INCIDENCE OF HEMORRHAGIC LIVER SYNDROME AMONG LAYING HENS FED DIETS CONTAINING DIFFERENT GLUCOSINOLATES

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Introduction

Several reports have indicated the occurrence of mortality from hemorrhagic liver syndrome when rapeseed meal was included in the diets of laying hens (Jackson 1969; Marangos et al. 1974; Olomu et al. 1975; Campbell 1979. Consequently canola/rapeseed meal is not recommended for use in laying hen diets at maximum levels (i.e. the sole protein supplement). Glucosinolates have been implicated in the etiology of hemorrhagic liver syndrome although a cause and effect relationship has not been delineated. The present experiment was conducted to study the effect of level and type of glucosinolates in the diet of laying hens on the incidence of hemorrhagic liver syndrome.

Materials and Methods

Diets differing in total glucosinolate content, complement of individual glucosinolates and level of supplemental vitamin K (menadione) were fed to SCWL laying hens in a 336-day production trial. Six hundred forty hens were allotted at random at 22 weeks of age to five experimental diets (Table 1) and egg production, feed consumption and mortality were recorded. Cause of death was determined by autopsy and representative groups (4/treatment at monthly intervals throughout the experiment and 12/treatment at the termination of the experiment) were killed to assess the influence of diet on livers and thyroids. Glucosinolate analyses were conducted according to methods described previously (Papas et al. 1979a) and treatment means were analysed according to standard statistical procedures using $P<0.05$.

Results and Discussion

Feed consumption, egg production and mortality data are presented in Table 2. Hens fed diets containing a high content of glucosinolates (diets 3, 4 and 5) tended to consume less feed and lay fewer eggs than hens fed the control diet (diet 1) although the effect was significant only for diet 4. The hens fed the low glucosinolate diet (diet 2) had an egg production rate more similar

[1] Deceased

to the control than to the high-glucosinolate groups. A similar response was noted by Ibrahim and Hill (1980).

In the current experiment canola/rapeseed meal was added to the diet as the sole protein supplement consequently the levels used were in excess of those recommended for use commercially. In this regard, mortality attributable to hemorrhagic liver syndrome was influenced markedly by diet and was associated with rapeseed/canola treatments (Table 2). Sixty-two to 88% of deaths were caused by hemorrhagic liver syndrome which is similar to that reported by Grandhi et al. (1977). The pattern of mortalities throughout the production cycle is shown in Table 3. No mortality due to hemorrhagic liver syndrome occurred during the first month of the experiment. In general the majority of the deaths occurred during the second to the fifth months of production although mortalities were not noted until the fourth month among hens fed diet 2 and tended to persist into the latter stages of the production cycle among hens fed diet 5. The peak in mortality coincides with maximum egg production and hence maximum metabolic activity in the liver.

Total glucosinolate content of the diet influenced the incidence of hemorrhagic liver syndrome since hens consuming the high glucosinolate diets (diets 3 and 4) showed a 2.8 fold higher incidence than those hens consuming the low-glucosinolate diet (diet 2). This is in agreement with other reports (Grandhi et al., 1977; Campbell 1979; Ibrahim and Hill 1980). Level of glucosinolate, per se, had a more marked influence on the incidence of hemorrhagic liver syndrome than the content of individual glucosinolates i.e progoitrin. In this regard, hens fed diets 3 or 4 which contained similar levels of total glucosinolates but different progoitrin contents had a similar mortality rate whereas hens fed diets 2 or 3 with a similar low level of progoitrin had markedly different mortality rates. A similar lack of correspondence of diet progoitrin content with incidence of liver hemorrhagic syndrome was noted by Marangos et al. (1974) when meals produced from mustard seed and B. napus rapeseed were compared.

The addition of vitamin K to the diet accentuated mortalities attributable to hemorrhagic liver syndrome among hens fed high glucosinolate B. napus meal (Table 2). This effect on mortality may have resulted in the altered trends in production noted for hens fed these two diets. An increased mortality due to vitamin K supplementation is not in agreement with previous results from this laboratory where a beneficial response was noted (Papas et al. 1979b; Israels et al. 1979). In the current experiment, however, the level of supplemental vitamin K used was greater (10x requirement vs 2x requirement). Further research is needed to

identify the role of vitamin K in the etiology of hemorrhagic liver syndrome in the laying hen.

Thyroid enlargement was evident among the hens fed high glucosinolate B. napus rapeseed meal within 2 months of the initiation of the experiment and persisted throughout the experiment (Table 4). Hens fed diet 2 tended to have larger thyroids than control hens but the effect was significant only for the observations taken during the fifth and sixth months of production. In contrast, hens fed diet 3 had thyroid weights similar to those of control hens. It can be suggested from this data that glucosinolates or glucosinolate-derived products other than progoitrin may also be involved in thyroid enlargement. Average liver weight of hens killed during the experiment are shown in Table 5. Although there was a trend toward heavier livers among hens fed the high-glucosinolate B. napus diets the weight of livers of hens killed during the experiment were markedly less than those of hens that died of hemorrhagic liver syndrome. Livers of the birds that died weighed an average of 51.9 g/kg BW. Liver weight, per se, among surviving birds is not closely associated with the incidence of hemorrhagic liver syndrome.

Summary and Conclusions

The incidence of hemorrhagic liver syndrome among laying hens fed diets containing high levels of rapeseed/canola meal is related more to the total content of glucosinolates than to individual glucosinolates such as progoitrin. Vitamin K (menadione) when added at high levels (10x requirement) to the diet of the laying hen tends to increase the incidence of hemorrhagic liver syndrome.

References

Campbell, L.D. 1979. Incidence of liver hemorrhage among white leghorn strains fed on diets containing different types of rapeseed meals. Br. Poult. Sci. 20:239-246.

Grandhi, R.R., S.J. Slinger and J.D. Summers. 1977. Productive performance and liver lesions in two strains of laying hens receiving two rapeseed meals. Poultry Sci. 56:1904-1908.

Ibrahim, I.R. and R. Hill. 1980. The effects of rapeseed meals from Brassica napus varieties and the variety tower and the production and health of laying fowl. Br. Poult. Sci. 21:423-430.

Israels, E.D., A. Papas, L.D. Campbell and L.G. Israels. 1979. Prevention by menadione of the hepatotoxic effects in chickens fed rapeseed meal. Gastroenterology 76:584-589.

Jackson, N. 1969. Toxicity of rapeseed meal and its use as a protein supplement in the diet of two hybrid strains of caged laying hens. J. Sci. Food Agric. 20:734-740.

Marangos, A., R. Hill, B.M. Laws and D. Muscamp. 1974. The influence of three rapeseed meals and a mustard seed meal on egg and broiler production. Br. Poult. Sci. 15:405-414.

Olomu, J.M., A.R. Robblee, D.R. Clandinin and R.T. Hardin. 1975. Effects of span rapeseed meal on productive performance, egg quality, composition of liver and hearts and incidence of fatty livers in laying hens. Can. J. Anim. Sci. 55:71-75.

Papas, A., L.D. Campbell, P.E. Cansfield and J.R. Ingalls. 1979a. The effect of glucosinolates on egg iodine and thyroid status of poultry. Can. J. Anim. Sci. 59:119-131.

Papas, A., L.D. Campbell and P.E. Cansfield. 1979b. A study of the association of glucosinlates to rapeseed meal-induced hemorrhagic liver in poultry and the influence of supplemental vitamin K. Can. J. Anim. Sci. 59:133-144.

Table 1. Diet composition

Ingredients and analyses	Units	Diet[1] 1	2	3	4	5
Wheat/barley,	%	61.6	61.6	61.6	61.6	61.1
Canola/rapeseed meal[2],	%	-	24.0	24.0	24.0	24.0
Soybean/alfalfa meal,	%	24.0	-	-	-	-
Tallow,	%	5.0	5.0	5.0	5.0	5.0
Limestone/Caphosphate,	%	7.9	7.9	7.9	7.9	7.9
Premix,	%	1.5	1.5	1.5	1.5	1.5
Vitamin K (added),	mg/kg	-	-	-	-	5.0
Glucosinolate analysis						
Total glucosinolate[3],	µmoles/g	0	4.6	21.0	25.4	25.4
Progoitrin,	µmoles/g	0	1.7	0.7	15.1	15.1
SCN-glucosinolates[4],	µmoles/g	0	1.8	0.5	2.4	2.4

[1] Contained 11.5 kJ/g ME and 17.5% protein.

[2] Diet 2 contained *B. napus* canola; diet 3 contained *B. campestris* spp. triocularis rapeseed and diets 4 and 5 contained *B. napus* rapeseed.

[3] Measured as glucose released on hydrolysis with myrosinase.

[4] Includes those glucosinolates yielding thiocyanate ion on hydrolysis with myrosinase (corrested for free thiocyanate ion).

Table 2. Feed consumption, egg production and mortality of laying hens fed diets containing varied amounts and types of glucosinolates

	Diet[1]					
	1	2	3	4	5	SE
Feed consumption g/hen/day	110[a]	107[ab]	106[ab]	104[b]	106[ab]	1.27
Egg production hen-day, %	81.6[a]	79.6[ab]	74.4[ab]	72.3[b]	75.6[ab]	1.98
Mortality[2]						
Total number	6	13	29	31	41	
Hemorrhagic liver	0	8	21	23	36	

[1]See Table 1 for a description of the glucosinolate and vitamin K contents of the diets.

[2]Total number of hens/treatment at initiation of the experiment was 128.

[ab]Treatment means within a row with the same superscript are not significantly different (P>0.05).

Table 3. Number of deaths throughout the production cycle attributable to hemorrhagic liver syndrome among hens fed diets containing varied amounts and types of glucosinolates

Diet[1]	Month of production					
	1	2-3	4-5	6-7	8-9	10-12
1	0	0	0	0	0	0
2	0	0	5	1	2	0
3	0	10	7	2	2	0
4	0	11	8	3	1	0
5	0	17	6	6	5	2

[1]See Table 1 for a description of the diet.

Table 4. Thyroid weight (mg/100 g BW) of hens fed diets[1] containing varied amounts and types of glucosinolates and killed at periodic intervals throughout the experiment

Month of production	Diet 1	2	3	4	5	SE
1-2	8.76^{c}	12.79^{bc}	9.34^{bc}	16.98^{ab}	19.93^{a}	2.06
3-4	9.15^{b}	15.53^{b}	10.08^{b}	37.17^{a}	49.23^{a}	3.96
5-6	9.57^{c}	21.46^{b}	9.20^{c}	54.16^{a}	66.70^{a}	3.06
7-8	11.74^{c}	23.11^{c}	12.13^{c}	100.03^{a}	56.38^{b}	6.26
9-11	9.78^{b}	14.78^{b}	9.48^{b}	80.63^{a}	77.30^{a}	5.75
12	8.46^{b}	15.04^{b}	9.77^{b}	103.99^{a}	101.08^{a}	7.33

[1]See Table 1 for a description of the diets.

^{abc}Means within a row with the same superscript are not significantly different ($P>0.05$).

Table 5. Liver weight (g/kg BW) of hens fed diets[1] containing varied amounts and types of glucosinolates and killed at periodic intervals[2] throughout the experiment

1	2	3	4	5
22.3	22.8	22.9	24.4	25.8
±0.53	±0.45	±0.52	±0.75	±0.87

[1]See Table 1 for a description of the diets.

[2]Data for all intervals were combined.