by allowing butter to melt in a tall glass. On standing warm, the butterfat rises to the top. Below is seen a layer of water holding the salt in solution. White specks of curd appear at the bottom. Nearly all butter is artificially colored with a harmless yellow dye.

TABLE II
SOME STATE STANDARDS FOR MILK AND CREAM

From "Market Milk" by Kelly & Clement, published by John Wiley & Sons, New York.

States	Percent Total Solids	Percent Solids Not Fat	Percent Fat
California	11.5	8.5	3.
Connecticut	11.75	8.5	3.25
District of Columbia	12.75	9.	3.5
Georgia	11.75	8.5	3.25
Illinois	....	8.5	3.
Indiana	....	8.5	3.25
Iowa	11.5	...	3.
Kansas	....	8.5	3.25
Maryland	....	8.5	3.25
Massachusetts	12.	...	3.25
Michigan	11.5	8.5	3.
Minnesota	13.	...	3.25
Missouri	12.	8.75	3.25
Nebraska	....	...	3.
New Jersey	11.5	8.5	3.
New York	11.5	...	3.

For ice cream and candy making, sweet butter is sometimes used, differing from ordinary butter in that is is made

without salt. The average composition is butterfat 84.7%; Water 14.5%; milk solids not fat 1.5%

"SOLIDS"

As we see by Table I, milk is commonly divided into "water" and "total solids" which latter are all of the milk except the water, i. e., the valuable part of milk. Powdered whole milk is a commercial example of "total milk solids." The total solids in turn are often referred to for conveniences as "fat" and "milk solids not fat" The fat is, of course, butterfat. The solids not fat are all of the milk except the water and the fat. Powdered skimmed milk is a commercial example of "milk solids not fat."

BACTERIA

It has long been known that there exists in the air and in most food products plants. These are known under the general name of "micro-organisms." Taken alone, they are too small to be seen by the naked eye, but when millions and millions of these single plants are grouped together, they are visible. One type of micro-organism with which you are already familiar is yeast. A cake of yeast consists of very many millions of single yeast plants. Other kinds of micro-organisms are "bacteria." These are likewise minute plants, much too small to be seen with the naked eye, but easy to study under the microscope.

Bacteria exist almost everywhere, that is, in the air, in water, in goods, on our hands, in utensils. The numbers present are at first astounding. For example, ordinary good tap water may contain up to 1,000 per cubic centimeter. Good milk contains 100,000 bacteria per cubic centimeter, while some poor milk sold for drinking purposes in restaurants contains 4,000,000 and more bacteria per cubic centimeter. (A cubic centimeter is approximately 1/30 of a fluid ounce.)

Most bacteria are entirely harmless only a very small proportion can cause disease. They often bring about important changes in food products in which they grow just as yeast does, though the effects of the different bacteria may be quite different from one another.

Many kinds of bacteria will grow easily and rapidly in liquid milk. These bacteria get into the milk from the air, milk pails and from many other sources. Milk, therefore, contains many bacteria as soon as it is drawn. Great cleanliness is necessary in order to keep the numbers from becoming excessive. The bacteria which do get into the milk grow rapidly if the milk is warm. In the cold, they grow more slowly.

The commonest form of bacteria found in milk are those which produce lactic acid and hence cause souring. The action of these bacteria starts as soon as the milk is drawn. Milk, therefore, becomes steadily more and more acid the longer it stands after milking before it is used. This growth of acidity is naturally more rapid the more bacteria there are in the milk and the warmer milk has been kept. Such growth takes place only in the presence of moisture. No bacterial action occurs in milk from which the water has been removed.

Lactic acid is advantageous in bread dough. The presence of acidity in a dough ingredient hastens the conditioning of the gluten and shortens the time of fermentation. The difficulty of utilizing the acidity of fluid milk is that it is never uniform, being influenced by a great variety of factors difficult to control. Old milk makes the dough come quickly, while very fresh milk will give a young dough in the same length of time.

Bacteria may be killed by boiling, but this practice causes changes both in the flavor and in some of the properties of the milk. Most of the bacteria, however, can be destroyed by heating the milk to a temperature considerably below the boiling point and keeping it hot for some time. The method is known as "pasteurization." It kills off practically all of the disease producing organisms and most of the others. Pasteurization is an important aid in the production of a safe milk with a low bacterial content.

Pasteurization is more common in some localities than in others. In some places, especially cities, all liquid milk offered for sale (except certified) must be pasteurized. Most powdered milk is pasteurized before drying and sweetened condensed milk is heated even higher. Though pasteurizing greatly reduces the bacterial count of milk, it does not prevent the growth of such bacteria as get into milk after the pasteurizing process. As long as there is sufficient water present these will grow, though they cannot do so after the milk has been dried.

NUTRITION

Every manufacturer of a food product should keep always before his mine value of his goods. After all, the prime object of a food is to nourish the body.

High nutritive value is one of the important advantages of milk as a bakery ingredient. Milk is the only raw material used in the bakery which is intended by Nature primarily as a food. It is the most perfect natural food known.

The butterfat of milk is not only highly digestible but also carries with it t so necessary for human nutrition. The proteins of milk (casein and albumin) are of the finest grade. As the proteins of flour are not of such high quality, the addition of marked increase in the nutritive properties of the resultant baked product.

Milk is especially rich in mineral matter which is so essential to the building teeth, and to the healthy growth of children.

Milk also contains all' three Vitamins, those mysterious substances, which such minute amounts, but which are known to be absolutely essential for growth, health, and even for life itself.

MILK PRODUCTION ON THE FARM

Liquid milk is produced by dairy farms under a wide variety of conditions. On the best farms, we find healthy cows, in clean barns and well fed. Equipment for handling milk on the farm has been improved so that the farmer can now draw the milk into clean utensils, cool it promptly and keep it cool until it is sold.

Such are the conditions in the best dairy sections where the farms are subject to inspection. In too many instances, opposite conditions prevail so that milk of very uncertain quality may be produced.

MARKETING LIQUID MILK

Milk may be marketed in liquid, evaporated, sweetened, condensed, or powdered form.

In a few instances, the farmer carries his milk direct to the consumer. In many instances, however, especially near cities, a number of farmers haul their milk to a central shipping point from which it is shipped, generally by train to the city, and is then distributed from a city milk station.

Somewhere along the line, the milk from each customer must be inspected and weighed or measured. It is also customary to test the milk for butterfat and to standardize to some predetermined standard. It may or may not be pasteurized. Two or more days may elapse between the milking and consumption of the milk. Daily deliveries to customers are necessary.

When everything runs smoothly, this method gives satisfactory results. The many difficulties, however, have caused fewer and fewer bakeries to use their milk in liquid form, especially in the larger cities. These difficulties are uncertainty of delivery, difficulty of ordering exactly the right amount of milk in advance, loss from souring and the necessity for cold storage. In carefully run bakeries, the inevitable lack of uniformity in the acidity of liquid milk caused by bacterial action is likewise an important objection.

SWEETENED CONDENSED MIK

One of the most popular forms of milk for the bakery is sweetened condensed milk, often referred to merely as "condensed milk." The milk to be condensed, may be half skimmed, or skimmed. Briefly, the process consists in adding sugar to the evaporating it down in a vacuum pan until part of the water has been driven off.

The composition of sweetened condensed milk varies considerably according to the portion of sugar added and the amount of water evaporated. Definite inform: obtained only by chemical analysis of each lot.

Average analysis of Sweetened Condensed Milk:

	Whole	Skimmed
Water	31%	29%
Cane Sugar	41%	43%
Butterfat	8%	
Milk Solids Not Fat	20%	28%

For bakers' use, condensed milk is commonly put up in barrels.

On account of the high content of sugar and the comparatively low moisture, sweetened condensed milk keeps well, but not perfectly. The barrels should be kept in ready for use. Keeping qualities are uncertain. Some barrels keep well, others not so well, especially in the summer time, when bacterial action sets in, both gas and acidity may be produced.

Sweetened condensed milk provides the baker not only with milk but with sugar. In fact, it should be remembered that this form of milk contains more of the solids from the sugar cane than from the cow. However, it is often convenient to have some of the sugar ready mixed with the milk. It makes excellent bread and gives the baker milk in a very inexpensive form.

Sweetened condensed milk is such a thick product that it not infrequently rates. The lactose of the milk will sometimes crystallize out, causing the mi "grainy." These crystals tend to settle, so that the bottom of the barrel may be quite different from the top. Less often, the casein will curdle.

EVAPORATED MIK

Evaporated milk sometimes is called also "Unsweetened condensed" or merely "condensed milk." It is formed by the evaporation of part of the water from liquid milk without the addition of any other substance. Evaporated milk may be of two quite distinct kinds. The commonest kind is evaporated until it contains about 72% water and 28% milk solids. It is then placed in cans and superheated to 230° F. This process cooks the milk so that it thickens, coagulating the albumin, much as an egg thickens on heating. The heat also gives a yellow shade and a particular taste to the milk.

The superheating sterilizes the milk, killing all the bacteria so that it will keep indefinitely as long as the cans remain unopened. If the cans are opened, the milk will spoil rapidly due to the large portion of water present which allows the bacteria to grow readily.

Due to the nuisance of opening a large number of cans and for other reasons, this form of milk is little used in the bakery.

The other type is the “bulk evaporated (or condensed) milk.” This milk is more highly concentrated than evaporated milk in sealed cans. "Whole milk is concentrated to a content of about 36%' total milk solids, and skimmed milk to 40% milk solids, not fat. This milk is sold in 10 gallon milk cans. It is not sterile, but will keep several days if cold.

Where a bakery is located near a reliable condensery which makes this form of milk, it is often, advantageous for the baker to purchase his milk in this way. Bulk evaporated milk is often the most inexpensive form in which milk solids can be purchased. At a distance, or where transportation is uncertain, this form of milk cannot be used, due to its limited keeping. Unless the condensery is carefully run, there is likewise danger from variations in moisture content and acidity of the evaporated milk causing lack of uniformity in the bread.

POWDERED MILK

Many of the inconveniences and disadvantages of milk disappear entirely when it is reduced to powdered form as is the case with so many other food products. Sugar, for example is supplied to us by Nature in the form of the juice of the sugar cane. In this form, it is difficult to transport and quickly sours. Reduced to dry form, however, these troubles vanish. The same is true of powdered milk.

Powdered milk is produced by two principal types of processes. The first process by which the milk is applied to the outer surface of a heated iron roll, turns, the film of milk sticks to it. Moisture is driven off by the heat before a completed, the milk is dry and is removed from the surface by a scraper. By so these rollers operate in a vacuum.

In the Spray process, part of the water is first removed in a vacuum pan of the water is removed by the spray process itself, which is remarkable for its p its simplicity. The milk is sprayed into a heated chamber along with a current of filtered heated air. The spraying reduces the milk to minute drops. Water evaporates of these as they float in the air away from contact with any hot metal. The co: ration takes but a fraction of a second. The particle of milk solids remaining has evaporated falls to the bottom of the drying chamber like snow.

When carefully carried out, the spray process produces a product consisting of the milk with only a trace of moisture (less than 2%). The albumin of the milk is not coagulated, the fresh natural taste is retained and none of the properties of the fresh liquid milk of importance to the baker is impaired.

Analysis of Spray Process Powdered Milk:

	Whole	Skimmed
Water	1½%	2½%
Butterfat	27½%	1½%
Milk Solids not Fat	71	96

When this process is properly carried out, the milk is powdered within a milking. Once it is in powder form all bacterial action ceases. For this reason well made powdered milk is lower in acidity than any other milk. It is the most uniform of all milk products.

But even a good process cannot produce a good powder unless it is carefully run. The liquid milk must be clean and properly handled. The drying must be scientifically controlled. Otherwise, the powdered milk may be dirty, under-dried, overcooked, full of specks, etc.

For a long time there was a general belief that bread made from powdered milk did not have as good a flavor and did not keep as well as bread made from sweetened condensed milk. Recent work at the American Institute of Baking show that bread made from powdered milk is fully equal to condensed milk bread in these respects. (See Am. Inst. Baking Annual Report 1923 and 1924).

VALUE OF SKIMMED MILK

Interest in the constituents of milk has focused on the butterfat more than is perhaps warranted. The value of the solids not fat, i.e. the skimmed milk hag been correspondingly overlooked. The result of this is that skimmed milk products has never commanded the price to which their real worth entitled them. This was never more true than today. Almost every item used by the baker has advanced since 1914, but powdered skimmed milk sells at approximately the same price as in 1914. In other words compared with other bakers' raw materials, skimmed milk in its various forms, is cheaper than ever before.

APPLICATION OF FACTS

Having now a general knowledge of the composition, production and commercial forms of milk, we can consider the definite application of the facts learned toward answering the three practical questions with which this article was begun.

HOW TO BUT MILK TO BEST ADVANTAGE

In purchasing any raw material, any one of three courses may be followed

First: We may purchase only products of established quality, or if we purchase through a bakers' supply house, we may choose a house that has the best reputation for square dealing. Such a policy has much to recommend it. If the baker has not time to materials carefully, he should certainly stick to those of assured quality which watching.

Second: We may purchase in each case that brand which costs the least per pound, under the impression that we are thereby saving money. Few members of the American Society of Bakery Engineers will follow such a policy in purchasing their raw materials.

Third: We may make an intelligent study of raw materials, carefully examine samples submitted and form our own conclusions regarding the relative merits of the different brands. This method of purchasing involves more trouble than the others, but it unquestionably gives best result.

We find from the above study that milk is a valuable, but also a delicate aid highly perishable product—easy to spoil at any step of its journey from the farm to the bakery. There are good and bad brands of liquid, sweetened condensed, evaporated and powdered milk. The conclusion is that only reliable milk products should be purchased. Like many other raw materials which the baker buys, it is generally cheaper in the end to purchase first class milk products.

We find from our study that there is a wide variation in the composition of milk products. Moisture varies from 1 ½ % to 88%; butterfat from 0 to 27 ½ %, etc. In purchasing, we should therefore, be careful to consider not only the cost per pound but also what we are getting in our pound—how much of it is water, how much is added sugar, how much is real milk solids. The above tables of analysis will give you valuable information on these questions. In case of large purchases, more exact figures can be obtained by written guarantees from the manufacturers as to composition, or by chemical analysis. In smaller purchases, this is unnecessary.

Bakers should be especially careful to be clear as to whether they are buying! a whole milk product, or one which has been wholly or partially skimmed. This can usually the label if care is taken to avoid confusion.

The per cent of butterfat in whole milk products is as follows:

	% Butterfat
Liquid Whole Milk	3% to 4%
Sweetened Condensed Whole Milk	8.%
Evaporated Whole Milk	8.%
Powdered Whole Milk	27½%

From this, we see for example, that liquid milk containing 4%' butterfat is whole milk, but sweetened condensed milk containing 4% fat represents a half skimmed product. Similarly a sweetened condensed milk with 8% butterfat is whole milk, but a powdered milk containing this proportion of butterfat is less than half skimmed.

For those who wish to test the quality of milk products for themselves, the following test is recommended. This test is often made comparative, two samples of milk products being tested side by side.

In the case of sweetened condensed, evaporated or powdered milk, water should be added to restore them to the same water content as normal liquid milk.

First taste the samples. Overcooked, scorched, sour or abnormal flavors will be at once apparent. On the other hand, a natural fresh milk taste will indicate the better samples.

Allow the dissolved samples to stand in tall glasses over night in a cool examine the bottoms of the glasses for black specks. Insoluble milk constituents will be evident as a white sediment.

Now allow the samples to stand again, this time in a warm place until they sour naturally and curdle. Cream milk will give a clean sour taste not unpleasant and will form a curd without gas. Other milk products may have off flavors and show gas holes in the curd.

This test is simple and easy for the baker to perform and gives him valuable information about any milk product.

One precaution is necessary. Only the cleanest and purest water should be used in dissolving the milk. If the water is impure or contains specks of iron rust, the test will not be a fair one. A good source of supply is drinking water from a glass water-cooler. For the same reason the glasses should be covered while standing to prevent dust from the air settling in. The glasses themselves, should likewise be free from specks.

HOW TO USE MILK TO BEST ADVANTAGE

Though milk has been used for many years in the baking industry, many bakers do not use it in such a way as to have the fewest failures and secure the best results. A few precautions—some of them self-evident though nevertheless often overlooked—should be mentioned.

In bread, all milk products cause the dough to tighten up somewhat after this reason, bread dough containing milk should be mixed somewhat slacker than dough without milk. The dough will tighten up during fermentation so as to be just reaches the bench or divider.

In using liquid milk special care should be taken to keep it cold until use the rapid increase in acidity (even though it does not actually sour) will cause variation in the baked goods, especially bread. The milk should be stirred after standing even distribution of the cream.

With sweetened condensed milk one of the principal points is in the handling. Condensed milk sticks to any utensil in which it is handled. Care must be taken to scrape them out well each time a batch of dough is made; otherwise,

the amount of milk which actually gets into the different batches will vary widely. If the sweetened condensed milk is grainy or lumpy, the contents of the barrel must be well stirred before use.

When powdered milk is used for bread making, it should be dissolved in part of the water to be used in the batch before adding it to the rest of the ingredients. In this respect, it is like compressed yeast. This is conveniently accomplished by placing the water in a receptacle such as a pail or can, adding the powder on *top* of the water, and beating it in with an ordinary baker's whip until lumps are all broken up. This is easy to do and takes but a minute or two.

When powdered milk is added to a bread formula which previously contained no form of milk, from 1 to 1 ½ pints of extra water should be added at the same time for each pound of powdered milk used to take care of the extra absorption caused by the powdered milk.

In cake mixing, however, the powdered milk can be added to the mix with the sugar. Here it helps the sugar to beat up into a light foamy mass with the shortening and eggs. This foamy mass of sugar, milk and shortening, etc., carries air in to the cake and gives a lighter texture than can be obtained in any other manner.

HOW MILK AFFECTS BAKED PRODUCTS

In cakes, the effect of milk depends, of course, upon the type of cake, and the way in which the milk is used. In the enormous majority of commercial cakes, such as pound cakes, cup cakes, wine cakes, layer cakes, etc., some form of wetting is necessary in addition to the eggs In such high class products as cakes, milk is naturally used instead of water for wetting. From a scientific point of view the milk helps to emulsify the shortening and hold it in the cake. The baker knows that when he uses milk instead of water for cakes, he cake with a better flavor, better keeping qualities and a better yield.

In fried cakes, milk adds richness and keeping qualities without greasiness.

In custard, pumpkin or other soft pies and in cream fillings, -milk is the gives richness and fine flavor at a reasonable cost.

In all yeast—raised sweet goods, milk likewise adds richness, flavor, keeping yield, compared with the same products made with water only.

The variety of all of the above products is so great that the effect of milk out only in general terms.

In bread, the effect of milk has been more carefully studied both in the commercial bakery and in the laboratory. Repeated tests have shown that good milk in bread has the following effects:

1. Gives a softer texture.
2. Gives a better color to crust.
3. Improves the taste.
4. Improves the flavor.
5. Prolongs the keeping qualities.
6. Increases the yield.
7. Promotes the nutritive value.

All of these properties are of importance in bread. Probably the most important to the baker is the improvement in taste and flavor for it is this which really increases the consumption of bakers' bread.

No better ending to an article of this sort can be found than the following quotation from a Fleichmann Co. pamphlet:

"Milk is one of the most important ingredients of bread. It not only supplements the wheat protein, adds calcium and generally increases the nutritive value, but gives it a distinct flavor that cannot be obtained in any other way."

"The increased use of milk opens the gate to increased sales. The best advertisement in the world is a quality loaf of bread and a quality loaf of bread cannot be made without milk."

"The wisdom, business acumen, and foresight of a baker may be measured by the amount of milk he uses."

REFERENCES

For those who desire further information on milk and its products, the following books are recommended:

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"Chemistry of Food and Nutrition" by Henry C. Sherman, published by the MacMillan Co., New York, 2d Ed., 1919.

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Booklets and Charts of the best producers of liquid, sweetened, condensed and powdered milks.