

effects of electrical currents, and stated that the general tendency of the mechanical forces is to make the self-induction circuit a maximum. This theorem, which, we believe is due to Lord Rayleigh himself, is little known among electrical engineers, but is a most valuable one, as by its means all the various attractions and repulsions of electric currents are reduced to one law. Barlow's wheel was exhibited—the principle of which is used in all electric meters which have a disk rotating on mercury—and its action explained by the attempt of the circuit to assume a state of maximum self-induction. He mentioned also how the method is used in Lorentz's apparatus for determining the unit of electrical resistance in absolute measure, and referred to his own experiments to determine this twenty years ago. Prof. Viriamu Jones' modification of this apparatus has been set up at Bushy House, and it was intended to make further experiments by this method. Lord Rayleigh suggested that it would be useful in measuring the very small resistances which shunt ammeters for reading very high currents. We fail, however, to see how it could be applied for this purpose, as, even if possible, it would be exceedingly difficult to eliminate the resistances of the points of contact. In conclusion the lecturer praised the Kelvin balance, and stated that he was doubtful about the permanency of the magnetism in the Weston instruments.

THE CHEMICAL CHANGES IN THE RIPENING OF CHEESE.*

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CHEESE is that portion of milk coagulated by rennet which has undergone more or less decomposition by the combined action of microbes and ferments.

According to the latest investigations, milk consists of water, fat, milk sugar, casein, lactalbumin, lactoglobulin, and mineral matter, this last composed largely of calcium phosphate. When rennet is added to milk the casein undergoes a change, one portion being precipitated and another remaining dissolved. The name given by Hammarsten to the first is paracasein, to the second whey-protein. This paracasein, with the fat and lactoglobulin which are held in the precipitated mass, together with a small amount of milk sugar, constitute the curd or basis of cheese; in the serum or whey remain the whey-protein, lactalbumin, and some of the milk sugar and salts. Since the curd has practically the same composition, no matter from what animal the milk is derived, or at all events contains the same constituents, the question might easily arise, "How is it possible that from the same basis a number of varieties of cheese can be produced?" It is evident, then, that, during the after-treatment of the curd, some particular flavor-giving microbe is more favored than others, and by its peculiar action, the taste and appearance of the particular cheese is obtained.

The freshly prepared curd is opaque, practically tasteless, insoluble in water, and whitish in appearance; while the ripe cheese is semi-transparent, has usually a strong taste and smell, is partly soluble in water, and yellow in color. The cheese has undergone some fundamental change, and the passage of the fresh curd to the finished cheese is called the ripening process.

A final explanation of the ripening process is still wanting. Two agencies appear to be the chief causes of the ripening, viz., microbes and enzymes. Of these, the microbial action is the most varied, and on it probably depends the peculiar tastes of different cheeses. In cheese ripening, the lactic acid bacilli, the cause of sour milk, play a part, but more important than these are the digestive or peptonizing bacteria, which act on the nitrogenous substances of the milk, like the digestive enzyme pepsin. This class has been investigated thoroughly by Duclaux, who isolated them from Cantal cheese, and gave them the general name of tyrothrix. According to him these were the most active agents in breaking up the paracasein. A new phase of the study of the causes of cheese ripening was opened up by the discovery, in 1897, by Babcock and Russell, of an inherent milk ferment, which possesses the property of digesting paracasein without the aid of micro-organisms. This ferment, which they named galactase, shows strong resemblance to the pancreatic enzyme trypsin, as well as to the digestive bacteria usually found in cheese, so that these widely different agents together produce the same result. It has been suggested by Duclaux that a ferment similar to galactase, which he called casease, was present in cheese, but that it was of bacterial origin, being produced by a variety of the tyrothrix group. Babcock and Russell, however, proved that the new ferment was not produced by bacteria, and that, moreover, cheese could be ripened by its action alone, without the aid of micro-organisms. They succeeded in ripening, in chloroform, a cheese previously treated with galactase. That the micro-organisms take no part in the actual ripening process is, of course, absurd; and it must be admitted that, although certain substances exist naturally in milk, which are capable of peptonizing the casein, it is the combined action of microbes, ferments, and light which bring about this change. It may happen that most of the peptonizing action can be brought about by galactase alone, e. g., when the digestive bacteria are not present in large quantities; Freudenreich recently found that ordinary Swiss cheese did not contain many digestive microbes, their growth being retarded by the enormous quantities of lactic acid bacilli present.

Another agent in the ripening process, especially in soft cheeses, is the mold. Johan-Olsen, who has paid particular attention to these, finds that they are capable of ripening cheese alone, and he succeeded in obtaining good qualities of Gorgonzola and Roquefort by inoculating sterilized curd with various pure cultures of molds obtained from these kinds. The molds or fungi need air for their growth and find a favorable medium in the soft cheeses, which are not pressed and are often made flat so as to allow the air to act over a large surface. The quantity of lactic acid in these unpressed cheeses greatly assists the rapid growth

of the molds. The most important function of these fungi is the oxidation of the lactic acid or carbonic acid and water, thus destroying the activity and giving more scope to the digestive bacteria.

It is the micro-organisms, present naturally in, or intentionally introduced into, the curd which determine the numerous varieties of cheeses. Every variety of cheese has its special bacteria and can be prepared by isolating certain dominant bacteria and placing them in the milk before renneting and then allowing to ripen under the conditions peculiar to the variety.

In the ripening the first constituent of the curd attacked is the milk sugar. The lactic acid bacilli begin as soon as the curd is molded, and in a few hours completely transform the sugar into lactic acid, which remains as such during the rest of the time, excepting a portion which is neutralized by the ammonia formed. The amount of acidity at this stage has much influence on the final quality of the cheese.

There is very little change in the nitrogenous matter of the curd until the lactic acid fermentation is over, when by the united action of the agents already mentioned, it splits up into crystalline substances soluble in water. Duclaux was the first to isolate the various substances formed, and he showed that first of all an albumose intermediate between the paracasein and peptones—which he named caseone—was formed; this is next split up into peptones, which are later changed into crystallizable bodies, chiefly amido-acids from which leucine, tyrosine, glutamic acid, diamino-acetic acid, phenylamido-propionic acid have been isolated. The final product of decomposition is ammonia, which is easily detected in ripe cheese. The milk fat does not change perceptibly, but it is supposed that a partial saponification takes place, by which fatty acids, especially butyric, and glycerin are set free. Although glycerin has never been isolated in cheese, still a larger amount of volatile free acids are found in cheese than in milk. These acids must have come chiefly from the butter fat present, though it is possible for butyric acid to be formed by fermentation from lactic acid. One hears occasionally that the total amount of fat is greater in the cheese than in the fresh curd, and the reason generally given is that fat is one of the decomposition products of the albuminoids. But although some fatty acids are formed by the decomposition of paracasein, it is hardly possible for true fats to be formed. It is probable that an error in the analysis gave too high figures, and the ether used in the fat estimation also dissolved some substances other than fat.

Whether the mineral constituents of cheese undergo any radical change during the ripening or not, is not known, and it is evident that their action would be very limited, and only of use during renneting.

The best explanation of the changes which the constituents of cheese undergo during ripening is by comparing the composition of fresh curd with that of ripe cheese. With this object in view a cheese was prepared for me at the Dairy Institute, Worleston, and from this samples were taken from time to time and analyzed at the laboratories of the Agricultural College, Holmes Chapel.

The methods employed in the analysis were those suggested by Stutzer (Zeitschr. Analyt. Chem. 1896, p. 493), as follows: The ash was determined by incinerating 10 grammes of the cheese in a platinum dish over the free flame till constant weight. For the remaining constituents Stutzer recommends grinding up the cheese with pure sand, so that a homogeneous sample can be taken. Moreover, the finely divided state of the cheese allows of its being more easily acted upon by the various reagents. I then mixed intimately 50 grammes of cheese with 200 grammes of washed and ignited sand, and from this portions were taken for the various estimations.

The water was found by heating 15 grammes of the sand mixture in a water oven till constant weight.

The dried residue from the water estimation was then extracted with anhydrous ether in a Soxhlet's apparatus, and the fat dried at 105 deg. C. and weighed.

The lactic acid was determined by macerating 15 grammes with cold water and filtering, and titrating the filtrate with N/10 NaOH.

The total nitrogen was found by Kjeldahl's method, using 10 grammes, the oxidation being carried out with a mixture of 100 parts of conc. sulphuric acid and 20 parts of phosphoric anhydride, together with a little mercury.

For the separation of the nitrogenous decomposition products, several methods have been suggested, none, however, based on purely chemical lines, owing to the lack of knowledge of the albuminoids, and each one merely consists in precipitating them in groups and estimating the total nitrogen in each. There are methods for isolating a few of these compounds, but till they can all be completely separated it is as well to leave them in their respective groups. The general scheme of separation is as follows: The paracasein being insoluble in water, and the albumen rendered insoluble by boiling water, to remove these the cheese is treated first with boiling water and filtered. In the filtrate are the remaining nitrogen compounds, the albumoses, peptones, amido acids, ammonia, etc. Although the albumose and peptones dissolve in water, they are easily rendered insoluble by the addition of various substances, among which tannic acid, phospho-molybdic acid, phospho-tungstic acid, trichloro-acetic acid, have been tried with success. In the precipitate obtained in this way the nitrogen is estimated. The filtrate from this group contains the amido acids and ammonia compounds, and in this the total nitrogen is determined, and the amount found for ammonia deducted from this.

I used a solution of 120 grammes sodium phosphate, 200 grammes sodium tungstate, 100 c. c. dilute sulphuric acid (1 : 3) in one liter of water, being the one recommended by Stutzer and others. The nitrogen existing as albumose and peptones was determined by mixing 20 grammes of the sand mixture with 100 c. c. water, boiling in a porcelain dish for half an hour, and pouring off the supernatant liquid into a 500 c. c. flask, the same process being repeated with the same amount of water till 500 c. c. of liquid was obtained. After cooling, the flask was filled up to the mark, filtered, 200 c. c. of the filtrate taken, and, after adding an equal volume of dilute sulphuric acid, pre-

cipitated with 50 c. c. of the phospho-tungstic acid solution. The liquid was then filtered, the residue well washed with dilute sulphuric acid, and then estimated for nitrogen by Kjeldahl's method.

The amido-nitrogen could of course be estimated in the filtrate from the last experiment, but a safer way is as follows: 20 grammes were mixed with 150 c. c. water and well shaken in a bottle for 15 minutes, then allowed to stand for 15 hours, after which 100 c. c. dilute sulphuric acid were added, then 50 c. c. phospho-tungstic acid solution. The mixture was filtered and washed as before, and in an aliquot part of the filtrate the nitrogen was estimated in the usual way. From the nitrogen found the quantity existing as ammonia was deducted.

The ammonia-nitrogen was determined in 20 grammes of the sand mixture by distilling with barium carbonate (other alkalies, such as magnesia, caustic soda, baryta, cannot be used here, since they decompose the albuminoids present, setting free ammonia), the ammonia being collected in N/10 sulphuric acid.

By subtracting the amount of nitrogen found as ammonia, amides, albumose, and peptones from the total nitrogen, the nitrogen existing as casein and albumen is obtained.

The following tables give the rate of decomposition of the various ingredients, and the various changes during the ripening process of the cheese, beginning with the fresh curd:

TABLE I.

	Date of Analysis.		
	July 10.	August 23.	October 16.
	Per cent.	Per cent.	Per cent.
Water.....	38.07	37.36	36.54
Acid	1.818	1.246	1.116
Fat.....	31.18	32.08	32.06

TABLE II.

Nitrogenous Decomposition Products as Nitrogen.

	Date of Analysis.		
	July 10.	August 23.	October 16.
	Per cent.	Per cent.	Per cent.
Total N.....	4.824	4.916	5.021
Casein and albumin.....	..	2.203	1.850
Albumose and peptones	1.586	1.288
Amides.....	..	1.120	1.848
Ammonia.....	..	0.007	0.025

In conclusion, I wish to express my best thanks to Miss Forster, Lady Principal of the Dairy Institute, Worleston, and Mr. F. H. Billington, one of my students, who helped me considerably in the experimental part of the work.

BESSEMER STEEL PRODUCTION IN THE UNITED STATES.

THE American Iron and Steel Association presents complete statistics, received direct from the manufacturers, of the production of Bessemer steel ingots and castings in the United States in 1901; also of the production of Bessemer steel rails by the producers of Bessemer steel ingots. The ingot statistics include a few thousand tons of Bessemer steel castings.

Ingots.—The total production of Bessemer steel ingots in 1901 was 8,713,302 gross tons, against 6,684,770 tons in 1900, showing an increase in 1901 of 2,028,532 tons, over 30 per cent. The production of 1901 was by far the largest in our history. The following table gives our production of Bessemer steel ingots and steel castings in the last six years, including the production of the Robert-Bessemer and Tropenas works. Of the production last year 6,764 tons were steel castings, against a similar production in 1900 of 6,467 tons. The figures are in long tons:

1896.....	3,919,906	1899.....	7,586,354
1897.....	5,475,315	1900.....	6,684,770
1898.....	6,609,017	1901.....	8,713,302

Below is given by States the production of Bessemer steel ingots in the last four years:

	1898.	1899.	1900.	1901.
Pennsylvania.....	3,402,254	3,968,779	3,488,731	4,293,439
Ohio.....	1,489,115	1,679,237	1,388,124	2,154,846
Illinois.....	1,105,040	1,211,246	1,115,571	1,324,217
Other States.....	612,608	727,092	692,344	940,800
Total.....	6,609,017	7,586,354	6,684,770	8,713,302

There were no Clapp-Griffiths works in operation in 1901 and only two Robert-Bessemer plants were active. Seven Tropenas plants were at work, the same number as in 1900. All the Robert-Bessemer and Tropenas plants were employed in the production of steel castings.

Rails.—The production of all kinds of Bessemer steel rails by the producers of Bessemer steel ingots in 1901 was 2,836,273 gross tons, against a similar production in 1900 of 2,361,921 tons and 2,240,767 tons in 1899. The maximum production of Bessemer steel rails by the producers of Bessemer steel ingots was reached in 1901. The year of next largest production was 1900, which was closely followed by its predecessor, 1899. In 1887, fourteen years ago, 2,044,819 tons were made. This was the fourth year of largest production. The following table shows the production by States of Bessemer steel rails by the producers of Bessemer steel ingots in the last four years. The figures given do not include a small quantity of rails made each year from purchased blooms or from re-rolled steel rails, statistics for both of which products for 1901 are not yet available.

	1898.	1899.	1900.	1901.
Pennsylvania.....	1,052,771	1,224,807	1,195,355	1,406,008
Other States.....	902,656	1,015,960	1,166,666	1,430,265
Total.....	1,955,427	2,240,767	2,361,921	2,836,273

At the request of the manufacturers the Association reported for 1897, for the first time, the production of Bessemer steel rails weighing 45 pounds and less

* Read before Society of Chemical Industry.