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COTTAGE CHEESE PROBLEMS IN PRODUCTION AND SANITATION

QUALITY CONTROL IN COTTAGE CHEESE[1]

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Most of the spoilage occurring in cottage cheese is microbial rather than chemical. The organisms involved are usually psychrophiles that cause surface slime, or yeasts and molds. In general psychrophilic organisms are restricted to the genera *Pseudomonas, Alcaligenes, Flavobacterium* and *Achromobacter,* with the first two being the most frequent causes of spoilage. These organisms produce pigmented slime or gelatinous film along with objectionable flavors and odors (5).

Spoilage by molds occurs less frequently but is extremely objectionable. The molds most commonly encountered are *Geotrichum candidum* which produces an off-white or light tan to yellow color,

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species of *Mucor* which are usually gray and quite filamentous, and species of *Penicillium* which are blue-green to gray.

The yeasts most frequently involved in cottage cheese spoilage are species of *Rhodotorula* that cause vivid pink spots and eventually pink slime, and species of *Torulopsis* that produce a yellow slime.

SOURCES OF CONTAMINATION

Water is a much more important source of contamination than many processors and sanitarians realize. Water supplies, both municipal and private, which are examined at regular intervals and declared "safe" by technicians in health department laboratories, actually may be grossly contaminated with psychrophiles. These laboratories frequently limit their tests to the determination of coliforms, the presence of which may be associated with pathogens. Frequently water supplies are coliform free but may contain substantial numbers of psychrophiles commonly associated with food spoilage. Cheese washed with contaminated water will be thoroughly and uniformly contaminated. These organisms are non-fastidious in their nutritive requirements and may be present in large numbers in pipe lines and vats used for storage of water. Several inches of organic sediment have been found in water reservoirs used to supply dairy plants.

Water supplies examined in representative butter and cottage cheese plants in Michigan *(6)* usually contained $<$ 1 coliform per ml but frequently contained several hundred or thousand psychrophiles per ml. Counts on water samples taken at or near the place where the water entered the plant or reservoir were usually much lower than counts on samples taken where the water entered the vat or churn. Sections of hose or pipelines, such as those used to run cold water into vats or churns, are frequently submerged in the whey or buttermilk and spoilage organisms may gain access to plant water systems through these lines. Sanitary pipe which can be removed and sanitized should be used for this purpose.

Equipment is second to water in importance as a source of contamination. Many of the psychrophilic organisms most frequently involved in spoiling dairy products are more or less indigenous to dairy products and are found in and on poorly sanitized equipment.

Contamination from air, dust and condensation can be a significant hazard to keeping quality. These particles are blown about by air currents created by the movement of personnel and mechanical equipment and are deposited on exposed products or equipment. Microbial counts on samples of air, or on nutrient agar plates exposed in processing rooms attest to the significance of this type of contamination.

Additives such as the creaming mixture or chopped vegetables may be an important source of contamination. The latter may be an especially significant source of coliforms.

COOKING TEMPERATURE AND DESTRUCTION OF SPOILAGE ORGANISMS

Careful and uniform agitation is important. In commercial practice cooking temperatures usually range from 120 to 140 F with holding times of 20 to 30 minutes or perhaps longer. Usually we use high cooking temperatures with high acid (low pH) cheese and also with curd formed from milk which has been subjected to high pasteurization temperature. During cooking there is some destruction of organisms, the amount of which is related to temperature and pH. The lethal time-temperature requirements for relatively resistant strains of *Escherichia coli, Pseudomonas fragi, Streptococcus cremoris* and *Streptococcus lactis* were determined by Collins *(4)*. Using hypothetical but logical assumptions of initial populations and numbers to be tolerated in the finished cheese it was shown that a minimum cooking temperature of 130 F and a minimum holding time of 18 min were required to accomplish sufficient destruction of *E. coli* and *P. fragi*. This would also destroy most of the streptococci but these are not particularly important in spoilage of refrigerated products.

Bonner and Harmon *(2)* reported that none of the 12 species of bacteria representing five genera, which had been isolated from spoiled cottage cheese, survived heating at 120 F for 15 min in whey at pH 4.55. These were random strains of organisms, not selected for resistance, and were heated in whey only, in which the thermal resistance is probably less than it would be in a mixture of whey and curd. Chaudhary *et al. (3)* reported that the spoilage organisms *Pseudomonas viscosa, Pseudomonas fluorescens* and *P. fragi* did not survive cooking at 120 F for 30 min. There was a decrease of 90% in the population of these organisms during setting and cutting, which was attributed to sensitivity to the acidity being developed by the starter.

MICROBIAL POPULATIONS IN COTTAGE CHEESE

There is an extreme variation in the microbial populations normally encountered in commercial cottage cheese. Thirty-five samples of cheese obtained from Michigan plants immediately after the cheese was packaged contained from $<$ 1 to 1300 coliforms per g and the psychrophile counts ranged

from 20 to 3,600,000 per g *(7)*. Only five of the samples contained less than 1000 psychrophiles per g and only one contained less than 100 per g. Only seventeen of the samples contained < 10 coliforms per g. The yeast and mold counts varied from < 1 to 17,000 per g and 18 contained < 100 per g. The counts on 48 samples of cheese purchased from retail markets in Michigan were considerably higher, ranging from < 1 to 1,200,000 coliforms per g, 30 to 920,000 yeast and mold per g and 800 to 190,000,000 psychrophiles per g. Four market samples contained < 10 coliforms per g and four contained over 100,000 per g. The above data were obtained in 1954 and 1955. Substantial improvement has probably been made since that time.

In a similar study of cheese quality in Tennessee, Overcast and Skean *(11)* found coliform populations in fresh cheese ranging from < 1 to 715,000 per g, yeast and mold counts of < 1 to 750,000 per g, and psychrophile counts ranging 200 to 546,000,000 per g.

Angevine *(1)* reported that 66 samples of fresh cheese from three different plants had total counts ranging from 3,000 to 7,400,000 per g, coliform counts of < 1 to 14,000 per g and yeast and mold counts of < 1 to 13,000 per g.

The effect of psychrophilic contamination on keeping quality was demonstrated by Zimmerman and Kester *(14)* who found that the surface spoilage defect was consistently produced in 5 to 7 days at 50 F by inoculating the cheese with < 10 causative organisms per g.

PREDICTING SHELF-LIFE

It is important for the manufacturer to be able to anticipate the shelf-life of the products which he merchandises. Various incubation tests are used for this purpose. One of the several different time and temperature combinations recommended for incubating samples of cottage cheese to estimate shelf-life involves holding the cheese at 72 F for 2 or 3 days. This time and temperature combination is relatively useless in ascertaining the presence of psychrophiles. Even though this temperature is in the optimum range for growth of psychrophiles, lactic organisms, particularly streptococci and lactobacilli, usually out-number the spoilage organisms in cottage cheese. At temperatures of 60 F or above the lactics promptly overgrow the psychrophiles and produce sufficient acid to reduce the pH below the level tolerated by the psychrophiles. This type of spoilage is distinctly atypical from that which would occur under normal storage conditions.

The author recommends an incubation temperature of 55 F for 3 to 5 days to detect cheese with a predisposition to spoilage by psychrophiles. In cheese with a normal pH of 5.1 to 5.3 the psychrophiles will over-grow the lactics at the above temperature if the psychrophile contamination is sufficient to be a major factor in spoilage.

Reduction tests commonly used on raw milk supplies have been used to assess the quality of various other food products. A modified reduction test has been developed to predict the shelf-life of cottage cheese *(8)*. This test has some of the limitations common to all reduction tests, however, a statistical analysis of the data resulting from the examination of 101 commercial samples of cheese show the method is useful, particularly for identifying cheese with short shelf-life. Some of the problems related to developing the test were: (*a*) the psychrophiles have long generation times, (*b*) they are relatively weak in their ability to reduce dyes, (*c*) they are sensitive to low pH and (*d*) in a dairy product they are usually over-grown by streptococci or lactobacilli. To over-come these limitations and enhance the accuracy of the reduction test, bile salts no. 3 (Difco) were added to inhibit the Gram positive lactic organisms, trypticase soy broth was added to the diluted cheese to stimulate the growth of the psychrophiles, the cheese samples were neutralized to a pH of 6.5 ± 0.5 and incubated at 75 F. Nineteen of 20 samples of cheese which produced an organoleptically detectable defect within 48 hours when stored at 50 F reduced resazurin to pink in 7.75 hrs or less. All samples requiring more than 23 hours to reduce resazurin retained satisfactory quality for 6 or more days when stored at 50 F.

IMPORTANCE OF pH IN CONTROLLING PSYCHROPHILES

Data from a study of the relationship between pH and growth rate of several psychrophiles identified with spoilage of cottage cheese show that the growth rate is usually much less at a pH of 5.2 or lower than at a pH of 5.4 and above *(2)*. The consumer wants a bland cheese therefore we should exploit methods of reducing the pH of the cheese without incorporating the sour flavor which accompanies high acid cheese. This can be done by making cheese with as much acid as is consistent with consumer acceptance, acidifying wash water, and addition of culture to the creaming mixture if the manufacturer can be certain the creamed cheese will be effectively refrigerated until consumed. Some manufacturers have added acids such as lactic, citric or phosphoric to the creaming mixture but this must be done carefully after the cream is refrigerated to avoid curdling.

The pH of municipal and private water supplies

usually ranges from 7.5 to 10.0, depending on local conditions and previous treatment. Washing cheese with alkaline water will raise the pH of the curd. The acidification of wash water prior to chlorination at the rate of about 5 ppm is common practice and has the dual advantage of permitting much more effective microbial destruction and reduces the pH of the cheese about 0.1 to 0.2 of a unit. The pH of the water should be reduced to between 5.0 and 6.0 and carefully controlled. If the pH of the water is lower than the iso-electric point of casein (about 4.7) the wash water may cause significant damage to the physical character of the curd. Also, the lower the pH the greater the corrosion caused by the chlorinated water. The wash water system must be so arranged that the chlorine will have some residence time in the water to accomplish microbial destruction. It is futile to chlorinate the water as it enters the cheese vat because the organic matter (cheese) in the vat inactivates the chlorine.

It is important to have adequate refrigeration for the wash water. At the conclusion of a proper cooking procedure there should be a minimum number of organisms present in the cheese. From this point on it is important to minimize contamination and refrigerate the cheese promptly to prevent the growth of any contaminants. Two or perhaps three wash waters may be used. Excessive washing causes a bland or even flat flavor. The first water should be about 45 to 50 F and the second water should be as near 32 F as possible. The cheese can be cooled more quickly and effectively with water than by any other method. Some manufacturers are reducing the temperature of the curd to as low as 40 F with water and certainly the curd should be cooled to 45 or 50 F by this method.

The creaming mixture can also be an effective cooling agent. A common blending ratio is one part of creaming mixture to two parts of curd. Creaming mixtures usually contain 3 or 4% salt and therefore can be cooled to 26 or 27 F prior to adding to the curd. If two parts of curd at 45 F and one part of cream at 27 F are blended, then theoretically the temperature of the creamed cheese would be 39 F, except for the loss of refrigeration due to friction and handling in non-refrigerated equipment. Admittedly this is idealistic, however there are manufacturers following this practice who are putting cheese into the package at 45 F or lower. This together with prompt efficient subsequent refrigeration is extremely important and can make a difference of many days in shelf-life. Spoilage organisms of greatest concern to the cottage cheese industry grow fairly well at 48 to 50 F and very slowly at 40 to 42 F.

MISCELLANEOUS FACTORS INFLUENCING QUALITY OF COTTAGE CHEESE

Mather and Babel *(10)* have reported on a method which involves the inoculation of creaming mixtures with cultures of *Leuconostoc* species for the purpose of inhibiting some common psychrophilic spoilage organisms. The inhibition is due to action other than the presence of propionic and acetic acids resulting from the fermentation of citric acid by these cultures, or the reduced pH resulting from acid development by the lactics.

With the increased incidence of staphylococci in milk supplies and the greater danger of infection of food with staphylococci from human sources, it is appropriate for sanitarians to aid in alerting the cottage cheese industry to the danger of holding "slow vats" until coagulation occurs. When antibiotics, bacteriophage or other inhibitory agents are present in the milk starter organisms may be inhibited but there is a possibility that staphylococci, which are most resistant to the antibiotics and non-susceptible to lactic phages, may produce lethal quantities of toxin in slow vats before acid development and coagulation are accomplished by secondary starter organisms.

Floating curd due to the presence of carbon dioxide is one of the problems in cheese manufacture. Starter cultures with associate organisms capable of producing high quanitites of biacetyl also produce carbon dioxide as a by-product of the fermentation. Careful selection of cultures will minimize this problem. Sandine *et al. (12)* have shown that troublesome cultures produce 3 to 5 times as much gas as those which do not cause floating curd. There is more apt to be gas in cheese made by the long set at 72 F than when made by the short set at 90 F because the gas producing associate organisms do not grow well above 80 F. Over-ripening starter used for cottage cheese manufacture is also an objectionable practice because of excess gas production. *Streptococcus diacetilactis* is particularly noted for biacetyl and CO_2 production and has a higher optimum temperature than the leuconostocs. Starters containing this organism should be avoided in cottage cheese manufacture.

Tsantilis and Kosikowski *(13)* compared the keeping quality of cheese packaged under normal atmosphere, vacuum, nitrogen and carbon dioxide. Carbon dioxide was the most effective in extending keeping quality, followed by nitrogen, vacuum and normal atmosphere.

In recent years numerous claims have been made in behalf of the beneficial and therapeutic effect of "sea water salt." This propaganda has extended to the merchandising of salt for use in the food in-

dustry. It has been shown (9) that sea water salt has no effect in improving the shelf-life or microbiological or organoleptic quality of cheese.

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SPECIAL FEATURE

OUR HERITAGE — 50 YEARS IN RETROSPECT[1]

The Second Decade 1921-31

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Dr. C. K. Johns, former president of the International Association of Milk and Food Sanitarians (1934-35), is a native of London, England and moved to Montreal, Canada in 1910. Dr. Johns has been very closely aligned with milk sanitation throughout his career with the dairy industry.

Following overseas service during World War I, he began working on a farm and later attended the School of Agriculture, Olds, Alberta. He earned his bachelor's degree (B.S.A.) in 1925 from the University of Alberta. As the recipient of the Macdonald Scholarship, he attended Macdonald College in 1925-26. He received his master's degree from McGill. His formal academic education was completed in 1937 when he received his Ph.D. degree from the University of Wisconsin.

At the time Dr. Johns began working on his academic degrees, he was associated with the Grande Prairie Creamery, first as a butter-maker in the summer and later as manager, and with the Edmonton City Dairy. Following his master's work, he was employed as a bacteriologist with the Alberta Dairy Branch in Edmonton until August, 1927. He then began employment with the Division of Bacteriology, Canada Department of Agriculture, Central Experimental Farm, Ottawa.

Dr. Johns has been very active in milk sanitation with special emphasis on chemical sterilization, tests for bacteriological quality, care of milking machines, and is best known for his studies on lye soak solution for milking machine rubber parts, the resazurin triple reading test for milk, and preliminary incubation of samples before testing.

The IAMFS Citation Award was presented Dr. Johns in 1954. Since 1938, he has served as a member of the Committee on Standard Methods for the Examination of Dairy Products, APHA. He is currently chairman of the Subcommittee on Thermaduric Thermophilic and Psychrophilic Bacteria. In 1943, Dr. Johns became a Fellow of American Public Health Association and in 1950, a Fellow of the Agricultural Institute of Canada.

In 1959, when the Dairy Technology Research Unit became autonomous and was renamed Dairy Technology Research Institute, he was appointed director. He now holds the position of head of the Dairy Section, Food Research Institute, Canada Department of Agriculture.

[1]The second of a series of reports covering each of the five decades of the INTERNATIONAL ASSOCIATION OF MILK AND FOOD SANITARIANS, INC.

[2]President of IAMFS, 1935