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Correlation Between Serum Iron and Copper in Different Animals *

For some years now, copper has been related to the iron metabolism and it has been considered that anaemias caused by copper deficiency in the diet were the result of a reduction in the biosynthesis of haemoglobin.

Iron is found in the serum united to a beta-1-globulin, transferrin, in the form of a trivalent iron and its concentration, as well as the total serum binding capacity is known for different animals (13, 14).

Serum copper is found united to two protein fractions according to GUBLER *et al.* (7), identified later on as ceruloplasmin and albumin. Ceruloplasmin is an alpha-2-globulin containing 0.34 % Cu, considered as an oxidase enzyme whilst the albumin would have the job of transporting the copper in the serum.

It has been shown recently (9) how a copper deficiency does not affect the haeme biosynthesis and, nervertheless, it must be essential for the normal metabolism of iron or for the globin synthesis. FRIEDEN (5) suggests that the fundamental role of ceruloplasmin would be to act as ferroxidase in the conversion of Fe^{2+} into Fe^{3+} which is necessary for the transferrin to pick up and tranport the iron, facilitating the saturation of the transferrin and the utilisation of the iron in the synthesis of the haemoglobin and of other ferroproteins, both in man (12) and in amphibians (8). On the other hand, MARSTON and ALLEN (10) show the copper is specifically related to the release of the iron from the storage sites.

The relationship between the copper in blood or in the plasma and the concentration of ceruloplasmin is evident (2, 3). On the other hand, if we accept the bond between this cuproprotein and the serum iron transport proposed by FRIEDEN (5) as a working hypothesis, we have thought it of interest to study, for different animals, the possible correlation between their copper and serum iron contents and between the copper and the total iron binding capacity.

The serum iron and the total iron binding capacity have been determined according to methods described by RAMSAY (15, 16). The total serum copper is determined photocolorimetrically with batocuproin disulphonate according to the pattern laid down by Boehringer Laboratories (Mannheim), but comparing the results with a standard curve.

Five species of mammals and two species of birds have been studied, with a total of 125 and 67 speciments respectively. The hen lot is composed of laying and non laying birds. Table I shows the results obtained, as well as the correlations between the values studied.

The plasma copper content in mammals shows some obviously higher values in swine, as has already been mentioned (1, 3, 7, 11, 17), whilst the remaining values fell between 60 and 130 μg Cu %, which is the common mean value, including the human species, as had already been described (2, 3, 4, 7, 11, 17).

In birds, the copper values are lower

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Table I. *Values of serum Iron (SI), total Iron binding capacity (TIBC), serum copper (CU), and statistical data of its correlations in several mammals and birds.* Values are means ± σ.

Species		SI	TIBC	CU	Correlations		
		µg Fe %	µg Fe %	µg Cu %	SI - CU	TIBC - CU	SI - TIBC
CATTLE (32)	♀	100 ± 44	659 ± 140	54 ± 35	r = 0.88 P < 0.001	r = 0.77 P < 0.001	r = 0.68 P < 0.001
MULE (15)	*	76 ± 32	363 ± 63	87 ± 22	r = 0.61 P < 0.01	r = 0.68 P < 0.01	r = 0.83 P < 0.001
SWINE (15)	*	107 ± 15	817 ± 89	222 ± 25	r = 0.77 P < 0.001	r = 0.42 P < 0.05	r = 0.47 P < 0.001
SHEEP (15)	*	194 ± 64	437 ± 56	89 ± 18	r = 0.66 P < 0.01	r 0.60 P < 0.05	r = 0.55 P < 0.05
RABBIT (33)	♂	199 ± 37	378 ± 58	122 ± 38	r = 0.62 P < 0.001	r = 0.77 P < 0.001	r = 0.57 P < 0.001
(15)	♀	160 ± 45	380 ± 67	97 ± 29	r = 0.65 P < 0.01	r = 0.64 P < 0.01	r = 0.56 P < 0.05
TURKEY (13)	♂	156 ± 39	385 ± 152	37 ± 20	r = 0.67 P < 0.001	r = 0.79 P < 0.01	r = 0.73 P < 0.01
(19)	♀	164 ± 51	281 ± 84	32 ± 18	r = 0.51 P < 0.05	r = 0.58 P < 0.02	r = 0.52 P < 0.05
FOWL (20)	♂	117 ± 40	175 ± 39	21 ± 5	r = 0.72 P < 0.01	r = 0.60 P < 0.01	r = 0.59 P < 0.01
(15)	♀	398 ± 64	405 ± 62	103 ± 23	r = 0.46 P < 0.001	r = 0.64 P < 0.01	r = 0.82 P < 0.001

* Sex non differentiate.

and an increase is appreciated whith age and almost certainly with the laying state, which is also evident in the case of serum iron (14). The low copper concentration in these species agrees with the details given in the literature (1, 3, 17). Here the lack of ceruloplasmin in the turkey and hen (3, 6) is shown, although there is an oxidase activity under the effect of stress agents.

The serum iron concentration and the total iron binding capacity in the species studied are considered to be normal and are close to those obtained in other batches already published (13, 14) or pending publication.

The correlations established (Table I) are shown to be statistically significant in all the species analysed.

Our results show how the relation between the metabolism of the iron and of the copper would be established at the level of their respective contents in the serum, so that their concentrations in this would be bound together. This experimental observation could be considered to be logical consequence of the supposed intervention of ceruloplasmin, as ferroxidase, in the formation the transferrin-iron complex, as FRIDEN (5) suggests and, therefore, in the absorption and transport of the iron by the serum. Likewise, our results

make us think about one of the two possible conclusions suggested by LEE *et al.* (9) who, in a study on copper deficient swine, conclude that the copper is essential for the normal iron metabolism once its intervention in the haeme group biosynthesis has been rejected.

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