

the properties of the casein of milk are affected by heat so as to have a marked influence on the precipitation of casein by acids and on the hydrophylic properties of the casein thus precipitated. Apparently the addition of soluble calcium salts to milk helps to restore the conditions existing in raw milk which govern the normal rennet clot. All the interrelations of calcium and rennet coagulation have obviously not been determined. A study of these relations is at present in progress in this laboratory.

SUMMARY.

It is shown that the partial fixation of the calcium salts of milk by pasteurization or boiling is readily explained simply on the grounds of the effect of heat on colloidal solutions of CaHPO_4 , the calcium phosphate natural to cow's milk.

It is shown further that the effect of heat in retarding the rennet coagulability of milk is not related directly to the loss of colloidal CaHPO_4 because the addition of colloidal CaHPO_4 to dialyzed milk does not restore its coagulation by rennet, while the addition of CaCl_2 or HCl does restore this property.

The phenomenon of rennet coagulation is discussed briefly from the standpoint of the chemical and physico-chemical reactions involved, and also from the standpoint of the possible bearing which the addition of calcium salts to heated milk has on this phenomenon.

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The velocity of development of the demarcation current in the frog's sartorius.

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Urano and Fahr have experimentally established the fact that the potassium ion is almost exclusively the only cation within the muscle cell of the frog's sartorius. Overton has shown that the demarcation current of the frog's sartorius may be inhibited or have its sign reversed by replacing the lymph fluid surrounding the muscle cell by a fluid containing K ions in place of the normally

Na ions. This action is reversible. The author has repeated Overton's experiments and in addition to confirming them found that the relation of K in the muscle cell bathing fluid to the potential developed by injury of the muscle is a quantitative one and also that it is possible to get not only a change of direction for the demarcation current by replacing Na in the cell bathing fluid by sufficient K but also to get a pseudo action current under these circumstances. This pseudo action current only travels a short distance along the muscle, is of slow rate of progression and is accompanied by a small, slow contraction.

From the above experiments it was concluded that a displacement of K ions across a semi-permeable cell boundary was responsible for the demarcation current of muscle. At the moment of cutting or injuring a muscle cell there is opportunity for ion equilibrium at the cut surface, whereas there is ion and thus electric strain at the uncut surface. If this hypothesis is true the velocity with which the demarcation current develops to its maximum intensity is of the order of $1/100,000$ of seconds because of the speed of ions and the distance to be travelled by them. Garten has cut the surface of the frog's sartorius and determined the speed with which the demarcation current rises to its maximum value by means of the capillary electrometer. He believes that his experiments show that more than $1/1,000$ of second is necessary for the demarcation current to develop.

The analysis of Garten's capillary electrometer curves is based on the formula $D(ds/dt) + Ks = Ci$. This formula neglects the mass factor because usually the mass is so small in relation to the friction that it may be neglected.

$$M \frac{d^2s}{dt^2} + D \frac{ds}{dt} + Ks = Ci$$

is the equation which accurately describes the forces acting on the capillary when a potential difference is applied to it.

Curves analyzed according to the first formula do not give an accurate picture of the development of potential difference during the first $1/1,000$ of a second. Therefore we do not believe that Garten has proved that it takes more than $1/1,000$ of a second to fully establish the current of injury of a frog's muscle.

In the year 1913 the author attempted to solve this question in the physiological laboratory of the University of Giessen under Professor Garten.

To establish the current of injury a frog's sartorius muscle was cut by a rifle bullet. This bullet cut a copper wire just before entering the muscle substance. The copper wire was shunted across a string galvanometer through which a constant current was passing. This galvanometer immediately responded with an excursion which was used as time marker. After passing the muscle the bullet cut another copper wire shunted across a second galvanometer. This galvanometer was connected to one electrode at the end of the muscle farthest from the injured portion. The other electrode lay beneath the injured portion of the muscle. It was possible to cut all but a few fibers of the muscle by means of the bullet and keep the muscle firmly attached to the electrodes. The moment the rifle trigger was pulled a kymographion carrying film was shot at the speed of 4,000 mms. per second. The galvanometer excursions were recorded on this. It was possible to get uniform velocity over a large portion of the film. A time marker recorded the time and ordinates were established as well as abscissæ by mechanical devices. After recording a current of injury the two copper wires were replaced and a bullet shot through them as before. In this experiment a constant current equal to the previously measured demarcation current was thrown through the galvanometer at the moment the second copper wire was cut. We thus had a picture of the excursion of the string under the influence of a constant current to compare with our demarcation current. It was possible to measure time with an error of less than $1/10,000$ of a second because of the speed of the film and the uniformity of the velocity of the kymographion. Apparently all the demarcation current excursions of the string reproduced the constant current excursions within the limits of errors of the method. That is the curves covered one another so closely that one could infer that the demarcation current is established with its maximum value within $1/10,000$ of a second after injury. The strongest objection to the ion theory of the demarcation current is therefore removed.