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TOXICITY OF NATURALLY OCCURRING FORMS OF SELENIUM TO DUCKS

Contamination of the environment with selenium can be hazardous to waterfowl. The dietary thresholds of selenium at which toxicity in waterfowl begins to occur have been established in the laboratory. However, laboratory studies will be most useful when the toxicity of the chemical form of selenium used in the laboratory is similar to the toxicity of selenium in natural foods. In laboratory studies, selenomethionine was the most toxic form of selenium to birds and is believed to be a major form of selenium in natural foods. In nature, however, selenomethionine is found almost exclusively in the L form, which is one of the two stereoisomer forms it can take. The other stereoisomer is the D form; it is found in equal amounts with L when selenomethionine is manufactured commercially. Until recently, only the DL mixture of selenomethionine was commercially available for use in laboratory toxicity studies. Also, in natural plant foods, selenium is biologically incorporated, largely as protein-bound seleno-L-methionine; whereas, in laboratory diets, it has been added as purified, crystalline selenomethionine.

TOXICITIES OF THREE FORMS OF SELENIUM WERE COMPARED

In the first study, mallard (*Anas platyrhynchos*) ducklings were fed a control diet or diets supplemented with 15 or 30 ppm selenium as purified seleno-DL-methionine, purified seleno-L-methionine, or selenized yeast, or 15 ppm selenium from high-selenium wheat. The selenium in selenized yeast and high-selenium wheat is present mostly as seleno-L-methionine. Because a source of wheat containing 20 ppm selenium was used to make the 15 ppm selenium diet based on wheat, all of the other diets were made nutritionally the same by formulating them to contain 75% clean wheat. Food consumption, growth, and survival were monitored for

2 weeks. The concentrations of selenium were measured in the livers of 2-week-old ducklings.

In the second study, the basic diet was a standard commercial duck diet, rather than one containing 75% wheat. Ducklings were fed a control diet or diets containing 30 ppm selenium from seleno-L-methionine, seleno-DL-methionine, or selenized yeast. The same measurements were made as in the first study.

In the third study, adult mallards were fed a control diet or diets containing 10 ppm selenium from purified seleno-L-methionine, purified seleno-DL-methionine, or selenized yeast. The basic diet was a commercial duck diet. Reproductive success of the mallards was measured and selenium concentrations in eggs were determined.

SELENO-L-METHIONINE WAS MORE TOXIC TO DUCKLINGS THAN SELENO-DL-METHIONINE ON A 75% WHEAT DIET

In the first study, when all the diets were composed of 75% wheat, survival to 2 weeks of age was lower for ducklings fed 30 ppm selenium as seleno-L-methionine (36%) than for ducklings fed 30 ppm selenium as seleno-DL-methionine (100%). Food consumption and growth were lower in ducklings fed either 15 or 30 ppm selenium as seleno-L-methionine than in ducklings fed seleno-DL-methionine, but not significantly so. The concentration of selenium in liver was similar for ducklings fed either 15 or 30 ppm selenium as seleno-DL-methionine or seleno-L-methionine.

In the second study, with a commercial duck diet, 100% of the ducklings survived to 2 weeks, regardless of whether

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they were controls or ducklings fed 30 ppm selenium as seleno-L-methionine or seleno-DL-methionine. Food consumption and growth were similar for the L and DL forms of selenomethionine. Concentrations of selenium in liver also were similar. The greater toxicity of seleno-L-methionine in the first study may have been related to the palatability or nutrient composition of the wheat-based diet used in that study.

SELENO-L-METHIONINE AND SELENO-DL-METHIONINE PRODUCED SIMILAR EFFECTS ON MALLARD REPRODUCTION

Although hatching success of fertile eggs, survival of ducklings, and the mean number of ducklings produced per female mallard fed 10 ppm selenium as seleno-L-methionine were lower than for females fed seleno-DL-methionine, these differences were not significantly different from each other. Both the L and DL forms of selenomethionine had harmful effects on all measures of reproductive success compared with the controls. The percentages of embryos that were deformed were similar for mallards fed seleno-L-methionine (28.2%) and seleno-DL-methionine (24.6%), and were higher than for controls (1.3%). Concentrations of selenium in eighth eggs were similar for mallards fed seleno-L-methionine (8.9 ppm, wet weight) and seleno-DL-methionine (9.2 ppm).

PURIFIED SELENOMETHIONINE WAS AT LEAST AS HARMFUL AS BIOLOGICALLY INCORPORATED SELENIUM

In study 1, food consumption, growth, survival, and selenium concentrations in liver were similar for ducklings fed 15 ppm selenium from high selenium wheat and ducklings fed 15 ppm selenium as seleno-L-methionine or seleno-DL-methionine. Growth and survival were greater for ducklings fed 30 ppm selenium from selenized yeast than for ducklings fed 30 ppm selenium as seleno-L-methionine, but were similar to results for ducklings fed seleno-DL-methionine. Selenium concentrations in liver were lower for ducklings fed selenized yeast than for ducklings fed the L or DL forms of selenomethionine, both at 15 and 30 ppm selenium in the diet. In study 2, ducklings fed 30 ppm selenium from selenized yeast grew faster and had less selenium in their livers than ducklings fed 30 ppm selenium in the L or DL forms of selenomethionine.

In study 3, hatching success of fertile eggs was worse for mallards fed 10 ppm selenium from selenized yeast (27%) than for controls (41%), but was better than that of mallards fed 10 ppm selenium as seleno-L-methionine (6%) or seleno-DL-methionine (8%). Survival of ducklings and the number of 6-day-old ducklings produced per female also were better in the selenized yeast treatment than in the seleno-L-methionine treatment, and selenium concentrations in the eighth eggs laid by females fed selenized yeast were lower than those laid by females fed the L or DL forms of selenomethionine.

RESULTS FROM LABORATORY TOXICITY TESTS ARE EXTRAPOLATED TO THE WILD

It is premature to say that the selenium in all natural foods would be no more toxic than the purified forms of selenomethionine tested on ducks in the laboratory; however, there is no evidence thus far suggesting that the selenium in natural foods is more toxic than purified selenomethionine. In fact, the selenium in selenized yeast seems to be somewhat less toxic than purified selenomethionine, and the selenium in this yeast has been shown in other studies to be one of the most highly bioavailable forms in any food.

There were some indications that purified seleno-L-methionine may have been more harmful than purified seleno-DL-methionine, but both are extremely toxic to ducks. Because high-selenium wheat and selenized yeast contain selenomethionine in the L form, and neither was more harmful than either purified form of selenomethionine, the difference between seleno-L-methionine and seleno-DL-methionine may not be great.

Although more work is warranted to examine the toxicity of selenium in natural foods of ducks and other birds, the evidence available to date suggests that the results from past laboratory studies, in which seleno-DL-methionine was fed, may be extrapolated to the wild to predict the hazards to waterfowl consuming selenium-contaminated foods.

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