Vicine and Convicine: the Fava and Egg Weight Depressing Factors in Faba beans (Vicia faba L.) - A Review

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Faba beans (Vicia faba L.) are one of the most important pulse crops in the world, being consumed in large quantities in the Middle East, Far East and North Africa, particularly Egypt. Except for the presence of vicine and convicine and relatively low concentrations of several other antinutritional factors, faba beans are an excellent source of protein with amino acid balance complimenting that of cereals (Marquardt, 1983; and Sarwar et al. 1975).

Vicine and convicine were first isolated by Ruhdusen (1881), in Vicia sativa. These compounds were subsequently found in other species of vicia including Vicia faba (Manager et al. 1969). The pyrimidine nucleoside structure of vicine as 2,5-diamino-4,5-dihydroxy pyrimidine, 5-(β-D-gluco-pyranoside) and convicine as 2,4,5-trihydroxy,6-aminopyrimidine, 5-(β-D-glucopyranoside) was established by Bendich and Clement (1953).

In search of the fava causative agent in faba beans, Manager et al. (1969) was aided by the fact that the agent had a capacity for oxidising glutathione (GSH) in glucose - 6-phosphate dehydrogenase (G-6-PD) deficient red blood cells and some were sparingly soluble in water and exhibited in neutral solution a loss of GSH oxidising activity (Lin, 1963; and Manager et al. 1969). The properties of the active fractions appeared similar to some pyrimidine derivatives known to occur in faba beans in the form of aglycones of β-glycosides formed vicine and convicine, the former being present in greater amounts than the latter (Manager et al. 1969; Higazi and Read, 1974). The aglycones, divicine and isouramil can be obtained from the respective glycosides vicine and convicine by mild acid hydrolysis or by enzymatic splitting with β-glycosidase (Manager et al. 1969).

The aglycones are highly unstable in the presence of oxygen and are almost instantaneously destroyed by boiling. The rate of their breakdown is most rapid at alkaline pH and falls with decreasing pH values (Manager et al. 1969). At room temperature the half-life is in the order of 30 to 40 minutes. The breakdown of the pyrimidine aglycones is accelerated by traces of copper (Cu++) and other heavy metals (Manager et al. 1969).

All the characteristic properties of the aglycones are abolished by substitution of the hydroxyl group at C-5, such as that represented by the glycosidic linkage present in vicine and convicine (Manager et al. 1969). These glycosides show none of the reducing properties of their aglycones, are heat stable and their ultraviolet spectra are different from those of their aglycones (Manager et al. 1969).

Incubation of human red blood cells with the aglycones, divicine and isouramil resulted in a rapid fall in their glutathione (GSH) level. Addition of glucose prevented the injurious action on normal erythrocytes but not glucose 6-phosphate dehydrogenase (G-6-PD) deficient ones...
The results with the laying hen give insight to what happens in favism in humans. The susceptibility of erythrocytes to hemolysis, the increased incidence of blood in the yolk, and decreased haematocrit concentration are similar to the haemolytic effects observed following the ingestion of faba beans by G-6-PD-deficient humans. The marked elevated plasma lipids and lipid peroxides together with the depressed amount of yolk which is primarily lipid in composition indicate that these compounds interfere with transport of fat across the yolk membrane.

The above observations together with the protective effects of vitamin E with regard to hatchability and fertility of eggs are consistent with the proposal, that the aglycones of vicine and convicne produce free radicals which not only react with erythrocytes but also other membranes and tissues to cause tissue damage and loss of functional properties.

The relative insensitivity of the young chick to vicine and convicine in contrast to the laying hen (Muduuli, 1982), may be attributed to their ability to re-synthesize reduced glutathione from NADPH in the presence of aglycones of vicine and convicine at a sufficiently rapid rate so as to neutralize their toxic effects (Chevion et al 1982). In the laying hen, there is a high demand for NADPH due to the high rate of fat synthesis (Griminger, 1976), which presumably results in limited availability of NADPH for other biological functions. In the presence of compounds such as vicine and convicine which induce oxidant stress, NADPH becomes limiting and as a result the laying hen is not able to neutralize these effects through the glutathione peroxidase system.

A similar, but more specific condition, occurs in human RBC. The net effect in both species is an increased sensitivity of the erythrocytes to the effects of vicine and convicine. Other tissues and organs, however are also affected in the laying hen which may be attributed to a general shortage of NADPH under stressful conditions as compared to the specific limitations of NADPH in the erythrocytes of G-6-PD deficient human.
References


