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Iowa blue cheese

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By E. F. Goss, V. Nielsen and M. Mortensen

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

R. E. BUCHANAN, Director

DAIRY INDUSTRY SECTION

AMES, IOWA
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Iowa Blue Cheese

A Roquefort Type Cheese Made From Cows' Milk

BY E. F. GOSS, V. NIELSEN AND M. MORTENSEN

Iowa is an importer of cheese. In 1933 Iowa dairy plants manufactured 1,491,822 pounds of cheese. In the same year consumption is estimated to have been 10,254,397 pounds, using the 1933 United States Department of Agriculture figure of 4.15 pounds per capita and 1930 Iowa census figures as a basis of computation. In 1933 Iowa dairy plants produced 14.6 percent of the cheese consumed in the state. If this percentage could be greatly increased it would result in a larger and more diversified market for Iowa milk.

Production of cured cheese in Iowa has up to the present consisted almost entirely of the staple variety known as Cheddar or American cheese. Small production has not been the result either of lack of milk or of inability to produce an acceptable cheese. Rather it has been the inability of the average dairy plant to pay enough more for milk to be used for cheesemaking to divert the milk from other manufacturing uses, principally butter. The high value placed by the Iowa farmer upon skim-milk for feeding purposes when used as a supplement to corn in hog production has undoubtedly been one important factor in limiting the production of cheese. When milk is made into cheese the skim-milk is not available for feeding on the farm. Instead, whey, which is estimated to possess half the value of skim-milk, is available for the feeding operations. This and other factors require that the dairy plants must be able to pay a substantially higher price for milk fat for cheesemaking than for buttermaking if milk is to be available for the former. Expansion of cheese production in Iowa apparently depends upon some method of increasing the returns which can be obtained.

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1 Project 386 of the Iowa Agricultural Experiment Station. Manuscript submitted for publication Sept. 4, 1934.
2 Data from the Iowa Department of Agriculture.
from cheese so that a relatively larger payment can be made to the milk producer.

New varieties of cheese offer possibilities of increasing the return for milk to the farmer. According to the United States Bureau of Foreign and Domestic Commerce, in 1933 the United States imported 48,396,740 pounds of cheese from foreign countries. Many varieties of cheese, especially those which are imported, sell for high prices. The production of some of these special varieties of cheese in demand by the consumer but not now produced in Iowa should permit an expansion of the cheese industry upon a profitable basis. Iowa Blue Cheese, the manufacture of which is described in this publication, offers possibilities for development in Iowa.

DESCRIPTION OF IOWA BLUE CHEESE

Iowa Blue Cheese is a Roquefort-type cheese made from cows' milk. A Roquefort-type cheese possesses a distinctive peppery flavor due to the growth and activity in it of certain molds. Many types of cheese are known in which one of the major ripening agents is a mold. The growth of such a mold throughout the cheese produces a distinctive and characteristic marbled blue color. This class of cheeses is referred to as blue-veined because of its appearance. In addition the enzymes elaborated during the growth of the mold produce a certain pleasing peppery flavor which is typical and is largely responsible for the high esteem in which the Roquefort-type cheese is held by epicures.

Of the blue-veined mold-ripened cheeses Roquefort has been considered the best both in quality and uniformity. The manufacture of this cheese originated more than a thousand years ago in the province of Aveyron in southern France centering about the village of Roquefort, for which the cheese was named. Certain natural conditions in the mountains of that section favored the manufacture and curing of this sort of cheese. Later the uncertainties of natural conditions led to the supplementing of them with air-conditioned curing rooms as modern machinery and equipment became available. Also it has been the advent of air-conditioning equipment or "controlled climate" which largely has been responsible for the success which
has more recently attended the manufacture of a Roquefort-type cheese from cows’ milk in sections far from the natural conditions under which this cheese was originally developed from sheep’s milk. The successful adaptation of the manipulation of the process to cows’ milk has resulted in a product which has met with high favor with many who are well acquainted with the characteristic fine peppery flavor of a blue-veined mold-ripened cheese. One retailer reported sales of the Iowa Blue Cheese as ten times the volume of other blue mold cheeses which he handled. It is hoped that the manufacture of Iowa Blue Cheese will develop into a permanent and profitable part of the Iowa dairy industry.

**HISTORICAL**

The blue mold cheeses have attracted attention in the United States for many years because of the relatively high price at which Roquefort, Gorgonzola and Stilton, the more commonly

![Fig. 1. An active lactic cheese culture is added at the rate of 1½ to 2 percent.](image-url)
known varieties, have sold. As a result of studies on the ripening agents responsible for the changes taking place in this variety of cheese, Thom in 1906 wrote, "In the ripening of Roquefort cheese the only organisms found necessary are lactic bacteria and the Roquefort species of Penicillium." Matheson in 1921 outlined a process for the manufacture of cows' milk Roquefort cheese. His efforts were the result of several years of experimental work designed to duplicate insofar as possible the French product. Hall and Phillips in 1925 published a study of the application of the Roquefort process to the milk of goats. The investigations of these workers and others have served to clarify many of the perplexing problems which arise in attempting the manufacture of a high quality blue mold cheese of the Roquefort type. The American dairy industry, however, has not been able to replace with a domestic product the cheeses of this type which are imported in considerable quantities from France as Roquefort and from France, Denmark, Norway, etc., as blue cheese. Since the duty-paid price of these cheeses has not decreased during the recent 4 years in proportion to the reduction in the price of milk for manufacturing purposes in this country, renewed interest in these cheeses as a means of obtaining an added return to the producer for milk is timely. Recent wholesale prices for various brands of blue mold cheeses range from 31 to 61 cents per pound as compared with 12 cents per pound for mild fresh American cheese of the Cheddar type. It is the high price of the imported cheese, together with present low prices for milk and other manufacturing costs, which stimulates renewed interest in a blue mold cheese industry in this country.

**PURPOSE OF EXPERIMENTAL WORK**

The present efforts were directed particularly toward producing a type of blue cheese which would meet the present market demand in the Middlewest and which could be made by a sufficiently simple and easily controlled process to insure the

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dairy plant operator some degree of confidence that a uniform product could be produced at a reasonable cost of manufacture. The cheese most in demand in the Midwest is generally one of mild flavor. Apparently some mild brands of blue cheese have had a considerable success in competition with the very highly cured forms frequently required by certain eastern trade outlets. If such a type of cheese can be regularly produced with uniform characteristics, it is felt that the market open to it would greatly exceed the present demand for the conventional highly flavored Roquefort-type cheese. Elimination of irregularities of quality and characteristics in blue mold cheeses is especially difficult, but it is believed that the process herein described will be of some assistance. It must be remembered, however, that the making of mold-ripened cheeses is one of the most difficult processes in the art of cheesemaking.

The process described below differs in some respects from the conventional French process as described by Marre\(^6\) and Matheson.\(^7\) These variations have for their objectives the simplification of the process, the reduction of losses or the production of a more uniform quality. The cheese has been made at the Iowa Agricultural Experiment Station on a semi-commercial scale and the product marketed through regular retail outlets. Over a period of 18 months 72,499.0 pounds of milk have been made into cheese. The results which have attended the method used in this laboratory seem to offer some promise of success in the commercial plant, and the process is recorded here in the hope that it will lead to the establishment of a successful blue cheese industry in Iowa.

\(^6\) Marre, E. Le Roquefort. Carrère Rodez. 1906.

EQUIPMENT NEEDED

It is assumed that the manufacture of Iowa Blue Cheese will be carried on in a dairy plant already supplied with the necessary receiving, testing and refrigerating equipment. Below is a list of the additional equipment necessary for the utilization of 2,000 pounds of milk daily.

EQUIPMENT FOR THE MANUFACTURE OF IOWA BLUE CHEESE FROM 2,000 POUNDS OF MILK PER DAY

<table>
<thead>
<tr>
<th>Number</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acid test, complete</td>
<td>Any standard acid test using decinormal alkali and phenolphthalein as an indicator.</td>
</tr>
<tr>
<td>1</td>
<td>Air conditioning unit</td>
<td>Adequate to keep curing room at 46° F. and humidity at 93 to 95% of saturation.</td>
</tr>
<tr>
<td>1</td>
<td>Brine tank</td>
<td>Cypress or concrete; approximately 12 ft. long, 3 ft. wide and 2 ft. deep; outlet at bottom for cleaning.</td>
</tr>
<tr>
<td>1</td>
<td>Cheese moisture test outfit</td>
<td>Includes scales, electric oven, pans, etc. 27 in. x 54 in.</td>
</tr>
<tr>
<td>1</td>
<td>Cheese truck</td>
<td>2,000 lb. capacity, jacketed for hot water or steam heat.</td>
</tr>
<tr>
<td>1</td>
<td>Cheese vat</td>
<td>Length as required. Flat wooden.</td>
</tr>
<tr>
<td>1</td>
<td>Conductor head and spout</td>
<td>1(\frac{1}{2}) in. cut.</td>
</tr>
<tr>
<td>1</td>
<td>Curd fork</td>
<td>1(\frac{1}{2}) in. cut.</td>
</tr>
<tr>
<td>1</td>
<td>Curd knife horizontal</td>
<td>3-gallon size.</td>
</tr>
<tr>
<td>2</td>
<td>Curd pails</td>
<td>Regular size, 8 in. x 11 in x 3(\frac{1}{2}) in. A linen cloth such as is used for swiss cheese or other similar strong open weave material 6 ft. x 6 ft.</td>
</tr>
<tr>
<td>2</td>
<td>Curd scoops</td>
<td>To fit drain vat. 3 ft. x 7 ft.</td>
</tr>
<tr>
<td>4</td>
<td>Drain cloths</td>
<td>Same as cheese vat. 8 oz. for measuring rennet. Stainless steel or tinned steel 7(\frac{1}{2}) in. diameter, 6 in. tall, 6 rows of 20 (\frac{3}{4}) in. holes. Wet and dry bulb. 20° F. to 120° F. 50 stainless steel needles. Marshall’s. Double beam counter, 1 oz. graduations, 100 lb. capacity. 8 in. x 3(\frac{1}{4}) in. stainless steel. (\frac{3}{4}) in., 25 ft. Floating dairy, accurate to 1° F. Galvanized iron, round bottom.</td>
</tr>
<tr>
<td>1</td>
<td>Drain rack</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Drain table</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Drain vat</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Graduate</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Hoops</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Hygrometer</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Pricking machine</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Rennet test complete</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Scales</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Skewers</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Steam hose</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Thermometers</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Wash sink</td>
<td></td>
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Supplies needed will include the following:

Foil A plain pure block tin foil yielding 6,500 square inches to the pound or 5,450 square inches when interleaved. This may carry the brand and other information. The foil is cut 13 inches by 22 inches, which will yield 19 sheets per pound.
Salt
Parchment
Rennet
Mold powder
Lactic culture
Boxes
Excelsior
Brushes

Fine butter salt of good quality.
A white vegetable parchment.
Standard cheese rennet extract.
Suitable mold culture of *Penicillium roqueforti* grown on bread dried and very finely ground. This and the lactic culture should be obtained from a reliable culture laboratory.
Active lactic acid-producing cheese culture.
Wooden, 7½ inches wide, 10 inches deep and 22½ inches long inside. Sides, tops and bottoms of ¾ inch material and ends ¾ inch.
Ordinary packing. Clean.
Stiff ox fiber hand brushes for cleaning the surface of cheese.

In addition to the above, the usual cheese factory small tinware, cleaning equipment and supplies will be needed.

**METHOD OF MANUFACTURE**

The procedure followed in the manufacture of Iowa Blue Cheese is given in some detail below. The directions are as precise as it is possible to give at this time. The time schedule is given rather definitely not because it is possible to make the cheese solely or even largely on a time schedule but because such a picture of the process is helpful. The cheesemaker will require some experience in the manufacture of this cheese in order to afford a basis for the successful control of certain physical properties of the curd which aid in determining the characteristics and quality of the final product. If one is skilled in the manufacture of some other type of cured cheese, it should not take long to gain the experience needed for the correct interpretation of the description given below.

**THE MILK**

Clean, well cared for milk is necessary. Unless it is available the manufacture of the cheese should not be attempted. High
quality milk permits better control of the composition and physical properties of the curd, and the normal sequence of curing changes is more likely to occur in cheese from good milk.

The usual rules for the production of clean milk should be followed. Water in most sections of Iowa may be used to cool the milk close to 60° F. with the usual wooden cooling tank. Morning milk delivered promptly to the plant need not be cooled.

At the dairy plant, acidity, methylene blue reductase and fermentation tests will be found particularly useful in selecting suitable milk. Cheesemakers are commonly experienced in the use and interpretation of the results of these and other tests to determine the suitability of milk for cheesemaking.

The milk used in our experiments averaged 3.34 percent fat. To it was added cream to raise the average fat content to 3.79 percent. A normal milk with 3.8 to 4.2 percent fat has also been used with success.

Pasteurization of the milk for Iowa Blue Cheese has not proved advantageous. Cheese made from pasteurized milk did not develop as much surface growth of bacteria and molds, a lesser degree of flavor was present, and the cheese did not become as sweet during curing as the raw milk product. The pasteurized milk cheese carried 49.0 percent moisture in the 24-hour drained curd as compared with 47.4 percent moisture in the raw milk product. The poorer drainage properties of the pasteurized milk curd make it more difficult to obtain the right sort of body and texture. Losses of fat in the whey were .04 of 1 percent lower for pasteurized milk which is so slight that it is not significant. More experience with this sort of cheese will be required before the modifications necessary to avoid certain ill effects of pasteurization can be specified. It seems at present that Iowa Blue Cheese made from raw milk cures in a more nearly normal and satisfactory manner than that from pasteurized milk.

**RIPENING THE MILK**

After the milk has been placed in the usual American cheese vat, ordinary lactic cheese starter for ripening the milk is added at the rate of 1.5 to 2 percent. The acidity is permitted to develop until .19 to .20 of 1 percent has been reached, which
will usually require from 1 to 1\(\frac{1}{2}\) hours. At the end of the ripening period the Marshall rennet test will show 1\(\frac{1}{4}\) to 1\(\frac{1}{2}\) spaces. It is essential that an active and rapid lactic acid-producing starter be used. An inactive or slow culture will not facilitate satisfactory drainage, and the composition of the cheese cannot be controlled.

When cream was added to raise the fat content of the milk, enough was added to raise the fat percentage approximately .4 of 1 percent. This increase in the ratio of fat to casein has not appeared to cause any special difficulty in obtaining a sufficiently open cheese or satisfactory drainage. The setting temperature of 84° F. is lower than commonly used for most varie-

Fig. 3. Three ounces of rennet extract are used for each 1,000 pounds of milk. Just before adding the rennet extract to the milk, it is diluted with 20 times its volume of cold water.
Fig. 4. The temperature of the milk should be precisely 84° F. when the rennet extract is added.

ties of cured cheese, but this lower temperature seems to aid in the production of the desired body and texture.

SETTING THE MILK

When the acidity test shows .19 to .20 of 1 percent, the rennet extract is added at the rate of 3 fluid ounces or 90 cubic centimeters per thousand pounds of milk. The rennet is first diluted with 20 times its volume of cold water. Just before the rennet extract is added, the milk is set in motion. Thorough mixing of the diluted rennet extract should continue for 1 or 2 minutes to insure uniform distribution. It will be noted that no color is added since it is desired to have the finished cheese as white as possible. The veining with the blue mold then shows up in sharp contrast against the uncolored cheese.

CURDLING PERIOD

A relatively long curdling period is used which will usually consume 1¾ to 2 hours. During this time the milk thickens, then curdles completely and becomes progressively firmer, more brittle and inelastic. Beads of whey will stand out on the surface of the curd, gradually verging into larger areas until the entire surface will be covered with a thin film of clear whey. The curd is now ready to cut. Sometimes in the case of milk
slightly riper than usual, the curd will shrink away from the lining of the vat before it is ready to cut.

CUTTING THE CURD

With the ½-inch wire curd knives the curd is cut into cubes by means of a horizontal cut lengthwise followed by a vertical cut across the vat and finishing with a longitudinal cut with the same knife. Following this the whey will separate rapidly and the curd begin to settle out. An acidity test of the whey taken immediately after the cutting is completed will commonly show .14 to .15 of 1 percent of acid. Lower acidities have frequently been followed by difficulty in drainage.

FIRMING THE CURD

Following the completion of the cutting operation the curd is left undisturbed for about 15 minutes. At the end of this period it is stirred gently to prevent matting and this operation is repeated at intervals of a few minutes for the next half hour. Fifty minutes after cutting, the temperature of the curd is raised 2 or 3° F. by dipping out a pail of whey and heating this to a temperature of 170 to 180° F. by injecting steam.

Fig. 5. The firm curd is cut into ½-inch cubes with the wire curd knives.
directly into it. Enough whey can easily be heated in this manner to raise the curd temperature sufficiently without danger of the curd matting in the bottom of the vat. It also avoids too much heat being applied, which might occur if steam is admitted into the jacket to heat the curd. This hot whey should be added carefully to the vat and then be thoroughly distributed with the wooden curd fork.

**DIPPING THE CURD**

The firming temperature of 86 to 87° F. will slightly toughen the curd in a few minutes, and the acidity by this time will have reached .18 to .19 of 1 percent. This slight toughness prevents too much breaking up of the curd on the cloth to which it is now to be transferred. When this slight toughening has proceeded for about 15 minutes, some of the whey is drawn off through the vat gate, and one-half of the curd is transferred by means of curd scoops or flat sided curd pails to a nearby drain.
vat. In the bottom of this vat is placed a rack over which two of the swiss cheese cloths are spread. Drainage of the curd is assisted by raising and lowering the corners of the cloths occasionally, but too much manipulation will cause unnecessary breaking of the curd and losses of cheese solids. After 15 to 20 minutes the curd becomes a slightly tough, lumpy, porous mass. There will be very little free whey passing from it.

**HOOPING THE CURD**

The hoops used in this work were the so-called Meunster style mold. They are of heavy tinned-steel, round, 7½ inches in diameter, open at both ends, with 6 rows of twenty ⅛ inch holes drilled in the side for drainage. If the room is not sufficiently warm, it is well to dip the hoops in hot water just before using them. The curd may have cooled a degree or two during drainage before being placed in the hoops. The hoops may be placed on boards or directly upon a draining table, and each hoop filled one-fourth full with the pulpy, irregular curd.

Upon this first layer of curd is dusted a light layer of the prepared mold powder, using a pepper box. Following this a second and third portion of curd is added, and upon each mold powder is sprinkled lightly. The last fourth of the curd needed to fill the hoop is placed over the third layer of mold so that the

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**Fig. 7.** When fully drained the curd is a lumpy, open, porous mass from which little whey escapes.
hoop is filled with alternate layers of curd and mold powder. In the cheese made in this laboratory .06 to .07 percent of mold powder gave excellent results. Marre⁸ states that .01 percent of mold powder is advisable, while Matheson⁹ reports little advantage in using 2 grams as compared with .2 gram per cheese. Unless suitable laboratory facilities are available it will probably be more satisfactory to obtain the mold powder from a reliable laboratory than to attempt to prepare it in the dairy plant.

The curd is not packed in the hoop nor is any follower nor weight used. If the correct physical condition of the curd is obtained and the temperature is favorable, the surface of the cheese will close up reasonably well, but the cheese will remain rather open through the interior. The closing of the surface is desirable as it gives a smoother, cleaner appearance to the finished cheese and reduces losses during curing, but the open interior is necessary for proper mold growth. If difficulty is experienced in obtaining a smooth, well closed surface the cheese after draining 20 minutes may be surrounded with a small square of cheesecloth dipped in warm water. This procedure will insure a well closed surface, but this precaution has not generally been necessary in the college laboratory. Curd remaining in the whey still in the vat is now transferred to the cloths. This curd will have firmed somewhat during the draining and filling of the first lot of curd so that drainage of the remainder will require less time. Fat losses in the whey have averaged .25 of 1 percent.

**DRAINING THE CHEESES**

After 20 or 30 minutes in the hoops the cheeses are turned to smooth the upper surfaces and to facilitate drainage. A special draining room has not been used in this work, but the cheeses have been placed on cloths in the drain vat in the making room and their temperature held between 75 and 80° F. Usually there are five turnings of the cheeses at increasing intervals of time during the afternoon. It is important that the temperature be held sufficiently high to facilitate drainage, but not so

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high that the open texture is lost. The high drainage temperature permits the curd to drain sufficiently so that it may be salted within 24 hours after it is made. During the drainage period the weight of curd decreases to 3.02 pounds of cheese per pound of fat, based on the records of approximately 8,000 pounds of cheese. The cheese will show 45 to 46 percent of moisture when it is ready to salt.

**SALTING**

The salting of this type of cheese presents perhaps one of the major problems from the standpoint of producing uniform quality. A combination of brine and dry salting has been used by us to obtain the more than 4 percent of salt desired in the final product. Following drainage the cheeses are held at a
temperature of 75 to 80° F. over night, and are then placed in a wooden salting tank containing a saturated solution of butter salt. The temperature is kept near 55° F. The cheeses are sprinkled lightly with dry salt on the exposed surface and the next day are turned over in the brine and the upper surface again lightly dry salted. At the end of the second day in the brine the cheeses are removed and dry salted rather liberally on all surfaces. This dry salting is repeated in 48 hours. At the end of another 48 hours the cheeses are rinsed off with clear water. The salting operation covers a period of 6 days. During the first two days the cheeses are in brine and the last

Fig. 9. The cheese is first salted in a brine bath for 2 days, then are dry salted for 4 additional days.
four they are dry salted. During the salting period the surface of the cheeses becomes very firm but shows little evidence of surface growth. The hardness of the surface is not due to air drying but to the effect of the salt. Samples of good quality imported blue cheese have been analyzed which showed as high as 5.7 percent salt. Good blue cheese probably will not be obtained if the salt content is insufficient. It is important that a carefully prepared sample shows a salt content somewhat above 4.0 percent upon completion of the salting process. During the salting period the cheese continues to lose weight, producing 2.89 pounds of salted cheese per pound of fat as compared with 3.02 pounds of cheese per pound of fat at the beginning of the salting process. The acidity of the brine will rise with use. It should be kept below .3 of 1 percent acidity by the addition of proper amounts of milk of lime made from clean, unslaked, lump lime.

PUNCHING THE CHEESE

At the end of the salting period excess salt is rinsed from the cheese surfaces and when the surplus moisture has disappeared the cheeses are skewered.

The proper growth of the flavor-producing mold culture requires that a certain amount of air in addition to that present when the curd is placed in the hoops be admitted during the curing process. This additional air is provided by skewering or pricking the cheese in about 50 places with a ¼-inch diameter needle. These openings are evenly distributed over the flat sides of the cheese. Not only will this permit better growth of the mold in the many natural openings in the cheese but as will be noted from fig. 14, page 277, a luxuriant growth is frequently obtained along the line of puncture. If large quantities of cheese are to be made, a special machine should be used for punching in order to economize on labor and produce more uniform results.

CURING

The cheeses are placed on edge on special racks for the curing period, which will approximate 2 months. During this period the temperature of the curing room in which the cheeses are placed is held at 45 to 48° F. and the humidity above 90
Fig. 10. Each cheese is pierced 50 times with an \(\frac{1}{4}\)-inch needle to admit air to facilitate mold growth.

percent of saturation with slight or moderate air circulation. The rooms used at this station for the cheese were insulated with 4 inches of cork and provided with a floor drain and cold water connections. The cooling was effected by means of wall brine coils on one side of the room. High humidity and a slight air movement were produced by a fine water spray located at the top and discharging into a galvanized iron cylinder 6'\(\times\)1'6" open at both top and bottom and extending within a foot of the 8-foot ceiling and ending 1 foot above the floor not far from the drain. This cylinder can be seen in fig. 11, page 271. A fine spray of water passing downward through the cylinder humidified and circulated the air, the excess water passing onto the floor and down the drain. Manual adjustment of a valve on the water line regulated the humidity and to some extent the air circulation. A difference of around 1° F. between the wet and dry bulb thermometer readings was maintained. The correctness of the curing conditions was also to some extent determined by observing the sequence of fermentations on the cheese.
surfaces, the appearance and stickiness being used as evidences of the desired curing room conditions.

During the first 3 or 4 weeks following the pricking of the cheese a blue-gray mold develops in patches over the surface, sometimes almost covering the cheese. Some sticky surface-

Fig. 11. In the curing room the darker cheeses at the bottom are well covered with surface growth while the upper ones are comparatively fresh.
growth is mingled with the mold, but the mold should predomi­
nate. At this stage the surface mold and bacterial growth is
removed by immersion in cold water in a vat for ½ to 1 hour
which will soften the surface sufficiently so that a stiff brush
may be used to render the cheese white before replacing it in
the curing room. During the second period of 3 or 4 weeks
under curing room conditions, the reddish brown sticky sur­
face-growth will almost entirely displace the mold-growth
which predominated during the first month. This reddish
brown layer will probably need to be removed twice during the
curing process. Its development is an evidence of a normal
cheese and, to some extent, of suitable curing conditions. If,
however, it becomes too vigorous the surface of the cheese
softens too deeply, and large losses result. High temperatures
and infrequent removal favor too luxuriant growth. The re­
moval of the surface growth with the brush is responsible for
some loss of weight during curing. The high humidity of the
curing room largely prevents evaporation of moisture from the
cheese so that little loss of weight occurs on this account. The
total loss of weight from the time the cheese was placed in brine
until it was enclosed in foil amounted to 9.67 percent.

PLACING IN FOIL

After 8 or 10 weeks in the curing room the last removal of
surface growth takes place and the white cheeses are inclosed
in pure block tin foil as soon as surface moisture has largely
disappeared. The foil should be pressed upon the surface of
the cheese with the hands so that there will be close contact be­
tween the foil and cheese. The foil should bear the brand and
other information, in which case the sheets of foil will be inter­
leaved with tissue paper. This paper may be used to handle the
cheeses so that the outside surface of the foil may be kept en­
tirely clean. A yield of 2.72 pounds of cured cheese per pound
of fat at the time the cheese was inclosed in foil was obtained
in these experiments.

The cheese should be held at least 1 month in foil at a tem­
perature below 45° F. for short periods, or nearer 32° F. for a
storage period of some months. During this ripening period in
foil more of the characteristic peppery flavor develops and the
Fig. 12. The mold culture is grown on bread which is dried and finely powdered for use in the cheese.

Cheese becomes sweeter, losing certain raw curd characteristics which have not entirely disappeared at the time the cheese is inclosed in foil. The total time from making to selling for a mild cured cheese will be 3 to 4 months.

PACKING FOR SHIPMENT

Absence of a definite rind and the open friable characteristics of the cheese require precautions in handling and shipping to prevent injury. Just before shipment each cheese is wrapped with white parchment paper and tied with a heavy cord around its circumference. Cheeses for express or freight ship-
ment have been packed ½ dozen surrounded with clean excelsior in a special wooden box 7½ inches wide, 10 inches deep and 22½ inches long, inside dimensions. The tops and sides are of ¾-inch and the ends of ¾-inch material. For a single cheese a strong corrugated fiber box just large enough for the cheese has been used for express and parcel post shipments.

YIELD

In these experiments a yield of 2.72 pounds of Iowa Blue Cheese was obtained per pound of fat used. This yield is at the time the cheese is inclosed in foil. After the cheese is in foil the loss in weight will be relatively small, especially if it is held no longer than 1 or 2 months. The above yield would be at the rate of 10.88 pounds of cured cheese per 100 pounds of 4 percent fat milk.

The average composition of 9 cheeses from representative lots made by the method outlined contained 34.5 percent fat, 36.66 percent moisture and 4.79 percent salt. There was 54.5 percent fat in the dry matter.

COST OF MANUFACTURE OF IOWA BLUE CHEESE

The cost of manufacture of a Roquefort-type cheese is substantially greater than for most varieties. Labor, supplies, space, etc., are all relatively more expensive. Matheson 10 gives the estimated cost of manufacture as 46.32 cents per pound of cheese. Of the total cost, the milk cost amounted to 30.47 cents and other costs totaled 15.85 cents. Hall and Phillips11 give the estimated cost of making Roquefort-type cheese from goats’ milk as 40.77 cents, of which 22.2 cents was cost of milk and 18.57 cents the cost of conversion. Kiely12 calculated the cost of manufacturing Iowa Blue Cheese in the laboratories by an audit of the manufacturing and accounting records for the calendar year 1933 and found the conversion cost, exclusive of building costs and interest on investment, to be 13.48 cents. This datum would be the cost of manufacture of a pound of Iowa

Blue Cheese exclusive of the items of building cost, interest on investment and cost of milk. The table on page 276 utilizes whenever possible the data of the study by Kiely and also adjusts certain figures, particularly on labor, to an assumed utilization of 2,000 pounds of milk per day. Utilization of 2,000 pounds of milk per day would fully employ the time of a cheesemaker and a helper. The salary of the cheesemaker is figured at $125.00 and the helper at $60.00 per month. It is considered that cheese will be made 26 days each month. An average weight of 4\(\frac{1}{2}\) pounds per cheese is used in calculating the amount of such items as foil and boxes needed. The boxes will cost 25 cents each and are the half dozen size. The foil is calculated at 68 cents per pound, and as yielding 5,450 square inches per pound when interleaved.

The floor space required would be 1,500 square feet, including both making room and curing room. The making room requires 600 square feet and the curing room 900. The curing

Fig. 13. Examination of the mold growth shows it to be suitable for use in the cheese.
room space would be divided between salting, storage and the curing room proper.

The average per square foot construction cost of seven Iowa creameries reported by Giese and Mortensen\textsuperscript{13} is $3.77. This figure was used in estimating the investment in space. Depreciation and repairs were provided for by a 3 percent annual charge. Interest was charged at the rate of 6 percent. Taxes were estimated at 148.34 mills, which was the average millage rate of Iowa towns and cities for 1933, according to the Iowa State Board of Assessment and Review.

\begin{table}[h]
\centering
\begin{tabular}{lrr}
\hline
\textbf{Estimate Manufacturing Cost Per Pound of Cured Cheese When Utilizing 2,000 Pounds of Milk Per Day.} & \textbf{Cost in Cents per Pound of Cured Cheese} \\
\hline
Labor & 3.36 \\
Refrigeration & 3.96 \\
Steam & .12 \\
Water & .04 \\
Power & .02 \\
Supplies &  \\
Salt & .02 \\
Rennet extract & .04 \\
Mold powder & .09 \\
Tin foil & .80 \\
Boxes & .93 \\
Miscellaneous & .10 \\
Depreciation &  \\
Vats, hoops, etc. & .15 \\
Small tinware, drain cloths, etc. & .02 \\
Building, interest, depreciation, taxes, insurance & 1.03 \\
General administrative expense & .70 \\
\hline
Total & 11.38 \\
\hline
\end{tabular}
\end{table}

The cheese made during the period covered by this work has sold readily for 32 cents per pound wholesale, f.o.b. plant. The balance for milk after deducting the cost of manufacture, 11.38 cents per pound, is 20.62 cents per pound of cheese or 56.08 cents per pound of fat. This would permit a return of $2.24 per hundred pounds of 4 percent milk.

\section*{SUMMARY AND CONCLUSIONS}

1. The relatively high price of the imported blue mold cheeses suggests the possibility of profitable manufacture in Iowa.

2. A process (described herein) was formulated and used for the manufacture and curing of Iowa Blue Cheese, a Roquefort-type cheese from cows' milk.

3. The manufacture of 72,499 pounds of milk into Iowa Blue Cheese and the marketing of the product through regular grocer trade channels, largely in Iowa, at a wholesale price of 32 cents per pound indicates a potential market for the product.

4. A yield of 2.72 pounds of cured cheese per pound of fat in the milk was obtained.

5. The total cost of manufacture, exclusive of milk, is estimated to be 11.38 cents per pound of cheese.

6. The present price of 32 cents per pound of cheese would leave a balance of 20.62 cents per pound of cheese available for the milk. This would be 56.08 cents per pound of fat or $2.24 per hundred pounds of 4 percent milk.

7. The favorable reception accorded the Iowa Blue Cheese made during these experiments indicates that it would find a ready market among persons who already enjoy eating a good blue mold cheese and that the market would broaden as more people became familiar with its distinctive flavor.

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