THE CONTRIBUTION OF ADDED PROTEINS TO MUCUS VISCOELASTICITY

C. Marriott and D.T. Brown*, Departments of Pharmacy, Brighton Polytechnic, Brighton BN2 4GJ and *University of Nottingham, Nottingham NG7 2RD

The variation in biochemical composition of mucus in both normal and pathological conditions is becoming increasingly well understood (Roussel et al, 1978) and it is apparent that the concentration of serum proteins in the sputum of patients with chronic obstructive lung disease increases during infection (Roberts, 1974). However, little is known about the relationship between the rheological and the biochemical properties of mucus and no systematic study has been carried out to evaluate the rôle of serum proteins as cross-linking agents: it has been reported that the concentration of immunoglobulins in sputum is directly related to the state of infection and that the increase can be correlated with the rheological properties (Puchelle, Zahn & Havez, 1973).

A pure glycoprotein was produced from pooled sputum and it was found that this glycoprotein would produce a homogeneous gel merely upon concentration in an ultrafiltration cell without the addition of a cross-linking agent.

The proteins which were examined were bovine serum albumin (I), calf thymus deoxyribonucleic acid (II) and the immunoglobulins IgG (III) and secretory IgA (IV). The proteins were added to the glycoprotein gels, which had been equilibrated in pH 7.4 phosphate buffer at 25°C, in the form of dry powders in concentrations which varied from 0.05% (II) to 20% (I). Mixing was achieved with the minimum amount of agitation and a two hour period was allowed for interaction.

The rate of transport of the gels on a ciliated epithelium was determined using the excised upper palate of the frog (*Rana esculenta*) which had ceased to produce endogenous mucus. The viscoelastic properties of the same gels were evaluated by means of a variable stress rheometer, with cone and plate geometry, in the creep mode. The viscosities of the protein solutions were determined in the same instrument but in this case in the rotational mode.

A marked thickening effect was produced by all the proteins; the increase in elasticity and viscosity was such that a reduction in the transport rate on the excised palate was noted. Also, the resultant viscosity was greater than the additive viscosity of the glycoprotein and the proteins when measured separately. All the protein solutions produced linear flow curves with the exception of II which was non-Newtonian below 1%w/v and formed viscoelastic gels above this concentration. However, creep compliance analysis gave a residual shear viscosity (η_o) of 470P for 2% II at 25°C and this was considerably lower than in the presence of glycoprotein.

The increase produced by all the proteins was concentration dependent. The increase in η_o varied from 38% III to 322% for II at 2%w/v added protein and the overall rank order of effectiveness was I<III<IV<II which correlates with the molecular mass of the species. A sharp rise in η_o was apparent for II and IV at concentrations of 2 and 4% respectively whereas the two lower molecular weight proteins produced a smooth but non-linear response. The changes in muco-ciliary transport were equally dramatic and the lowest concentration of II resulted in a 65% reduction in transport rate.

It is clear, therefore, that the proteins which are commonly present in sputum do contribute to the viscoelastic nature. The quantity of these proteins in mucus is known to vary considerably and could thus provide the basis for the variation in physical properties of sputum observed during infection.

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