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Survey of selenium concentrations in wheat, sorghum and soybean grains, prepared poultry feeds and feed ingredients from Queensland

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Summary

Selenium concentrations in some Queensland grains and poultry feeds were determined from 1974 to 1978. Mean concentrations and ranges (mg kg^{-1}) were: wheat, 0.15 (0.02 to 0.8); sorghum, 0.17 (0.01 to 1.1); soybean, 0.15 (0.03 to 0.67); prepared poultry feeds, 0.22 (0.10 to 0.43). For grains, differences in Se concentrations for a given species from different sites were up to 100 fold. The maximum variation for species and varieties at any site was a factor of five. Low concentrations of Se in some grains appear to be associated with soils derived from Tertiary volcanic parent material.

1. INTRODUCTION

The role of selenium (Se) as both toxicant at higher levels and essential element in trace quantities for animal nutrition is well established (Underwood 1977). In poultry nutrition Se has been implicated in maintenance of hatchability and egg production (Cantor and Scott 1974) as well as in the prevention of exudative diathesis (Schwarz, Bieri, Briggs and Scott 1957). The range from adequate to toxic is about 0.1 to 5 mg kg^{-1} of biologically available Se in the feed (Scott and Thompson 1971; Neathery and Miller 1977). In the USA and Canada Se is added to certain poultry feeds to prevent deficiency disorders.

There is only one published account of a Se responsive condition in poultry in Australia. This occurred in a large broiler flock in Queensland where the diet contained less than 0.05 mg kg^{-1} of the element (Bains, MacKenzie and McKenzie 1975). The literature contains no other data on the Se content of poultry feeds and ingredients for this State. The aim of the present survey was to record concentrations of Se in Queensland grains, prepared poultry feeds and other ingredients.

2. MATERIALS AND METHODS

Sampling programme

Materials were collected and analysed during the period 1974 to 1978. As grain is the major component in poultry diets, wheat, sorghum, soybean and barley from the main grain growing areas of the State were analysed. Most grain samples (85%) were from Departmental varietal trials or State Wheat Board depots. The remainder were from farm sites of interest because of the parent geology of the soil. Regions sampled included the Darling Downs, South Burnett, Central Highlands and the Biloela district. The number of samples from a region represented an approximate weighting for production from the area so that about 60% of the 350 grain samples came from the Darling Downs.

Prepared poultry feeds and ingredients other than grain were collected during the period 1975 to 1978 from commercial feed mills. Only minor ingredients of the diet with potentially high Se content such as meat, fish and their by-products were analysed. Meat and bone meals were drawn from many parts of the State.

Chemical analysis

A fluorometric analysis for Se was used (Haddad and Smythe 1974) with some modifications. Ground samples were predigested in nitric acid overnight before completion of analysis on the following day. The diaminonaphthalene (DAN) solution was prepared fresh daily by heating at 50°C for 30 min and extracting fluorescent impurities into decalin.

Masking with ethylenediaminetetra-acetic acid was satisfactory for all samples analysed. Difficulty with digestion of the soybean samples was overcome by extracting the oil fraction with hexane before digestion. Wauchope (1978) showed that Se in soybean is associated with the oil free meal. Using the above method our results for three test samples were similar to those reported in a collaborative study involving three other interstate laboratories.

The Se analysis figures are reported on an 'as received' basis. The moisture content of 40 grain samples analysed during 1974 to 1976 ranged from 5 to 13.5% (wet weight basis). Compared with the large differences in Se content of grains (up to 100 fold) these moisture differences are insignificant.

3. RESULTS AND DISCUSSION

Grains

Effect of species

The mean Se concentrations for different species grown in the same area are shown in Table 1. Unpaired 't' tests indicated that while there was no significant difference between the Se concentrations of wheat and barley from the south eastern Darling Downs such differences ($P < 0.05$) did exist between sorghum and soybean from Kingaroy and between wheat and sorghum from Biloela. However, for Kingaroy the Se values for both species were at the lower end of the survey range and for Biloela both were at the higher end. The largest difference in Se concentrations between species at a given site (Table 1) was between wheat (0.23 mg kg^{-1}) and sorghum (1.1 mg kg^{-1}) at Biloela. This represents about a fivefold difference in Se content.

Table 1. Selenium concentrations in different species of grain from similar sites

	Se (mg kg^{-1})					
	Darling Downs (south eastern)		Kingaroy		Biloela	
	Wheat	Barley	Sorghum	Soybean	Wheat	Sorghum
Range	0.02–0.08	0.02–0.08	0.01–0.03	0.03–0.04	0.23–0.77	0.26–1.1
Mean*	0.04*a*	0.03*a*	0.02*a*	0.03*b*	0.36*a*	0.69*b*
s.d.	0.02	0.02	0.01	0.01	0.19	0.27
Number of samples ..	9	7	13	10	8	13

*For a site, means followed by different letters are significantly different ($P < 0.05$).

Effect of varieties

Ten varieties of sorghum and five varieties of soybean were grown at Hermitage, Kingaroy and Biloela as well as four varieties of wheat at six sites on the Darling Downs. Two-way analyses of variance for each species indicated no significant differences ($P > 0.05$) in Se concentrations between varieties of each species at each site.

Effect of rainfall

The distribution of Se concentrations in wheat from 31 Queensland State Wheat Board depots for the seasons 1976–77 and 1977–78 is shown in Table 2. A significant shift towards higher Se values in 1977–78, as shown by a paired 't' test ($P < 0.01$), can be attributed in part to the dryness of this season. Of the 29 sites for which rainfall data were available, all had lower rainfall and 25 produced wheat with higher Se concentrations in the 1977–78 season. When the Se concentrations of wheat from these sites were correlated with the mean rainfall in the two growing seasons, the correlation coefficient ($r = -0.41$) was statistically significant ($P < 0.01$).

Table 2. Distribution of selenium concentrations (mg kg^{-1}) in wheat from 31 Queensland State Wheat Board depots for 1976–77 and 1977–78

Class interval	Percentage of samples	
	1976–77	1977–78
0.21–0.40	6	32
0.11–0.20	52	45
0.06–0.10	36	20
< 0.06	6	3
Range	(0.04–0.23)	(0.05–0.40)
Mean*	0.12*a*	0.17*b*
s.d.	0.05	0.08

*Means followed by different letters are significantly different ($P < 0.01$).

Miltmore, van Ryswyk, Pringle, Chapman and Kalnin (1975) recorded high and negative (statistically significant) correlation coefficients for Se concentrations in oats and grass versus precipitation in British Columbia. There is evidence also (Gardiner 1969) that Se responsive diseases in grazing stock occur more often in times of high rainfall in susceptible areas.

Effect of sites: relationship to geology

The results in Table 3 show that the Se concentration in sorghum grown at different sites in Queensland can differ by a factor of 100. The site differences for wheat and soybean in Tables 1 and 3, although smaller, are still far greater than differences ascribable to species or varieties.

Consideration of the geology of grain growing areas in Queensland (Vandersee 1975; Murphy, Schwarzbock, Cranfield, Withnall and Murphy 1976; Geological Survey of Queensland 1975) indicated an association between the occurrence of low concentrations of Se in some grain and soils derived from Tertiary volcanic parent material. For example, there is a lower concentration of Se in wheat grown in predominantly Tertiary volcanic areas. This is shown in Table 4 where most samples came from different areas of the Darling Downs. The low Se content of sorghum and soybean (Table 1) from Kingaroy, another area with a strong Tertiary volcanic influence, further demonstrates this association. The Tertiary volcanic influence in the major grain regions of Queensland includes areas of the Central Highlands, the South Burnett and eastern Darling Downs. The black earths of the Central Highlands and eastern Darling Downs and the krasnozems of the South Burnett are the dominant Great Soil Groups of these areas.

Table 3. Selenium concentration in varieties of sorghum, soybean and wheat from different sites

	Se (mg kg^{-1})					
	Sorghum			Soybean		
	Hermitage	Kingaroy	Biloela	Hermitage	Kingaroy	Biloela
Range	0.10–0.22	0.01–0.03	0.42–1.1	0.22–0.24	0.03–0.04	0.32–0.47
Mean*	0.14*a*	0.02*b*	0.76*c*	0.23*a*	0.03*b*	0.38*c*
s.d.	0.04	0.01	0.25	0.01	0.01	0.06
Number of varieties..	10	10	10	5	5	5

Wheat (Darling Downs)

Site	1	2	3	4	5	6
Range	0.07–0.13	0.06–0.08	0.06–0.10	0.05–0.09	0.11–0.14	0.05–0.07
Mean*	0.10*a*	0.07*b*	0.08*b*	0.08*b*	0.12*a*	0.06*b*
s.d.	0.03	0.01	0.02	0.02	0.01	0.01
Number of varieties..	4	4	4	4	4	4

*For a species, means followed by different letters are significantly different ($P < 0.05$).

In the study of the relationship between sulphur and Se in Canadian soils, Levesque (1974) found that the sulphur content in soils was closely correlated with the Se and organic carbon content and that the sulphur-Se association in geological formations holds reasonably well through pedogenic processes. In Queensland it is of interest that substantial increases in yields of pastures after application of sulphur have been reported on Tertiary volcanic soils of the eastern Darling Downs (Loader and White 1979) and northern Queensland (Gilbert and Shaw 1979).

Grain with the highest values of Se came from the Tertiary sediments of the Biloela area and from the western and southern Darling Downs. In the survey no samples of grain with toxic concentrations of Se were found.

From the data given in Tables 1 to 4 for the Se content of Queensland grain, site differences (up to 100 fold) are more important than differences due to species or varieties (up to 5 fold). In preparing Figure 1, data from all grain types analysed were combined. This map summarizes the Se content of Queensland grain for 60 of some 150 sites or areas from which the 350 grain samples were taken. Where analyses for a number of closely related sites gave similar Se concentrations, for clarity these have been represented by a single symbol.

Poultry feeds and feed ingredients other than grain

Table 5 lists Se concentrations in some Queensland poultry feeds, and ingredients. These appear nutritionally adequate and are similar to results for Canada (Arthur 1971) and the USA (Scott and Thompson 1971). The Se contents of some Queensland animal products lie at the higher end of the range of overseas data. This may indicate a sufficiency of Se in most pastures of the State which is also suggested by the apparent absence of Se responsive disorders in grazing livestock.

Table 4. Distribution of selenium concentrations ($mg\ kg^{-1}$) in wheat from Tertiary volcanic and other areas in Queensland

Class interval	Percentage of samples	
	Tertiary volcanic	Others
> 0.2	0	36
0.11–0.2	4	43
0.06–0.1	37	19
< 0.05	59	2
Range	(0.01–0.14)	(0.05–0.8)
Mean*	0.05*a*	0.21*b*
s.d.	0.03	0.16
Number of samples	49	58
Location of samples	Darling Downs 38 Central Highlands 11	Darling Downs 50 Biloela 8

*Means followed by different letters are significantly different ($P < 0.01$).

Table 5. Selenium concentrations in Queensland poultry feeds and ingredients

Type of sample	Se ($mg\ kg^{-1}$)	
	Range	Mean ± s.d.
Poultry feeds		
Broiler		
Starter (11)*	0.14–0.32	0.22 ± 0.06
Grower (7)	0.15–0.31	0.22 ± 0.07
Finisher (15)	0.10–0.34	0.21 ± 0.07
Others		
Chick starter (4)	0.10–0.33	0.21
Growing all mash (2)	0.14–0.43	0.28
Turkey starter (2)	0.25–0.38	0.32
Turkey grower		0.34
Laying all mash		0.13
Feed ingredients		
Meat and bone meals (18)	0.22–0.49	0.33 ± 0.08
Meat meals (4)	0.36–0.65	0.44
Blood meals (2)	1.00–1.26	1.13
Offal meals (2)	0.66–0.98	0.82
Cottonseed meals (2)	0.34–0.50	0.42
Sunflower meals (2)	0.06–0.43	0.25
Soybean meal		0.34
Lucerne meal		0.25
Wheat germ		0.23
Mill run		0.22
Concentrates		
Chicken broiler		0.86
Broiler finisher		0.41
Layer premix		0.07
Chick starter premix		4.8

*Number of samples analysed.

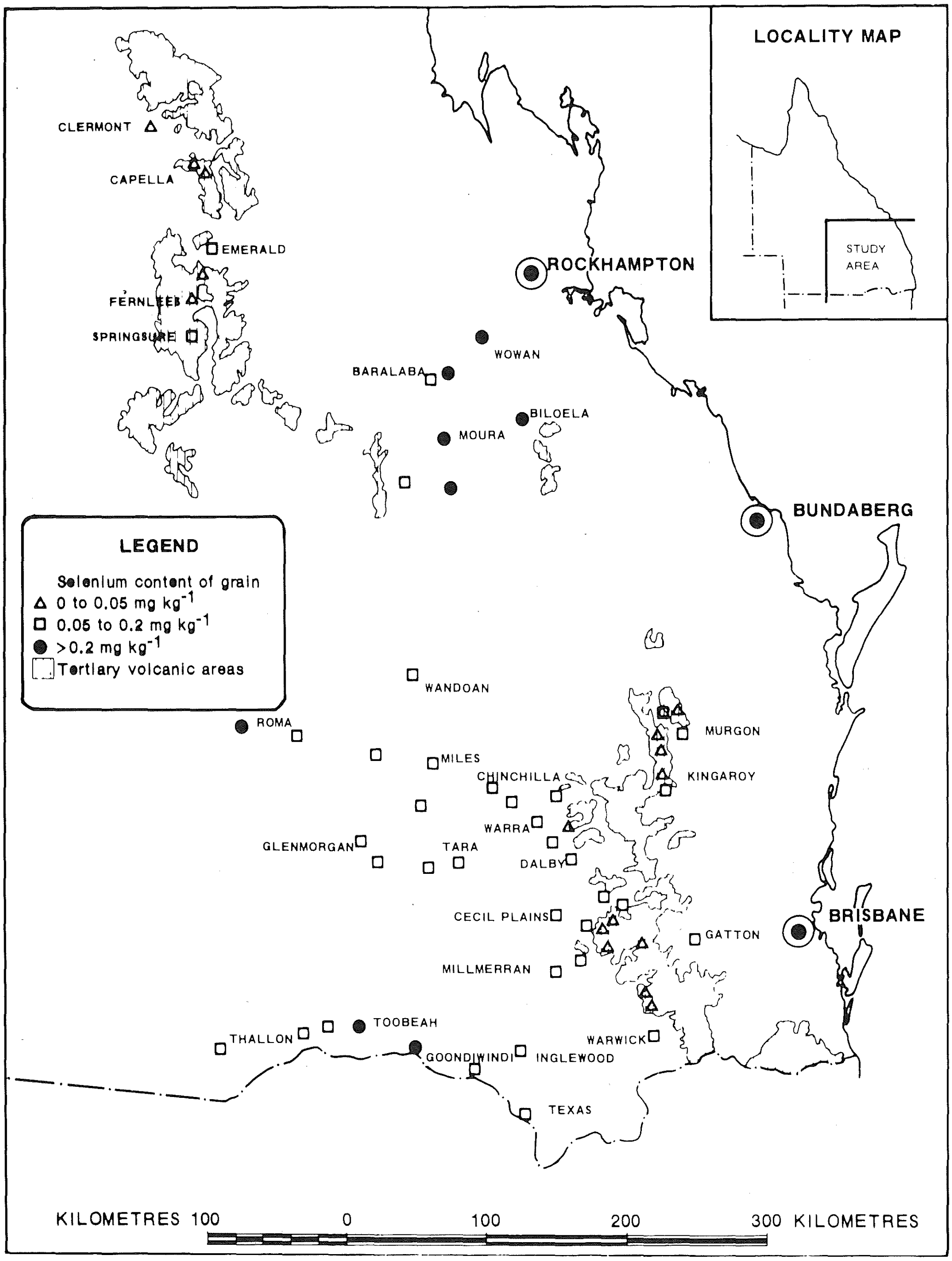

Figure 1. Selenium concentrations in wheat, barley, sorghum and soybean from Central and Southern Queensland during the period 1975 to 1978.

Scott (1975) states that 0.08 mg kg^{-1} of available Se is required by the starting chick to prevent exudative diathesis. From our data severe Se deficiencies in poultry are unlikely to occur in Queensland. Marginal deficiencies, however, are possible, as much of the element in the poultry diet is supplied by the grain ingredient (wheat or sorghum) and our results show that some Queensland grain is low in Se. The low biological availability of the element from animal by-products (Cantor, Scott and Noguchi 1975) and possible adverse interactions of Se with other nutrients or chemicals in the diet (Jensen 1975; Hill 1975) may exacerbate the problem.

If marginal deficiencies were a problem, consideration could be given to the inclusion of exogenous Se in Queensland poultry diets, as occurs in the United States and Canada. Rigid controls would be necessary, however, as the ratio of excessive to adequate concentrations is small.

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