RANCID FLAVOUR IN CHEDDAR CHEESE

BY

E. G. HOOD, PH. D.,

AND

A. H. WHITE, M.S.,

DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE

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INTRODUCTION

For many years Canada has enjoyed an enviable reputation in the world's markets for the production of Cheddar cheese of high quality. In order to maintain this standard and approach nearer the goal of perfection, continued attention must be given to those factors which count for quality so that the cheese industry will remain on a firm and permanent basis. While it is admitted that Canadian cheese occupies a very fortunate position in these days of keen competition, such a situation is not, however, without an element of danger, as over-confidence and self-satisfaction may result in a relaxation of effort on the part of those responsible. To maintain the present standard and to attain further improvement in quality, the necessity for co-operation and team work on the part of the patron, the factory owner and the cheesemaker must be recognized more fully than ever before.

Records of the Federal Grading Staff show each year a small percentage of Cheddar cheese in second and third grade through flavour defects. According to the Regulations of Part 2 of the Dairy Industry Act, descriptions of flavour defects are as follows: not clean, slightly fruity, fruity, very fruity, bitter, turnipy, weedy, sour, rancid and "off." While all of the above flavours are occasionally encountered by the graders, the last few seasons have been outstanding for one particular flavour defect—that of rancidity.

In so far as the grading records show, many factories experience this trouble only to the extent of the occasional "pick out," while in others it has been more or less persistent throughout the season.

Since the causative agents of this defect have never been thoroughly understood by the cheesemaker in terms of remedial measures, studies were made with the object of ascertaining an explanation of rancid flavour in Cheddar cheese.

Owing to the interest on the part of the cheesemaker and the increasing demand for information on the subject, an investigation was commenced in 1926. As material became available and time permitted, work was carried on during 1927, 1928, 1929 and 1930. The investigation embraced a study of the following points:—

1. To determine the cause or causes of rancid flavour.
2. To determine its source.
3. To establish methods of control.

AMOUNT OF CHEESE GRADED AS RANCID AND SLIGHTLY RANCID IN 1930

Figures obtained from the Federal Grading Service show a total of 1,256,175 boxes of cheese graded from the provinces of Ontario and Quebec in 1930, with a total of 12,511 boxes graded as slightly rancid or rancid. The amount of cheese graded in Ontario was 888,955 boxes with a total of 7,532 boxes graded as rancid or slightly rancid, or in other words, 0·85 per cent of all Ontario cheese graded showed the rancid defect. The amount of cheese graded in Quebec was 367,220 boxes with a total of 4,979 boxes graded as rancid or slightly rancid, or in other words, 1·4 per cent of all Quebec cheese graded showed the rancid defect.

While it is not possible to estimate accurately the amount of money lost through this defect, it would obviously amount to many thousands of dollars annually.

ARE RANCID FLAVOURS SEASONAL?

In table I, column 1, will be found the total number of boxes of cheese graded in Ontario and Quebec in 1930 as slightly rancid and rancid; in column 2 will be found the total number of boxes graded; and in column 3 the percentage of boxes graded as slightly rancid and rancid during each week, namely, from May 3 to November 29.

These figures show that the largest percentage of rancid and slightly rancid cheese were graded in the week ending May 17, and the smallest percentage in the week ending November 15. The weeks of May ending the 10th, 24th and 31st also show a higher percentage of the defect, indicating its prevalence during the month of May. While the months of June, July and August show some decline, its appearance during the months of September, October and November is much less marked.

While the figures in table I show that rancid flavours occur throughout the whole season, the percentage of the defect during the month of May was greater than at any other time. Assuming that such cheese was from ten to fourteen days old when graded, the highest percentage of rancid flavour cheese was therefore made during the first week of May, with other high percentages of the defect corresponding to cheese made during the last week of April and the second and third weeks of May. The occurrence of rancid flavour at this season appears to be rather significant in that it is associated with the opening of factories, less frequent delivery of milk, new patrons, and generally poor farmyard conditions.

TABLE I

CHEESE GRADING FOR WEEKS ENDING MAY 3 TO NOV. 29, 1930

Week ending	(1) Total Boxes Graded as Slightly Rancid and Rancid	(2) Total Boxes Graded	(3) Per Cent of Boxes Graded as Slightly Rancid and Rancid
May 3	75	4,755	1·57
" 10	274	10,745	2·55
" 17	743	10,011	7·42
" 24	527	18,769	2·8
" 31	750	31,762	2·36
June 7	707	40,841	1·73
" 14	779	46,168	1·68
" 21	673	58,609	1·14
" 28	803	60,288	1·33
July 5	632	60,079	1·05
" 12	579	67,310	0·86
" 19	672	57,487	1·16
" 26	695	59,991	1·15
Aug. 2	602	56,148	1·07
" 9	520	58,418	0·89
" 16	447	52,843	0·84
" 23	560	54,633	1·02
" 30	408	50,724	0·8
Sept. 6	336	50,247	0·66
" 13	386	46,829	0·82
" 20	187	46,829	0·39
" 27	205	42,017	0·48
Oct. 4	191	36,536	0·52
" 11	112	36,075	0·31
" 18	122	33,976	0·35
" 25	118	31,596	0·37
Nov. 1	83	24,091	0·34
" 8	133	24,852	0·53
" 15	23	18,966	0·12
" 22	90	14,889	0·6
" 29	32	8,170	0·39
Totals	12,464	1,214,654	1·02

WHAT IS RANCID FLAVOUR?

In the Federal grading of Cheddar cheese the terms slightly rancid and rancid are employed to designate certain types of flavour found in Cheddar cheese. While this flavour is readily picked out by the experienced grader, many makers are still unable to detect it. The odour of rancid cheese is most characteristic of and resembles most closely the odour of a chemical compound known as butyric acid. The objectionable flavour associated with rancid cheese is due to the production of this chemical compound through the action of certain types of undesirable bacteria (butyric acid bacteria) on the cheese constituents, and it is highly probable that the main source of butyric acid is from a breaking down of the proteins and fats of the cheese. Cheese at the time of grading may show varying rancid flavour intensities, depending upon the amount of butyric acid developed and the presence or absence of other objectionable flavours. It is not unlikely that some new cheese which are now graded as unclean might on re-grading show traces of rancidity. Where abnormal fermentations develop during ripening a blending of rancid and other undesirable flavours undoubtedly occurs and may result in a masking or a combination of flavours, frequently designated by graders as unclean.

IRREGULAR OCCURRENCE OF RANCID FLAVOUR

One of the most perplexing questions confronting the cheesemaker in connection with rancid flavour is its irregular occurrence. Rancidity occurs at all seasons of the year. In some factories it has been found to be fairly persistent, while in other factories it does not occur to any greater extent than the occasional "pick out." The records of high scoring factories are on rare occasions lowered through one or two vats showing the defect. While the unclean or unsanitary factory is more susceptible to the defect, it has frequently appeared in the "so-called clean or sanitary plants." Investigations have led us to believe, and as pointed out before, that the latter type of factory, while clean to the eye, has been found on a bacteriological survey to show results quite the reverse in some individual cases studied.

Unless one keeps in mind that rancid flavours are due to bacteriological causes it will be difficult for the maker to understand or explain to his own satisfaction the spasmodic occurrence of the defect, because he is under the impression that his milk supply and methods of manufacture vary little from day to day. Experienced cheesemakers know, however, that no two vats of milk behave exactly the same and that each vat of milk manufactured presents its own problem. To the trained bacteriologist and chemist this is readily understood, as the process of cheesemaking and ripening involves intricate chemical, biochemical, and bacteriological phenomena. In view of this, the appearance of the occasional vat of rancid cheese presents no mystery and may be accounted for by factors quite overlooked by the maker who is experiencing this flavour defect.

Keeping in mind the relation of bacteria to rancidity, we have been able to associate the following sources of infection as giving occasional trouble:—

(*a*) Old milk—especially true of Monday's make.
(*b*) Manurial and soil contamination in milk.
(*c*) Rusty cans—especially true of Monday's make.
(*d*) Infected milk from one or more patrons through careless production and handling.
(*e*) Patrons' unsterilized cans.

(*f*) Weigh cans contaminated with road dust.
(*g*) Wooden tanks and unpasteurized whey.
(*h*) Contaminated water supplies—from surface water, especially in wet seasons.
(*i*) Impure starters.

YEAST COUNTS AS AN INDEX OF CONTAMINATION

As it is generally conceded that yeasts are foreign to a good quality milk supply, it therefore follows that they should be absent in the finished cheese. The results of laboratory examination of a number of low grade cheese as given in table II show the presence of a large number of yeasts, which indicates that considerable contamination has taken place either in the milk supply or during the manufacturing process. Although yeasts have not been proven to be directly related to rancid flavour, their presence in large numbers is generally associated with undesirable bacterial contamination and may be used as an index of the sanitary conditions surrounding the production of the milk and the manufacture of the cheese.

TABLE II

YEASTS PER GRAM IN LOW GRADE CHEDDAR CHEESE

Collection No.	Collection Date	Yeasts per gram	Grader's Remarks
1	June 3, 1926	680,000	Not clean, weak.
2	" 3, 1926	478,000	Not clean.
3	" 3, 1926	4,880,000	Slightly rancid.
4	" 3, 1926	140,000	Not clean.
5	" 3, 1926	450,000	Slightly off.
6	" 3, 1926	690,000	Slightly rancid.
7	" 24, 1926	3,080,000	Fruity.
8	Sept. 14, 1926	3,000,000	Fruity.
9	" 14, 1926	380,000	Fruity.
10	" 14, 1926	280,000	Fruity.
11	" 14, 1926	3,240,000	Fruity.
12	" 14, 1926	550,000	Fruity.
13	Sept. 14, 1926	1,240,000	Fruity.
14	" 14, 1926	30,000	Fruity.
15	" 14, 1926	740,000	Fruity.
16	" 14, 1926	50,000	Fruity.
17	" 14, 1926	10,000	Fruity.
18	" 14, 1926	380,000	Fruity.
19	" 14, 1926	340,000	Fruity.
20	" 14, 1926	420,000	Fruity.
21	" 14, 1926	330,000	Fruity.
22	" 14, 1926	60,000	Fruity.
23	" 14, 1926	40,000	Rancid.
24	" 14, 1926	10,000	Rancid.
25	" 14, 1926	80,000	Slightly rancid.
26	" 14, 1926	10,000	Rancid.

As milk contains no yeasts when freshly drawn from the udder, the above figures would indicate that serious contamination was taking place from the milk supply or the factory equipment.

To determine the relationship of the milk supply to the high yeast content of low grade cheese the following tests were conducted.

On July 25, 1926, samples of milk were collected from all patrons at cheese factory (X). At the time these samples were collected this factory was experiencing considerable trouble with rancid flavour. These were analyzed in the laboratory. The results are given in table III.

TABLE III

YEASTS AND MOULDS PER C. C. IN PATRONS' MILK AS DELIVERED AT FACTORY

Patron's No.	Yeasts per c.c.	Moulds per c.c.	Patron's No.	Yeasts per c.c.	Moulds per c.c.
1	2,300	0	18	100	0
2	2,600	100	20	700	100
3	100	100	21	0	0
4	19,000	300	24	1,600	200
5	2,300	100	25	10,300	100
6	9,500	0	26	3,700	200
7	2,100	200	27	900	300
8	100	200	28	4,700	0
9	2,800	0	29	1,200	100
10	400	200	32	0	300
11	2,500	100	33	800	200
13	400	0	34	1,200	0
14	400	0	35	1,700	200
15	200	0	36	4,000	0
16	300	100	37	300	0
17	1,900	300	39	0	100

These figures would indicate that considerable contamination comes to the factory each day through a milk supply of this kind.

DISCUSSION OF FACTORS RESPONSIBLE FOR BACTERIAL CONTAMINATION

(1) EQUIPMENT

Dairy equipment may be a very serious source of contamination of the daily milk supply unless it is kept in good condition and is carefully washed and sterilized each day. Surveys conducted at a number of cheese factories showed that in many cases proper facilities for washing and sterilizing utensils were entirely absent, with the result that the equipment was not thoroughly washed and often no attempt was made to sterilize. Furthermore, in some instances the equipment was rusty and worn out, which made thorough cleaning impossible. Undesirable bacteria and yeasts multiply under such conditions, contaminate the daily milk supply and produce undesirable fermentations. To illustrate conditions found in cheese factories, the following field notes are given. All of these conditions were not necessarily found in one factory but are points that were noted among the factories included in the survey.

(*a*) Absence of sinks for washing small equipment.
(*b*) Absence of brushes for cleaning equipment.
(*c*) Lack of hot water and steam in cleaning equipment.
(*d*) Lack of good washing powder.
(*e*) Milk vats, weigh cans, conductor pipes, whey tanks and pumps improperly washed with no pretense at sterilization.
(*f*) Rakes, cutting knives, forks, pails and other small equipment washed in cold water. In some instances no washing or sterilization of this equipment was practised.
(*g*) Neglect of washing hoops, press cloths and gang presses.
(*h*) Use of dirty and broken followers.
(*i*) Use of cheese cloth instead of brushes for washing equipment.
(*j*) Use of rusty worn out equipment which was impossible to clean bacteriologically.

In many factories the equipment was bright and clean to the general observer, but from the bacteriological standpoint it was improperly cleaned. During the investigation experiments were conducted in cheese factories to determine the extent of contamination of the milk that may take place from the equipment. The results of a bacteriological survey of one factory as given in table IV will serve to illustrate.

TABLE IV

Bacteria, Yeast and Mould Counts of Factory Equipment

Equipment	Washed with	Bacteria per c.c. in wash water	Yeasts per c.c. in wash water	Moulds per c.c. in wash water
Weigh can	2 quarts sterile water	1,050,000	600	600
1st vat	10 " " "	1,060,000	22,000	900
2nd vat	10 " " "	1,560,000	16,000	0
Conductor pipes	2 " " "	33,000,000	1,400	500
Curd mill	1 " " "	660,000	6,500	100

General conditions in this factory appeared to be very satisfactory. The equipment looked to be bright, clean and well kept, but the above figures show that it had not been properly sterilized, and under such conditions equipment is a daily source of contamination to the fresh milk supplies, which is quite likely to set up undesirable fermentations in the cheese during manufacture or ripening.

(2) Impure Starters

One of the most important factors in determining the quality of the cheese is the starter which is used to hasten and control the acid fermentation of the milk, and it is, therefore, of the greatest importance that uniform starters of known high quality be used. It has recently been said by authorities that the starters as made and used in some of our cheese factories do more harm than good. This condition should not exist; but bacteriological analysis of starters from many factories shows that serious contamination by undesirable organisms was found in many cases.

Analyses of starters from twenty factories during the summer of 1927 showed that nearly all were more or less contaminated with yeasts and moulds and that nearly half of them either contained bacteria which produced undesirable fermentations or were not very active and gave slow coagulations.

During the summer of the next year a survey was made of the starters in use at one hundred and two factories. The results of the bacteriological analysis showed that only fourteen of these starters were entirely free of yeasts and moulds and many of them contained large numbers of these organisms. The following table gives a few results which indicates the serious contamination that existed in some of the starters analyzed:—

TABLE V

Yeast and Mould Counts of Starters

Collection No.	Date	Yeasts per c.c.	Moulds per c.c.
1	May 12	3,200	8,400
2	" 12	98,400	500
16	" 31	600	14,500
18	" 31	17,800	216
26	June 7	0	15,900
29	" 7	69,500	10,000
41	" 9	9,700	1
50	" 14	38,400	50,400
52	" 14	5,200	70,400
57	" 14	0	133,000
67	" 16	200,000	200
73	" 21	over 500,000	400
83	" 28	40,800	5
86	" 28	over 100,000	0
89	" 28	18,100	10,500
94	July 14	28,000	102,000
95	" 14	10,400	5,500

When starters are contaminated with such large numbers of yeasts and moulds, many undesirable bacteria are also present; and such contamination indicates either careless methods or a lack of knowledge of the fundamental principles involved in the propagation and handling of starters.

When one considers that conditions of temperature, food supply, moisture, etc., during the cheesemaking processes are extremely favourable to the growth and multiplication of these undesirable organisms, it is not difficult to understand how the use of such heavily contaminated starters may produce serious flavour defects in the cheese.

(3) Unpasteurized Whey

Improperly pasteurized or unpasteurized whey is undoubtedly a serious source of contamination to the milk supply when returned to the farms in the regular milk cans of the patrons. There is ample evidence to show that on the average farm the milk cans are not sterilized, and under such circumstances considerable bacteria, yeasts and moulds, which gain entrance to the cans by means of unpasteurized whey, find favourable conditions for growth and multiplication.

Bacteriological analysis of samples of whey from the tanks indicates that in many factories the whey is not properly pasteurized although the Acts relating to dairying for the province of Ontario state that all whey shall be heated to 155° F. for thirty minutes. At one factory actual tests showed that the whey entered the tank at a temperature of 117° F., heating took place for one hour and ten minutes and the highest temperature reached in the whey was 134° F. Samples of the whey were collected next morning as it was going into the patrons' cans and on analysis showed a yeast count of 6000 per c.c.

While these figures apply to only one factory, it is known that the present method of pasteurizing whey is very inefficient.

Shutt, of the Ontario Agricultural College, also found serious yeast and mould contamination of the whey after pasteurization at a factory having trouble with rancid cheese, and pointed out that the outlet pipe and hose were in a very unclean condition, which corroborates our investigations at other factories.

Where such conditions exist, the return of the unpasteurized whey in the patrons' cans is probably the main source of the large numbers of yeasts found in the milk supply as shown previously in table III.

(4) Poor Quality Milk

The maker must depend upon a number of patrons for his milk supply. Some of the latter, because of carelessness in production and handling, are constantly bringing in milk that is unfit for cheesemaking and this, when mixed with the other milk, lowers the value of the entire day's supply. Using the Methylene Blue test to study the quality of the patrons' milk at a number of troubled factories disclosed that a considerable quantity of low grade milk was taken in at these factories. To illustrate this point, the results of the Methylene Blue test of the patrons' milk at three cheese factories showed that 53 per cent of the supply in one case, 62 per cent in another, and 70 per cent in the third, would fall into a very low grade.

Evidence is also at hand to show that milk of this quality may contain rancid producing bacteria in large numbers as considerable contamination from manure, feed, soil and dust takes place during production, and a milk supply can be readily seeded from these sources before it is received at the cheese factory. While it is hard to believe that such serious contamination is of common occurrence, it however does happen under cases of gross neglect and it is also possible that these organisms find their way into the milk through indirect channels as well.

(5) Water Supply

It is obvious that the water used for cheesemaking purposes and especially for diluting the rennet should be pure. It should also be free from excessive organic and mineral matter and especially from undesirable bacteria. Water from shallow wells, ponds, creeks, lakes, and similar sources is often unsafe on account of the danger of contamination with organic and bacteriological impurities which may prove detrimental to the quality of the cheese. Such water should be boiled and cooled, especially for diluting the rennet. Water from running springs and from deep wells is generally free from excessive organic and bacterial pollution. In some instances such water, however, may contain an excess of compounds of iron and sulphur, which if used in setting the vat may jeopardize its flavour; such water is unsuitable for use in the cheese factory.

During 1926 a survey was made of cheese factory water supplies in the counties of Carleton, Dundas, Grenville, Hastings, Lanark, Leeds, Oxford, and Prince Edward to determine their quality. While water samples were collected at only one hundred and eight factories, this was considered as a fair index of the water supply in cheese factories of these counties. Using the Standards of the American Public Health Association, which are the official methods for water analysis in Canada, many of the waters examined showed the presence of B. coli, or in other words, showed the presence of sewage contamination; and such water would be considered unfit for drinking purposes by medical health officials. While it has been impossible during this investigation to connect contaminated water supplies directly to outbreaks of rancid flavours, it does seem probable that there is some relationship between certain undesirable cheese flavours and a poor quality water. To eliminate this source of trouble and to safeguard the quality of the cheese only pure water should be used.

(6) General Factory Sanitation

In order that measures of sanitation may be carried out to their fullest degree, certain fundamental requisites must obtain in a cheese factory. In this connection it is necessary to have a building conveniently arranged, a sound floor, good drainage and sewage disposal, a pure supply of water, modern equipment, steel whey tanks and a cool curing room. Where such conditions are not reasonably fulfilled the maker is seriously handicapped in applying the underlying principles of sanitation, with the result that the elimination of undesirable cheese flavours, such as rancid and not clean, will still remain a problem.

EXPERIMENTAL

The accumulated evidence of bacteriological surveys of cheese factory conditions indicated that many of the flavour troubles experienced, including rancidity, were generally associated with contamination of the milk or cheese by undesirable organisms. These facts suggested that experimental work be undertaken to determine whether or not the rancid flavour could be reproduced by controlled cultures of undesirable bacteria. Considering the above factors, twelve vats of experimental cheese were made.

In the experimental work a supply of milk delivered by the Ottawa Dairy to the Central Experimental Farm Dairy was used. All experimental vats were made from 240 pounds of mixed milk and from this two cheese of approximately 10 pounds each were made. The cheese were made by an experienced cheesemaker, following approved practical methods. As soon as each vat of milk was made up, one cheese from each vat was held at the following temperatures: 50° to 55° F. and 60° to 70° F.

Vat 1. The cheese from vat 1 were manufactured from 240 pounds of mixed milk. To this was added 1·25 per cent of lactic starter and ·375 per cent of a milk culture containing butyric acid bacteria (*Clostridium butyricum*). This culture was prepared by inoculating sterile skim milk with *Clostridium butyricum* and incubating for 48 hours at 25° C. (77° F.).

Vat 2. The cheese from vat 2 were manufactured similarly to vat 1 with the exception of the milk culture used. To this vat was added 1 per cent of a milk culture prepared from rancid cheese. The culture was made by grinding up two 4-inch plugs of cheese in sterile water, transferring to a quart of sterile skim milk and incubating for 48 hours at 25° C. (77° F.).

Vat 3. The cheese from vat 3 were manufactured similarly to vat 2 with the exception that only 0·5 per cent of the rancid cheese culture was used.

Vat 4. The cheese from vat 4 were manufactured similarly to vat 1 with the exception that 0·75 per cent of the milk culture containing butyric acid bacteria was added and the vat was set and drawn with less acid, namely, 0·18.

Vat 5. The cheese from vat 5 were manufactured similarly to vat 4 with the exception that 0·37 per cent of the milk culture containing butyric acid bacteria was added and the vat set and drawn at 0·19.

Vat 6. The cheese from vat 6 were manufactured from 240 pounds of mixed milk with the addition of 1½ per cent of lactic starter, with the addition of iron lactate at the rate of 1 part per 100,000 parts of milk.

Vat 7. The cheese from vat 7 were manufactured from 240 pounds of mixed milk with the addition of 1½ per cent of starter. To this vat was added 0·5 per cent of a milk culture containing butyric acid bacteria and iron lactate at the rate of 1 part per 100,000 parts of milk.

Vat 8. The cheese from vat 8 were manufactured similarly to vat 7 with the exception that 0·5 per cent of a milk culture made from rancid cheese was added in place of the milk culture made from butyric acid bacteria.

Vat 9. The cheese from vat 9 were manufactured from 240 pounds of mixed milk with the addition of 1½ per cent of starter. About 1 pound of corn silage was washed in water; 10 c.c. of this was inoculated into pasteurized milk and about 0.35 per cent of the culture added to the cheese milk.

Vat 10. The cheese from vat 10 were manufactured from 240 pounds of mixed milk. No lactic acid starter was added, but in place, 1¾ per cent of a starter was added, which was made by inoculating pasteurized milk with rancid cheese and incubating for 48 hours at a temperature of 25° C. (77° F.).

Vat 11. This vat contained the usual quantity of milk and starter and in addition contained 0·5 per cent of a milk culture which had been inoculated with a small quantity of soil taken from around the whey tank.

Vat 12. This vat contained the usual quantity of milk and starter. Before setting, 0·5 per cent of a culture made from corn silage by washing about one-half pound of silage in a pint of water was added.

SCORING

The cheese were scored approximately every two weeks after manufacture by Mr. Burgess and Mr. Hicks of the Federal Grading Staff.

The following table VI shows the vats which developed rancidity, together with the age of the cheese when rancidity was first detected.

TABLE VI

GRADER'S REMARKS ON EXPERIMENTAL CHEESE

Vat. No.	Age in days	Held at 60° to 70° F.	Vat No.	Age in days	Held at 60° to 70° F.
1	75	Flavour 38·5.	7	31	Slight rancid.
2	75	Slight rancid.	8	19	Rancid.
3	60	Rancid.	9	39	Rancid.
4	15	Fruity.	10	17	Slight rancid.
5	75	Rancio.	11	11	Very rancid.
6	75	Not clean.	12	15	Slight rancid.

Of the twelve vats manufactured, eleven contained cultures made from materials known to contain butyric acid bacteria and nine of these developed typical rancid flavours. At the end of the inspection period vat 1 was not a good flavour but did not show rancidity while vat 4 developed a fruity flavour in 15 days and remained as such throughout the inspection. Vat 6 which contained chemicals was graded as unclean at the end of the inspection period. As 83 per cent of the vats which contained butyric acid bacteria developed rancidity, it was evident that the cause of rancid flavours in the experimental vats was due to the presence of butyric acid bacteria which were added to the milk.

The results of the above experimental work are in agreement with data accumulated from a study of factory conditions, and it is quite evident that the cause of rancid flavour in Cheddar cheese may in a large measure be attributed to the action of undesirable bacteria (butyric acid bacteria) which find their way into the milk subsequent to or during the manufacturing process.

The manufacturing records of the experimental vats are given in table VII.

TABLE VII

RECORDS OF MANUFACTURE OF EXPERIMENTAL CHEESE

Vat No.	1	2	3	4	5	6	7	8	9	10	11	12
Date	4/11	4/1	4/2	4/8	4/10	4/4	4/9	4/3	4/22	4/23	4/24	4/25
Pounds milk	240	240	240	240	240	240	240	240	240	240	240	24 0
Per cent starter	1½	1½	1½	1½	1½	1½	1½	1½	1½	1¾	1¾	1½
Acidity of starter	·85	·88	·90	·85	·87	·86	·80	·90	·70	·80	·90	·85
Time set—A.M	9·02	9·50	9·40	9·08	9·12	9·00	8·58	9·07	9·08	9·33	9·15	9·22
Acid at setting	·19	·19	·195	·185	·19	·19	·19	·19	·19	·19	·19	·19
Ounces colour per 1,000 lbs. milk	1¾	1¾	1¾	1¾	1¾	1¾	1¾	1¾	1¾	1¾	1¾	1¾
Ounces rennet per 1,000 lbs. milk	3	3½	3	3	3	3	3	3	3	3	3	3
Temperature set—Fahr.	87	86	86	87	87	85	86	86	86	87	88	86
Time of 1st coag. in minutes	8½	7½	6½	8	8	9	8½	8	7	8	8	7
Time cut—A.M	9·23	10·09	9·56	8·24	9·32	9·25	9·19	9·27	9·28	9·53	9·35	9·38
Time setting to cutting in minutes	21	19	16	16	20	25	21	20	20	20	20	16
Acidity at cutting	·125	·12	·125	·125	·125	·13	·125	·13	·13	·13	·135	·13
Temperature cooked—Fahr	99	98	99	99	99	99	99	99	100	100	102	99
Whey started—A.M. and P.M	11·40	1·42	12·15	11·55	11·50	12·30	11·40	12·15	12·25	12·05	11·33	11·45
Acid when started	·185	·21	·20	·18	·19	·20	·18	·20	·19	·19	·195	·195
Acid when stirred out	·22	·27	·27	·22	·24	·24	·25	·27	·22	·23	·23	·26
Time piled—A.M. and P.M	11·45	1·45	12·25	12·05	12·00	12·35	11·45	12·25	12·35	12·15	11·35	11·50
Acidity when piled	·22	·27	·27	·22	·24	·24	·25	·27	·22	·23	·23	·26
Time milled—P.M	1·50	3·30	2·20	2·15	2·30	2·40	2·00	2·15	2·15	2·40	2·15	1·45
Acidity at milling	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Time salted—P.M	3·00	4·40	3·25	3·15	3·30	3·40	3·00	3·25	3·25	3·05	4·05	3·00
Pounds salt per 1,000 lbs. milk	2½	2½	2½	2½	2½	2	2½	2½	2½	2½	2½	2½
Temperature of curd after salting	86	80	82	82	82	82	82	82	82	84	82	84
Bandage placed directly in hoops	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time put to press—P.M.	3·20	4·50	3·25	3·35	3·45	3·50	3·10	3·40	3·40	3·15	4·30	3·15
Length of time in press—Hours	72	40	40	40	40	40	40	60	23	40	72	72

IMPROVING THE MILK SUPPLY

While considerable stress has been placed upon the condition of the equipment, poor quality milk may be of equal importance in that it may contain types of bacteria capable of producing rancid flavours. In so far as our experimental work has gone, we are unable to say which factor is of greater importance in producing rancidity—poor factory sanitation or poor quality milk. We have never found it where the milk supply was of good quality and the factory equipment was in good condition bacteriologically.

It is not within the scope of this investigation to outline methods for the production of a high quality milk. Attention, however, is drawn to the fact that where rancidity occurs in cheese a fair share of the trouble may be attributed to the milk supply. Where there is any suspicion that the milk supply from any one or more patrons is wrong, the cheesemaker should confirm this by the use of one of the milk quality tests and then point out to the farmer the things he should do in order to deliver milk low in bacteria. The animals should be kept reasonably clean at all times of the year by attention to stables and yards. Especial attention should be given to all milk utensils on the farm. This means washing them carefully, scalding them thoroughly and then allowing them to dry quickly. Milk should be cooled to 60° F. or lower to prevent too rapid growth of bacteria. Milking machines, in particular, need constant attention, or all of the patrons of a factory stand to lose more than the user of the machine gains. It must be remembered that in any cheese factory what any patron does in handling his milk is of equal advantage or disadvantage to all. In other words, the patron delivering poor milk harms every patron of that factory. The conclusion must be drawn that each one ought to be as much interested in how the other patrons produce milk as he is in his own methods. No patron of a cheese factory can live unto himself alone.

While it would be to the advantage of the cheesemaker to know whether or not rancidity is caused by a poor milk supply or by poor factory sanitary conditions, or whether or not one condition favours rancidity more than another, these questions cannot be answered as yet. However, experimental work shows that the trouble begins under such conditions; the maker's job is to control both, and only milk of the highest quality should be received and handled under the most ideal conditions of sanitation. The importance of cleanliness at the point of production cannot be too strongly emphasized, especially in the manufacture of cheese. As already known, many of the common flavour defects in cheese are brought about by the introduction of the wrong kinds of bacteria, previous to and during manufacture. The object should be to keep the milk as free as possible from germs or bacteria during milking and subsequent handling, so that the introduction of the proper types of bacteria by the use of a good starter will have complete control of the fermentation during manufacture and the ripening process.

DETECTING LOW GRADE MILK

In determining the quality of the milk on the weigh stand, the cheesemaker is mainly dependent on his senses of smell and taste. By this means the cheesemaker may detect certain flavours and odours in the milk, but he does not obtain any definite information about the numbers or types of undesirable bacteria which may be present.

There are some methods, however, adaptable to cheese factory practice, by the regular use of which the cheesemaker can grade the milk according to the numbers and types of bacteria. Among these are the Wisconsin Curd Test and the Methylene Blue Reduction Test.[1] By the use of the curd test, the cheese-

[1] Singleton, J. F. and Hood, E. G. The Testing of Milk, Cream, Butter, Cheese and Dairy By-Products. Bulletin No. 138 N.S. Department of Agriculture, Ottawa, Canada.

maker is able to determine the type and flavour of the curd produced from the milk of individual patrons. In this way it is possible to detect the milk containing undesirable types of bacteria which produce abnormal flavours and conditions in the curd.

The Methylene Blue test, on the other hand, does not give information as to the types of bacteria, but is a simple and reliable test for determining numbers of bacteria in milk. By this test the cheesemaker is able to obtain definite information regarding the quality of the milk, as high numbers of bacteria are an indication of poor quality and poor methods of production and handling.

While these tests may not be familiar to all cheesemakers, and require special equipment and attention, they can be successfully applied by the cheesemaker or instructor in locating patrons that produce bacteriologically low grade milk. They, therefore, should be more generally understood and used in cheese factory practice.

CLEANING AND STERILIZING EQUIPMENT

Since the rancid and some other flavour defects are caused by the presence of certain types of bacteria and yeasts, it is evident that if these organisms are to be controlled in the factory, equipment must not only be clean but it must be thoroughly sterilized as well if the entrance and propagation of undesirable bacteria and yeasts are to be avoided during manufacture. And cleanliness in connection with dairy equipment means more than having it clean to the eye. It means sterilization in order that all microscopic organisms, so prevalent in dairy factories, are destroyed.

The same principles apply in washing and sterilizing cheese factory utensils and equipment as in other dairy plants. First, all vats, pails, milk pipes or conveyers, strainers, etc., should be thoroughly rinsed in lukewarm water to remove as much as possible of the milk that is adhering to them. Hot water should never be used for the first rinsing, as it burns the milk solids such as casein and albumin onto the utensils, making cleaning difficult. After rinsing, the equipment should be thoroughly washed with clean hot water containing a good alkali or soda ash washing powder. Soap or a greasy powder should be avoided and the washing should always be done with a good stiff brush to loosen and remove the milk particles from the surface of the utensils. A cloth should never be used for washing milk utensils as it tends to smear the milk particles over the surface instead of loosening them as does a brush. Furthermore, such cloths are almost impossible to keep clean and they often become dirty and foul smelling, and may easily recontaminate equipment on which they are used.

After washing in hot water with washing powder and brush, the equipment should be thoroughly rinsed with clean hot water and then sterilized by means of boiling water or live steam.

These principles of washing equipment may be carried out in the cheese factory quite readily as hot water and live steam are always available and the equipment necessary is not expensive. For washing the smaller utensils such as pails, strainers, cutting knives, stirring rakes, starter cans, stirrers, etc., all cheese factories should be equipped with a suitable wash sink connected with water and steam. The wash sink preferably should have two compartments, one for washing and the other for rinsing, as such an arrangement saves time and labour. The larger equipment, as vats and weigh cans, must be washed, of course, from a pail with a good brush.

In sterilizing equipment it should be kept in mind that heat is the main factor and that boiling water or live steam is only the means of conveying the heat to the utensil. For proper sterilization, a temperature of at least 190° F. should be attained. The best method of sterilizing small equipment is by means of a cabinet connected with live steam. Such a cabinet may be purchased from

dairy supply houses or may be made by lining a strong wooden box with galvanized iron or steel so that it is tight enough to hold some pressure. The steam connection should be at the bottom of the cabinet and there should be several openings in the inlet pipe. The utensils should be placed on a false bottom in an inverted position as the steam rises to the top of the cabinet. After the temperature reaches 200° F. the steam may be shut off and the utensils left in the cabinet for about half an hour. After that time the utensils should be removed to a rack in a clean place in the factory to drain and dry, or they may be left to dry in the cabinet with the door open. Such a sterilizing cabinet is not absolutely necessary, and if it is not installed the small utensils should be sterilized in boiling water and then placed on a rack to dry.

The larger equipment such as vats, whey tanks, and weigh cans offer more difficulties in sterilizing. Steam from a hose is not effective. Boiling water is more satisfactory. The water should be heated by means of a hose connection for both water and steam to as near boiling temperature as possible, and weigh cans and vats thoroughly rinsed until they are too hot to touch with the bare hand. Vats may be effectively sterilized by turning on the steam under the inner lining and allowing the steam to flow until they are too hot to touch. The heat will sterilize the vat and it will soon dry so that there will be no moist or wet surfaces. After vats and weigh cans are dry they should be covered with clean covers to prevent recontamination from dust.

All utensils and equipment should receive this thorough washing and sterilizing every day they are in use, and this includes cheese hoops, followers, press cloths and the press itself. Especial care is necessary with the starter cans, stirring rods and other utensils used in the propagation of the starter. Otherwise the starter may become contaminated with undesirable organisms and yeasts, and if used may set up objectionable fermentations in the cheese. Cloth strainers should also receive special care in washing and should be thoroughly sterilized in boiling water before hanging up to dry.

The operation of cleaning and sterilizing equipment is solely in the control of the cheesemaker and more attention to this important phase of his work would undoubtedly often eliminate many of his flavour troubles and improve the quality of the cheese.

SUMMARY AND CONCLUSIONS

1. During 1930, 0·85 per cent of all cheese graded in Ontario and 1·4 per cent of all cheese graded in Quebec were found to be rancid or slightly rancid.
2. The highest percentage of rancid cheese were graded during the week ending May 17 and the lowest percentage during the week ending November 15.
3. Through the introduction of undesirable bacteria into the cheese milk typical rancid flavours were produced in experimental cheese.
4. Bacteria which produce rancid flavours may find their way into cheese from the following sources: poor quality milk, improperly sterilized equipment, poor starters, unpasteurized whey, bad water, and from lack of suitable factory sanitation.
5. Milk infected with manure, soil, dust, feed, and such materials may contain large numbers of butyric acid or rancid producing bacteria.
6. A study of the milk supplies at a number of troubled factories showed much of the milk received to be of a very low quality bacteriologically.
7. Rancid flavours have never been found in cheese where the quality of the milk was right and good conditions of sanitation prevailed.
8. It has been found from a survey of troubled factories that much of the equipment was not properly sterilized.
9. Laboratory examination showed many of the factory starters to be inactive and highly contaminated with moulds, yeasts and undesirable bacteria.

RECOMMENDATIONS

As pointed out in the present investigation, the main cause of rancidity has been attributed to undesirable bacteria. Such being the case, the tendency for cheese to develop rancid flavour may be effectively minimized by paying stricter attention to the quality of the milk supply, by rejecting low grade milk, and by a general improvement in the supply based on the use of the Curd test and the Methylene Blue test. Troubled factories should pay greater attention to detail in cleanliness and sterilization in all factory operations. Greater care should be exercised in the preparation and handling of starters, in the pasteurization of whey, in the selection of water used for diluting the rennet, and in general factory sanitation. In the final analysis, the control of rancidity lies in the hands of the cheesemaker, in his ability to keep his supply of milk up to a high standard, and in manufacturing such milk under the most ideal conditions of sanitation.

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PUBLICATIONS ON DAIRYING

The following Publications of the Dairy and Cold Storage Branch, Department of Agriculture, are available on application to the Publications Branch, Department of Agriculture, Ottawa.

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