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LORE A. ROGERS

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D. E. SALMON, D. V. M., Chief of Bureau.

THE

RELATION OF BACTERIA TO THE FLAVORS OF CHEDDAR CHEESE.

BY

LORE A. ROGERS,
Expert in Dairy Bacteriology, Bureau of Animal Industry.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., July 1, 1904.

SIR: I have the honor to transmit herewith a paper on "The relation of bacteria to the flavors of Cheddar cheese," being a report of the investigations made by Mr. Lore A. Rogers, expert in dairy bacteriology in this Bureau. The general plan and scope of this work was determined by the chief of the Dairy Division, and the experimental portion was conducted under the supervision of the chief of the Biochemic Division. I recommend that this paper be published as a bulletin of this Bureau.

Respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE RELATION OF BACTERIA TO THE FLAVORS OF CHEDDAR CHEESE.

By Lore A. Rogers,
Expert in Dairy Bacteriology, Bureau of Animal Industry.

INTRODUCTION.

Although cheese making has been carried on for many centuries, it is only in recent years that satisfactory scientific explanations have been offered for methods in use for ages. The impetus given by the work of Pasteur to biological research in general, and particularly to the study of fermentations, led naturally to investigations into the causes of cheese ripening. The first and most plausible explanation, that this change was brought about by bacteria and other micro-organisms, obtained such wide acceptance that it is still considered the correct one by all except those familiar with the most recent work. As this question came to be more carefully studied it was found that this theory was insufficient, for certain kinds of cheese at least, and that the complex changes taking place in the milk solids between the time the cheese is started in the vat and its sale as a food can be brought about only by a combination of causes. Our knowledge of these causes and the conditions governing them has been greatly advanced in the last few years by the work done in this country at the agricultural experiment stations in Wisconsin and New York (Geneva), and by Freudenreich and Jensen in Switzerland. While this work has gone a long way in clearing up the more obscure points, there is still much to be explained, and any data that will add to our somewhat limited stock of information will hasten the time when cheese making will be conducted entirely on scientific principles rather than by rule of thumb.

In this country we are especially interested at present in the ripening of Cheddar cheese, or, as it is more commonly called, American factory cheese, as this is the only kind made here on an extended scale. This kind of cheese is differentiated by its low water content from the soft cheeses of the Limburger and Brie type. The high water content of the soft cheeses, by making them a favorable medium for the growth of many kinds of organisms, changes the nature and rapidity of the fermentation. The American Cheddar resembles, in its method of manufacture, composition, and fermentations, the English Cheddar and the European Emmenthaler, or Schweizer.

The study of these fermentations is exceedingly complex, involving not only a great variety of biological questions, but also extensive

changes of the most obscure nature in the proteid compounds which make up the great bulk of the cheese curd. The most important of the final products of this digestion is, as we shall see later, a group of compounds known as amides.[a] Some of these have their own peculiar, penetrating odor and taste. Many of them are, as their names indicate, found in decaying organic matter, but certain of the amides which give putrefying material its characteristic odor are not found in cheese. Thus the ripening of cheese, while resembling in many ways, especially in the highly flavored cheese of the Limburger type, the ordinary putrefaction of proteid matter, is distinguished from it by certain of the end products, as well as by the quantities in which the amides and ammonia are formed.

Before going into a discussion of the experimental work it will be well to mention briefly the changes taking place in ripening cheese, and to review our present knowledge of the causes which produce these changes. By the ripening we do not mean simply the development of certain desirable flavors. While these are essential, they are only the final result of a long series of complex changes which must take place before the tough, indigestible curd becomes edible; all of these changes are a part of the ripening and must be understood before we can hope to explain or control the production of flavors. In studying the ripening of cheese we have to do with one group of compounds only. The sugar, while it is rapidly broken up and may under certain circumstances be connected with certain abnormal fermentations, breaks down most rapidly into comparatively simple acids which have little direct influence on the flavor. On the other hand, many of the decomposition products of fat (which is an important constituent of Cheddar cheese) have an especially pungent odor and taste. However, it is well established that the change in the fat is, at most, very slight (Weidmann).[1b] It is in the nitrogenous constituents—the casein, or, more properly, the paracasein—that we find the important changes.

In carrying on the work recorded in this paper the writer has received many valuable suggestions from Mr. Edwin B. Hart, associate chemist at the New York Agricultural Experiment Station. In the manufacture and initial bacteriological examinations of Cheeses IV and V, the bacteriological laboratory and the dairy of the New York Agricultural Experiment Station at Geneva were used. The many courtesies in this connection are acknowledged.

PHYSICAL CHANGES.

The changes in the physical condition of the curd are marked. The cheese as it comes from the press has the spongy consistency of a mass

[a] In this paper, under the term amide, are included all nitrogenous compounds not precipitated by tannic or phosphotungstic acid, except ammonia.

[b] See bibliography at end of bulletin.

of rubber, but may be broken into rough bits. During the ripening it becomes soft and waxy, until in a well-ripened cheese it may be spread with a knife like good butter. A thin rind is formed on the surface by the drying out of the curd and by the growth of molds and other organisms. This is always very thin and has no influence on the texture or flavor beyond a few millimeters from the surface.

CHEMICAL CHANGES.

The chemical changes in the nitrogenous constituents of the cheese are profound and affect very deeply its general appearance, its digestibility, and its flavor and aroma. In the milk nearly all of the nitrogen is in the form of casein floating in the serum as a fine suspension, which is coagulated by rennet, forming paracasein and thus greatly concentrating the proteids by separating from them a large part of the water. It has always been assumed that in the ripening process this substance was broken down directly into simpler bodies soluble in water. In a recent paper embodying the results of careful and exhaustive research, Van Slyke and Hart[3] show that there is formed in the early stages of the manufacture a monolactic acid salt of the paracasein. During the "ripening" of the milk and the heating of the curd after cutting, the milk sugar is split up into lactic acid by the acid-forming bacteria normally present in the milk or introduced as a starter, and the acid thus set free unites with the paracasein forming the unsaturated or mono-acid salt, if the acidity is normal; or a saturated or di-acid salt, if the acidity is abnormally high. This body is insoluble in water but soluble in dilute solutions of sodium chloride. In normal cheese it is present in quantities varying from 40 to 75 per cent of the total nitrogenous constituents. It has not been conclusively proved that the formation of lower compounds is at the expense of this body, but its gradual decrease and the proportional increase of water-soluble substances, during the ripening, point strongly to this assumption. This point is well illustrated in Table I, taken from Van Slyke and Hart's paper.

TABLE I.—*Amounts of salt-soluble and water-soluble products in a cheese at different ages.*

[From Am. Chem. Jour. XXVIII, 1902, p. 417.]

Age of cheese.	Per cent nitrogen of total nitrogen in cheese.	
	Nitrogen in form of compounds soluble in salt solution.	Nitrogen in form of water-soluble compounds.
1 day	58.7	6.78
1 month	42.4	19.30
3 months	33.4	26.02