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The role of selenium and iodine in controlling some egg minerals

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RIASSUNTO – Il ruolo del selenio e dello iodio nel controllo di alcuni minerali nell'uovo. *Una prova è stata condotta su sette gruppi di galline ovaiole, alimentate con un mangime di controllo (C) o contenente: olio di lino (L), olio di pesce (F), olio ricco di DHA derivante dalla micro-alga Schizochytrium* sp *in presenza o meno (A) di 5 ppm di ioduro di potassio (AI) o di selenito di sodio (ASe) oppure di entrambi i sali (AISe). I contenuti di selenio e di zinco e di altri minerali sono stati valutati nei tuorli delle uova. A fine prova la concentrazione di selenio era aumentata in modo significativo (P<0,001), mentre quella dello zinco si era ridotta (P<0,05) nei tuorli dei gruppi ASe e AISe. I valori di Ca, Mn, Fe, Cu, Cd e Pb, non differirono tra i tuorli dei vari gruppi, a parte il cadmio, la cui concentrazione si era ridotta nel gruppo AISe, attestando una influenza di iodio e selenio sulla deposizione di questo metallo.*

Key words: selenium, iodine, minerals, egg.

INTRODUCTION – Selenium (Se) is recognised as an essential trace element for animal and human health. It acts by improving immunity, decreasing free radicals, and providing protection against some diseases, such as thyroid dysfunctions and cancer. In some regions the presence of Se in the food chain is declining, so various strategies should be undertaken to increase its intake: for example, selenium can be concentrated in eggs by transfer from the diet fed to hens. Inorganic forms, such as selenate and selenite, undergo reductive metabolism, yielding hydrogen selenide, which is incorporated into selenoproteins. Selenomethionine can be incorporated non-specifically into proteins. Efforts should be focused on improving the contents of Se, and also of iodine, in diets, as both elements are known to play essential antioxidant and hormonal roles (Cocchi and Venturi, 2000); however, it is likewise important to know how these elements interact with other minerals in products of animal origin. Se/Zn interaction involves a link between cellular Zn and the redox state. Se, Zn, and Cu are linked together in cytosolic defence against reactive oxygen and nitrogen species. An intriguing role for Se in regulating, or normalizing, the levels of other mineral nutrients at key sites in the body has been suggested by several studies (Lyons *et al.*, 2004). It has also been argued that Zn is necessary for normal thyroid function and there is existing evidence of I interactions with Zn and Fe. In a broad study on the enrichment of eggs with n-3 PUFA using a DHA-rich algal product instead of fish or linseed oil, with or without a supplementation of iodine and/or selenium (Rizzi *et al.*, 2003), we also observed an interaction between Se and some minerals contained in eggs.

MATERIAL AND METHODS – Seven experimental groups of eighteen 18-week-old Warren laying hens (6 replicates of 3 birds each) received a complete isonitrogenous and isoenergetic diets throughout six weeks: C) control (I: 0.8 ppm; Se: 0.4 ppm); L) diet containing 1% linseed oil; A); AI); ASe) and AISe) diets containing

1.67% DHA rich oil from micro-algae *Schizochytrium* sp. (Omega Tech Gmbh) (A) and 5 ppm potassium iodine (I), 2.03 ppm sodium selenite (Se) or both the salts (ISe); F) diet containing 4.95% fish oil. The contents of the Se and Zn were determined in samples of yolk and albumen of all the eggs laid during a three-day period at 0 and 42 days from the start of the treatment. The sample of every cage was pooled (6 samples *per* treatment) and analysed. For the determination of mineral concentration, sample digestion was achieved by using H_2O_2/HNO_3 (1/3) mixture in a microwave-irradiated closed vessel system (Milestone model Ethos). Se was determined by a fluorimetric method following the procedure of Olson *et al.* (1975) with slight modifications as previously described (Borella *et al.*, 1998). We used a fluorescence spectrometer (Perkin-Elmer Mod. 204) equipped with xenon power supply Perkin-Elmer Model 150. At the end of the trial, the Ca, Cu, Fe, Mg, Mn and Zn content in the yolks of eggs of groups C, AISe and ASe was determined by atomic absorption spectrometry with flame air/acetylene (FAAS) (Perkin-Elmer A-analyst 200) and Pb and Cd analyses were carried out by graphite-furnace atomic absorption spectrometry (GF-AAS) (Perkin-Elmer A-analyst 600 equipped with an autosampler AS 800). Analysis of variance (ANOVA) and Bonferroni test for multiple comparisons were used to determine differences among experimental groups. Paired *t* test was used to compare mineral contents before and after the trial.

RESULTS AND CONCLUSIONS – One effect resulting from micro-algae and Se or I supplementation was an increase in egg weight (Rizzi *et al.*, 2003). As would be expected, the polyunsaturated profile of the yolk was significantly influenced by diet. Yolks from hens fed on diets L, A, AI, AISe and F exhibited a reduction in n-6 fatty acid (FA) content in response to dietary n-3 FA (C18:3 n-3 plus C20:5 n-3 and C22:6 n-3). DHA was higher in groups AISe and F. A similar influence of diets containing different concentrations of n-6 and n-3 on egg fatty acids has been observed in other trials as well (Herbert and Van Elswyk, 1996; Meluzzi *et al.*, 2000).

Table 1. Selenium and zinc content of egg yolk (μg/g dry matter; mean values ± S.D.).

	Selenium			Zinc		
Diet	Start	End	Time effect	Start	End	Time effect
C	1.16±0.08	1.08±0.09 Bc	ns	92.37±7.14	90.96±30.62 ABab	ns
L	1.09±0.07	1.19±0.14 Bc	ns	87.83±31.33	93.50±13.66 ABab	ns
A	1.08±0.11	1.12±0.29 Bc	ns	108.70±12.27	99.27±13.77 ABab	ns
AI	1.25±0.22	1.05±0.10 Bc	ns	107.67±24.50	128.43±23.28 Aa	ns
ASe	1.15±0.15	1.60±0.21 Aab	P<0.001	110.53±25.90	73.72±33.04 ABb	P<0.05
AISe	1.23±0.14	1.98±0.16 Aa	P<0.001	95.48±11.54	65.30±15.33 Bb	P<0.05
F	1.20±0.10	1.25±0.39 Bbc.	ns	93.80±5.49	84.20±14.43 ABab	ns

For Selenium: A, B: P< 0.001; a, b, c: P<0.005.
For Zinc: A, B: P< 0.01; a, b: P<0.05.

Table 1 lists the selenium and zinc contents of yolks at the start and end of the trial affected by diet (P<0.0001 and P<0.002 respectively for Se and Zn) and by time in groups ASe and AISe (P<0.001 and P<0.05 respectively for Se and Zn). In groups ASe and AISe, Se supplementation significantly increased Se concentration (P<0.001) and a corresponding reduction in zinc was observed during the trial period. Although the mean values of groups ASe and AISe did not differ significantly, iodine and selenium supplementation appears to have a synergic effect on the deposition of Se in yolk. Zinc concentration was lower in group AISe than in group AI (P<0.01) in eggs laid after 6 weeks of treatment. Albumens showed a lower content of Se than yolks: 0.148±0.024 (mean value ± S.D.). Se deposits itself more effectively in yolk than in albumen - in a ratio of 5-7:1 - as has also been observed by Sheng *et al.* (2002). The concentrations of other elements in yolks were not

significantly affected by diets containing Se or Se and I (table 2), though a tendency toward a reduction in cadmium (P=0.06) was observed in group AISe at the end of the treatment period. Zn and Se have been found to be particularly effective against cadmium toxicity in laboratory models and in White Pekin ducklings; this is possibly due to the changes that occur in cadmium protein binding in blood and tissues when selenium is coinjected with cadmium. It is not known, however, whether similar protection may be derived from an elevated dietary intake of Se in the presence of dietary cadmium. Moreover, a high level of Zn in hens' diets can reduce the detoxifying effect of Se on Cd (Nolan and Brown, 2000). Further studies are needed to determine the exact mechanisms underlying the protective and antioxidant effects and interactions resulting from I, Zn and Se supplementation.

Table 2. Mineral content of yolk egg (dry matter) at the end of the trial (mean values ± S.D.).

Diet	Mn (μg/g)	Ca (μg/g)	Fe (μg/g)	Cu (μg/g)	Cd (ng/g)	Pb (μg/g)
C	1.59±0.11	135.9±22.2	118.2±9.1	3.27±0.29	19.18±12.30	0.25±0.18
ASe	1.57±0.22	122.9±27.2	112.8±7.9	3.44±0.27	15.88±8.67	0.39±0.20
AISe	1.53±0.22	140.0±13.8	118.3±8.1	3.23±0.25	6.53±1.01	0.17±0.10
Diet effect	ns	ns	ns	ns	P=0.06	ns

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