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A COMPARATIVE STUDY OF THE CASEIN MICELLES
OF CAPRINE, OVINE AND BOVINE MILKS

A thesis presented in partial fulfilment
of the requirements for the degree of
Doctor of Philosophy in Physiology at
Massey University.

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ABSTRACT

Several different hypotheses of casein micelle structure have been proposed from the data obtained in the investigations carried out on micelles over the past twenty years. The present comparative study of caprine (goat) and ovine (sheep) casein micelle systems with that of the bovine was made in an attempt to demonstrate the validity of these hypotheses.

The casein contents, mineral levels, and Ca:phosphate ratios in the skim milks varied between species, but no significant differences in the Ca:phosphate ratios in the casein micelles or the sera were found. There were major differences between the electrophoretic patterns of the casein samples from the different species. Both caprine and ovine caseins contained two prominent bands in the β -casein region, while caprine casein also contained a smaller proportion of its casein in more mobile components (α_s -caseins) than the bovine. Three major α_s -caseins were observed in ovine casein, and one major α_s -casein in the majority of the caprine casein samples.

Bovine, caprine and ovine caseins, isolated from the whole milks, were separated into their major components by ion exchange chromatography. The κ -, β -, and α_s -caseins which were isolated accounted for 15%, 35% and 50%, respectively of bovine casein, 10%, 60% and 25%, respectively of caprine casein and 10%, 45% and 35%, respectively of ovine casein. The caprine and ovine caseins were identified as α_s -, β - and κ -type caseins by their chemical and physical characteristics.

The bovine, caprine and ovine κ -caseins were readily hydrolysed by rennin and were able to stabilize the Ca sensitive α_s - or β -caseins. Caprine β_1 - and β_2 -caseins which were present in equimolar amounts, had nearly identical amino acid compositions, and were similar to that of bovine β -casein^{A2}. The β_1 component, however, contained an additional phosphate residue.

The temperature dependent Ca sensitivities and the temperature dependent polymerization of the caprine β -caseins were similar to that of bovine β -casein. However, β_1 -casein

appeared to associate more easily than β_2 -casein, despite its higher net negative charge. Viscosity measurements indicated that the conformation of the two caprine β -caseins was similar to that of bovine β -casein, both at 4°C and at 25°C.

The major caprine α_s -casein was more similar to the minor bovine α_{s3} -casein than to bovine α_{s1} -casein. This was demonstrated by their behaviour on gel electrophoresis with Mg buffers, Ca sensitivities, amino acid compositions and molecular weights.

The two ovine β -caseins were similar to each other, and to the caprine and bovine β -caseins. The relationship between the ovine β -caseins was similar to that of the caprine β -caseins. Two of the three major ovine α_s -caseins were isolated. These were both similar to each other, and to bovine α_{s1} -casein.

The properties of the α_s -caseins from the three species were more variable than those of the β -caseins, which in turn were more variable than the κ -caseins.

The casein micelles from caprine, ovine and bovine milks were all highly solvated and roughly spherical. Although their size distributions varied, the micelles were in each case composed of sub-units about 12 nm in diameter. Gel chromatography of sub-micellar casein aggregates from the three species indicated that they had similar hydrodynamic sizes and appeared to be in equilibrium with their component caseins.

The finding that similar sized sub-units are formed in the casein micelles in the milks of the various species, suggests that the differing proportions of the various component caseins must compensate for the differences observed in the properties of the caseins. It appears likely that not enough emphasis has been given to the role of β -casein in micelle structure, and β - and α_s -caseins may be interchangeable.

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