Kinetics of fat and protein secretion in dairy cattle, sheep, goats and buffaloes

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RIASSUNTO – Cinetiche di secrezione di grasso e di proteine in vacche, pecore, capre e bufali – *I dati derivanti da 3 controlli funzionali (iniziale, intermedio e finale) di vacche Frisone e Pezzate Rosse, di pecore Sarde e Valle del Belice, di capre Sarde e Saanen e di bufale hanno mostrato un buon adattamento al modello* $y=ax^b$ *in cui* y *è la produzione giornaliera di grasso o di proteine (in g),* x *è la produzione giornaliera di latte (in kg) e* a,b *sono dei parametri dei quali solo il primo é stato significativamente influenzato dalla specie e, entro ciascuna specie, dalla razza.*

KEY WORDS: secretion kinetics, fat, protein, dairy ruminants.

INTRODUCTION – The negative correlations of fat and protein concentrations and milk yield, existing in all ruminants dairy species (Oftedal, 1984; Mepham, 1987), reflect a deep mechanism regulating the respective kinetics of secretion of carrier (mainly lactose which is the major responsible for the water drawn to the milk) and of fat and protein. Whereas the correlation coefficients are low (from –0.2 to – 0.4), fat and protein daily yield and milk production are positively and strongly linked (r = 0.8÷0.9). It means that more productive animals have higher fat and protein yield, but their milk has lower concentration of these components.

The aim of this work is to investigate the relationships between milk, fat and protein yield in all main ruminant dairy species by using a simple mathematical model.

MATERIAL AND METHODS – Data analysed consisted of 100 cows (50 Frisona Italiana and 50 Pezzata Rossa Italiana breeds), 117 ewes (67 Sarda and 50 Valle del Belice breeds), 82 goats (44 Sarda and 38 Saanen breeds) and 50 buffaloes cows sampled from official dairy records collected by the Italian Breeders Association within national genetic programs. In order to evaluate the effect of lactation stage on secretion kinetics, from each lactation were considered the first, the intermediate and the last monthly test day (TD) records. TD data of each breed were analysed with the simple model $y = ax^b$ where: y = daily fat or protein yield (in g); x = daily milk yield (in kg); a and b are parameters. First derivative of equation $y' = abx^{(b-1)}$ shows the concentration equation i.e. the pattern with which fat and protein content decreases as milk production increase.

The 39 a and b estimated parameters were checked for normality distribution, then they where analysed by two factors (species S and lactation stage LS) ANOVA. Breed effects was checked excluding buffaloes data and nesting this factor into the species. Last, general regression was obtained for fat and protein pooling the arithmetic means production of all animals.

RESULTS AND CONCLUSIONS – Fat and protein kinetics are in good agreement with the model, but the fitting of the former was lower (average $R^2 = 0.7443$ *vs* 0.8979). The coefficient b was always < 1, as expected: this value justifies the opposite signs of correlation between concentrations or yields of fat and protein and milk production. Interactions was never significant.

Table 1. ANOVA for the parameters of equation $y = ax^b$.

Paramet.	Species (S)				Lactation stage (LS)			SEM	Signific.	
	cattle	sheep	goats	buff.	first	inter	final		S	LS
Fat										
a	57.82	73.35	41.02	100.7	49.06	83.28	72.32	21.84	**	§
b	0.875	0.876	0.934	0.945	0.989	0.811	0.923	0.1500	ns	ns
R^2	0.643	0.757	0.839	0.730	0.710	0.695	0.821	#	#	#
Prot										
a	40.50	58.17	35.90	53.0	41.40	49.29	50.00	6.33	**	§
b	0.946	0.904	0.928	0.947	0.969	0.894	0.929	0.0780	ns	ns
R^2	0.896	0.895	0.935	0.832	0.889	0.868	0.912	#	#	#

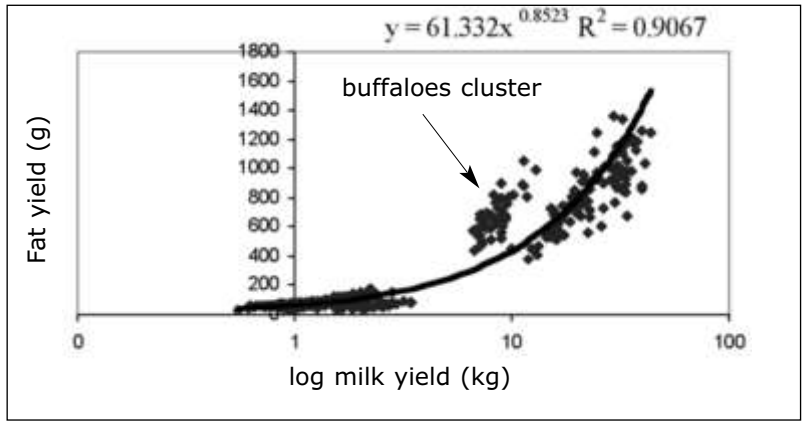
*** P<0.01; § P<0.1; # not performed because of its non-normal distribution.*

In fact, the first derivative, which describe the concentration pattern, shows a negative (and small) exponent of the x, therefore its trend decreases slightly. Kinetics are different among species for a values only; no effect of species and of lactation stages was found for b parameter and interactions between the two factors resulted always non significant (Table 1). This result indicates that the *curvature* of all equations is the same and they differed just for the relative efficiency in fat or protein to carrier secretion rates. Breed nested into species significantly affects a parameters both for fat and protein equations, but a linkage with the production level of each breed was not evident. Figure 1 shows, in log-scale, the uniformity of secretion kinetics among species. Notwithstanding with the difference among a coefficients, probably due to the difference in genetic levels of the different breeds, it seems that the general mechanism regulating the relative rate of synthesis of fat or protein and lactose is the same for all ruminant species, apart from buffaloes that seem to have a different behaviour, especially for fat synthesis.

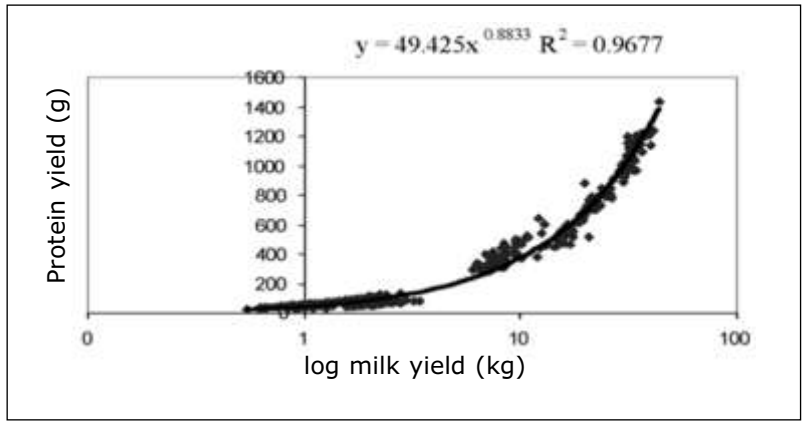
In conclusion, the model proposed seems able to describe the pattern of fat or protein yield compared to the milk production in all ruminant dairy species. Since the parameters a and b compress all the available information, they can be used as first steep for a deeper understanding of the kinetics mechanism relating milk fat and protein production.

Figure 1. Kinetics for fat (a) and protein (b) secretion in relation to milk yield (log kg) for dairy cattle, dairy sheep, goats and buffaloes.

(a)



(b)



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