ROLE OF THE CONTRACTILE PROTEINS IN DETERMINING THE RESISTANCE OF MUSCLE TISSUE TO EXTERNAL AGENTS

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During the study of the resistance of organisms to external environmental factors, the question arises of the role of individual tissue structures in determining the resistance of the organism as a whole. If increased resistance to hypoxia is created in rats and mice by means of acclimatization [1], their muscle tissue becomes more resistant to the action of various stimuli (vital staining of tissues by the Nasonov-Aleksandrov method).

Our experiments on animals with different resistance to external agents (fully grown and newborn albino rats) showed [4] that as a result of the action of alcohol, urea, mercuric chloride, a hypotonic sodium chloride solution, and anoxia the sorption of vital dyes by the muscle tissue was increased by comparison with sorption by uninjured control tissue, but this change was not so well marked in newborn as in adult animals. This shows that the resistance of muscle tissue to the action of noxious agents is higher in newborn rats.

The object of the present research was to seek the factors determining these differences in tissue resistance. Because of the suggested association between the resistance of a tissue and the physico-chemical properties of its proteins [1], we investigated the muscle proteins in fully grown and newborn rats.

The greater part of a muscle fiber is composed of the proteins of the actomyosin complex, and these are functionally the most important. In adult and in newborn immature animals, including rats, they differ in certain biochemical indices (interaction between actomyosin and ATP, fractional composition, etc.). Various writers have suggested that the molecules of the muscle proteins of embryos and of immature newborn animals differ in structure from the corresponding proteins of adult animals [5, 6, 7, 10]. To obtain additional information on this matter we studied the viscosity of the proteins of the actomyosin complex in different dilutions. No information of this nature is present in the literature, and the curves of the specific viscosity and characteristic viscosity are of great importance for assessing the structural differences between proteins, which are probably associated with the resistance of the proteins to denaturation. Contractile protein was isolated by the method described by V. V. Oppel' and T. P. Serebrenikova [9].

The curves in Fig. 1 show that the specific viscosity of the protein solutions from newborn rats was much less than in adult rats, the protein content in the sample being the same. In Fig. 2, the straight line intersects the axis of ordinates at a point corresponding to the characteristic viscosity of the protein, reflecting the asymmetry of its molecules, i.e., the ratio between the lengths of the axes of the molecules. The characteristic viscosity of the proteins of the actomyosin complex in the newborn rats was less than in adult rats. This showed that the protein complex which we were studying contained predominantly shorter molecules in newborn rats than in adult rats, i.e., the structure of these proteins differed in adult and newborn rats.

To elucidate the role of proteins in determining the resistance of muscle tissue, it was important to explain the resistance of the muscle proteins themselves to denaturation. This was investigated in the next series of experiments in which the proteins of the actomyosin complex, obtained as described above from the muscles of the same experimental animals, were treated by one of the agents used in the experiments on intact young mice, namely urea. The degree of denaturation of protein was determined by A. D. Braun's method [2], based on the finding that the fixation of the triphenylmethane dyes by protein (as shown by their decolorization) increases with an increase in the degree of denaturation of protein. The investigation was conducted with solutions of actomyosin in a concentration of 1.83 mg/ml. As dye we used an aqueous solution of brilliant green in a concentration of 0.01%.

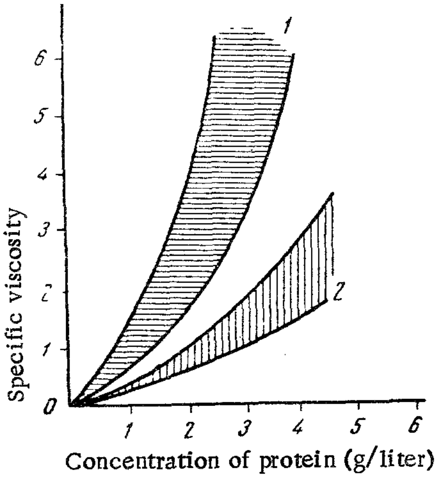

Fig. 1

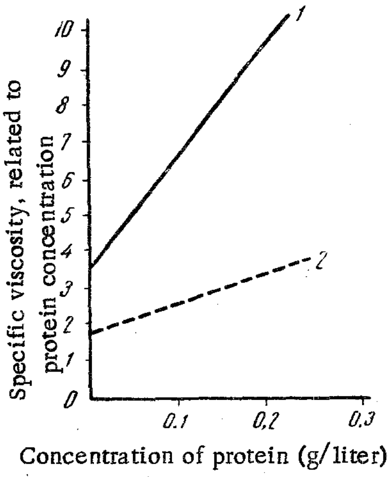

Fig. 2

Fig. 1. Changes in the specific viscosity of the proteins of the actomyosin complex of skeletal muscles in adult (1) and newborn (2) albino rats with different dilutions of protein.

Fig. 2. Characteristic viscosity of proteins of the actomyosin complex of skeletal muscles of adult (1) and newborn (2) rats.

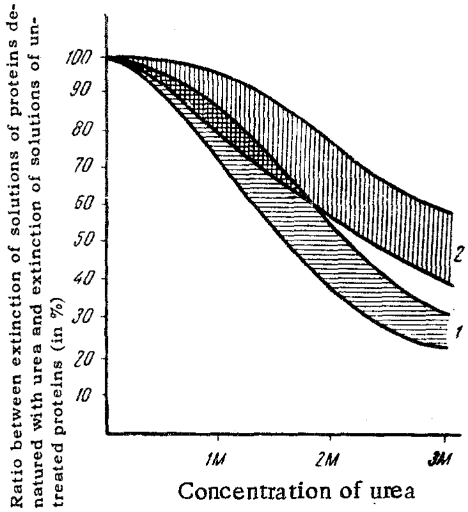

Fig. 3. Decolorization curves of brilliant green by solutions of proteins of the actomyosin complex of skeletal muscles of adult (1) and newborn (2) rats depending on the degree of denaturation of the protein with urea.

It will be clear from Fig. 3 that as the urea concentration rose, so also did the degree of decolorization of the dye, expressed as a percentage of the decolorization of the dye by untreated protein. The degree of decolorization was less with material from newborn rats. This showed that the proteins of the actomyosin complex from newborn rats were more resistant to denaturation.

It can thus be concluded that the higher resistance of the muscle tissue of newborn rats to the action of denaturing agents [4] can be correlated to the greater resistance of its component proteins. Other writers have commented on the parallel between the resistance of muscle tissue and of some of its proteins [3, 8, 11], but their work was carried out mainly on invertebrates and cold-blooded vertebrates, and was concerned only with resistance to heat.

By comparing the higher resistance of the muscle tissue of newborn rats to denaturation with the structural features of its contractile proteins and with their higher resistance to denaturation, we may conclude that the role of the contractile proteins in determining the resistance of the muscle tissue of warm-blooded animals is very considerable. We cannot exclude the possibility that other cell components may play a part in determining this resistance, but the role of the contractile protein here is not in doubt.

SUMMARY

A study was made of some properties of the contractile proteins of muscles in adult and newborn albino rats, which differed both by their body resistance and by the resistance of muscular tissue to the injurious effects. It appeared that the difference in the viscosity of these proteins could indicate the difference in their molecular structures. Resistance of these proteins to the denaturing effect of the urea also differed. These data led to a conclusion on the participation of the contractile proteins in determining the resistance of the muscular tissue to alteration.

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All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of this issue.