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A Comparative Study of the Nutritive Values of Triticale and Wheat for Laying Hens

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SUMMARY

Egg producers wish to know whether wheat can be substituted by triticale, a generally cheaper cereal grain, without prejudice to performance of the flock or egg quality. Taking into account expected quantitative differences in non-starch polysaccharide (NSP) contents of triticale and wheat, feed intake, egg weight, excreta moisture and incidence of soiled eggs are the traits more likely to be affected by grain substitution. Finally, egg producers are likely to want to know whether commercial glycanase enzyme products can be used in layer diets to improve economic performance of layer flocks

The objectives of this study were (a) to compare the nutritive value of triticale with wheat by substitution of wheat for triticale in nutritionally balanced layer diets, and (2) to determine the effects of a commercial enzyme product in diets based on wheat or triticale, on laying performance, egg quality and incidence of soiled eggs from a commercial breed of laying hen.

The results of this study indicate that triticale is a useful alternative to wheat for inclusion in diets for laying hens. However, this particular sample of triticale was somewhat inferior in nutritive value compared to the wheat judging by small losses in laying performance. On the other hand, there were no indications that triticale was inferior to wheat in regards to egg weight, incidence of soiled eggs or shell thickness. Excreta moisture was not affected by either the type of cereal used in the diet or by enzyme supplementation. Use of enzyme in the triticale diet improved feed conversion to egg mass. The cost-effectiveness of triticale for inclusion in laying diets will depend on whether the price differential between triticale and wheat will be sufficient to cover relatively small losses in performance due to triticale.

Egg producers considering the purchase or use of triticale in laying diets should take into account that this cereal grain is likely to vary widely in energy and protein contents depending on variety and seasonal factors, as have been observed for wheat and barley. The other point to consider is that commercial feed enzyme products currently available in Australia do not have identical properties or characteristics in relation to enhancement of the nutritive value of different types of cereal grains. Producers

should seek expert advice on the need to use enzymes and the most appropriate types of enzymes to use in their particular circumstances.

INTRODUCTION

Egg producers wish to know whether wheat can be substituted by triticale, a generally cheaper cereal grain, without prejudice to performance of the flock or egg quality. Taking into account expected quantitative differences in non-starch polysaccharide (NSP) contents of triticale and wheat, feed intake, egg weight, excreta moisture and incidence of soiled eggs are the traits more likely to be affected by grain substitution. Simple substitution of one grain by another is likely to lead to false results particularly if the grains differ substantially in crude protein content unless attempts are made to formulate diets to meet minimum nutrient requirements. The diet formulation approach used in this proposal was to take a nutritionally balanced, commercially-relevant, wheat-based diet and to replace some of the wheat with triticale then make fine adjustments to essential nutrient levels in the diet such as calcium, phosphorus, linoleic acid and methionine to achieve parity between experimental diets. Finally, egg producers are likely to want to know whether commercial glycanase enzyme products can be used in layer diets to improve economic performance of layer flocks

The objectives of this study were (a) to compare the nutritive value of triticale with wheat by substitution of wheat for triticale in nutritionally balanced layer diets, and (2) to determine the effects of a commercial enzyme product in diets based on wheat or triticale, on laying performance, egg quality and incidence of soiled eggs from a commercial breed of laying hen.

MATERIALS AND METHODS

Location

The experimental work took place over a 12-week period at the Pig and Poultry Production Institute (PPPI), Roseworthy Campus, University of Adelaide commencing with the allocation of experimental feeds to laying hens 46 weeks of age Thursday 2 July 1998.

Experimental methods

A total of 960 laying hens (Hy-Line Gold) were housed five per cage in 192 Harrison "Welfare" back-to-back, single-tier cages (each 500 mm wide by 545 mm deep; 545 cm^2/bird) in a layer shed equipped with a thermostatically controlled evaporative cooling system set to operate when shed temperature at bird level reaches 25^oC. A 16-hour light program was provided by incandescent globes on at 0400 h and off at

2000 h (Central Standard Time). Birds had access to feed in hoppers and water from nipple drinkers at all times. All birds received a high quality layer mash from housing at 18 weeks of age (15 December 1997) until the start of a previous 12-week experiment then again between 38 and 46 weeks of age.

Experimental feeds

Eight dietary treatments (12 replicates; 10 birds in two adjacent cages for each replicate) were examined in a randomised block experiment. The dietary treatments comprised:-

Diet	Description
1.	Wheat 100% of grain component of the diet
2.	Wheat 80% / triticale 20%
3.	Wheat 60% / triticale 40%
4.	Wheat 40% / triticale 60%
5.	Wheat 20% / triticale 60%
6.	Wheat 0% / triticale 100%
7.	Wheat 100% plus appropriate enzyme product
8.	Triticale 100% plus appropriate enzyme product

The exact formulation of each experimental diet is shown In Table 1. All diets supported a high level of performance; none were nutritionally deficient. As far as practical, all diets had similar energy to nutrient ratios for key dietary components such as protein, linoleic acid, essential amino acids (particularly methionine and lysine), calcium, total and available phosphorus, sodium and chloride. The enzyme product used in this study (Roxazyme G at 100 g/tonne) was added to diets by substitution of some of the millrun diluent. Micro-ingredients, enzyme product and millrun were carefully blended then added to the bulk of the ingredients in the mixer. Two batches of each experimental diet were used in this study. The second batch of feed was mixed midway through the 12-week period. Feed was transported in bulk bags and stored in the layer shed.

TABLE 1. Measured values (as-fed basis) for apparent metabolisable energy (AME) and amino acids (g/100 g) in wheat and triticale

	Wheat	Triticale
AME (MJ/kg)	11.6	12.0
Crude protein (N × 6.25)	12.6	14.0
Alanine	0.42	0.48
Arginine	0.59	0.64
Aspartic acid	0.70	0.77
Cystine	0.31	0.29
Glutamic acid	4.03	3.25
Glycine	0.55	0.54
Histidine	0.33	0.32
Isoleucine	0.44	0.41
Leucine	0.91	0.90
Lysine	0.34	0.43
Methionine	0.24	0.24
Phenylalanine	0.59	0.56
Proline	1.40	1.10
Serine	0.61	0.60
Threonine	0.39	0.41
Tyrosine	0.29	0.31
Valine	0.55	0.55

TABLE 2. Composition (as-fed basis) of experimental basal diets

Experimental diet	#1	#2	#3	#4	#5	#6
	Triticale as % of total cereal grain content of the diet					
	0%	20%	40%	60%	80%	100%
Ingredient (%)						
Wheat	74.75	59.80	44.85	29.90	14.95	-
Triticale	-	15.37	30.74	46.11	61.48	76.85
Soybean meal (solvent)	6.00	5.64	5.28	4.92	4.56	4.20
Meat and bone meal	8.50	8.40	8.30	8.20	8.10	8.00
Marble	8.00	8.02	8.04	8.06	8.08	8.10
Tallow	0.50	0.46	0.42	0.38	0.34	0.30
Sunflower oil	0.50	0.54	0.58	0.62	0.66	0.70
Sodium bicarbonate	0.15	0.16	0.17	0.18	0.19	0.20
L-lysine	0.17	0.18	0.18	0.19	0.19	0.20
DL-methionine	0.13	0.13	0.14	0.14	0.15	0.15
Vitamin/mineral premix	0.10	0.10	0.10	0.10	0.10	0.10
Choline chloride (60%)	0.04	0.04	0.04	0.04	0.04	0.04
Yolk colorant in millrun diluent	1.16	1.16	1.16	1.16	1.16	1.16
Proximate composition (%)						
Metabolisable energy (MJ/kg)	11.4	11.4	11.4	11.4	11.4	11.4
Crude protein	16.5	16.6	16.7	16.7	16.8	16.9
Calcium	3.77	3.77	3.77	3.76	3.76	3.76
Phosphorus (total)	0.62	0.61	0.60	0.60	0.60	0.59
Phosphorus (available)	0.43	0.42	0.42	0.41	0.41	0.40
Sodium	0.15	0.16	0.16	0.16	0.16	0.16
Chloride	0.16	0.16	0.16	0.17	0.17	0.17
Methionine	0.38	0.38	0.39	0.39	0.39	0.39
Lysine	0.77	0.78	0.77	0.77	0.77	0.77
Linoleic acid	1.13	1.14	1.14	1.15	1.16	1.16

The diet formulations were determined on amino acid contents of the samples of triticale and wheat which were measured by HPLC methods. AME values for wheat and triticale were measured in a broiler chicken bioassay. The measured values for wheat and triticale used in the diet formulations are shown in Table 1. The amino acid profiles for wheat and triticale are comparable with those reported by Ravindran *et al.* (1998). Assumed values for nutrient composition of other dietary ingredients were used in diet formulations.

Data recording

Data were recorded on each experimental replicate of 10 birds in two adjacent cages. Egg production and mortality were recorded daily. Weighed amounts of feed were given at least twice each week to ensure that hens never went without feed and to minimise feed spillage. Uneaten feed in hoppers was measured at weekly intervals. Birds were weighed at the start and end of the experiment. In the final week of the experiment (birds 58 weeks of age), egg weight of all eggs laid over a three-day period were recorded. Shell characteristics and yolk colour of eggs laid between 8.30 am and 12.30 pm daily were measured. Incidence of dirty eggs were assessed visually. Fresh excreta was collected for moisture determination.

Statistical analysis

Base SAS® software (SAS Institute) was used in this study. Analysis of variance (by GLM procedure) was used to determine the effects of block and dietary treatment. Duncan's Multiple Range Test was used to separate means of diet effects.

Animal ethics

The Animal Ethics Committees of the Department of Primary Industries South Australia and the University of Adelaide approved this AME bioassay study. All procedures complied with "Australian code of practice for the care and use of animals for scientific purposes" (Australian Agricultural Council, 1990) and "Australian model code of practice for the welfare of animals. Domestic Poultry" (Standing Committee on Agriculture and Resource Management, 1995).

RESULTS AND DISCUSSION

Results of analysis of variance, and means and standard deviations for effects of dietary treatments are shown in Tables 3 - 16. Weekly changes in hen-day egg production and feed intake for the entire flock during the 12-week experiment are shown in Figures 1 and 2.

Egg production

There were no significant effects ($P > 0.05$) of dietary treatments at any stage during the experiment (Tables 3 and 4). However, during the first 4-week period of the study, effects of dietary treatments approached significance ($P = 0.06$). An apparent difference between diets seems likely to be the result of random error involving lower than expected production of hens given the diet in which wheat and triticale comprised 60 and 40%, respectively, of the cereal component of the diet. While not statistically significant, trends in the data suggest that a high dietary inclusion of triticale does not support a similar rate of lay as wheat despite the respective diets having similar nutrient specifications. Decline in egg production with age of bird (Figure 1) was consistent with the expectations of the Hy-Line Company for this breed of laying hen.

Feed intake

There were highly significant effects of dietary treatment at each stage in the experiment (Table 5). Enzyme supplementation of the wheat diet resulted in significantly reduced feed intake in the first eight weeks, but not in the final four weeks (Table 6). For data pooled over 12 weeks, enzyme supplementation effectively reduced feed intake on the wheat diet (Table 6). In contrast, there were no benefits of enzyme supplementation of the triticale diet at any stage in the study.

The trend towards increased feed intake as triticale progressively replaced wheat suggests that laying hens did not effectively utilise energy in triticale compared with wheat. This observation appears to be at odds with the results of AME testing of these grains using broiler chickens. In a previous experiment using the same flock and similar diets based on the same wheat and triticale, there were also increases in feed intake on triticale diets compared with wheat diets (Hughes and Zviedrans, unpublished data).

Feed conversion

There was a general reduction in feed efficiency as triticale progressively replaced wheat (Tables 7 and 8). Feed conversion on the triticale diet was significantly poorer than any other diet (Table 8). Addition of enzyme to the triticale diet significantly improved feed conversion to the extent that it was not significantly different from other diets, although numerically it was still poorer than all diets containing wheat.

TABLE 8.

Summary of the effect of diet on conversion of feed to eggs at 58 weeks of age

(means ± standard deviations)

	Feed conversion *g feed/g egg*
Wheat (W) 100%	2.13 ± 0.12 b †
W 80% / T 20%	2.13 ± 0.14 b
W 60% / T 40%	2.22 ± 0.20 b
W 40% / T 60%	2.27 ± 0.19 b
W 20% / T 80%	2.26 ± 0.23 b
Triticale (T) 100%	2.49 ± 0.38 a
W 100% + Enzyme	2.25 ± 0.18 b
T 100% + Enzyme	2.31 ± 0.19 b
	2.26

† Means followed by the same letter are not significantly different at the 5% level (Duncan's multiple range test)

Live weight

Dietary treatments had no effects on live weight after 12 weeks, or on live weight gain during that period (Tables 9 and 10). Hens on the wheat plus enzyme diet started the experiment at a slightly lower live weight than some other dietary treatments Table 10). This is likely to be due to random variation in live weight of the flock which appeared to have no bearing on the outcome of this experiment. In general, live weight changes were trivial over 12 weeks.

Egg quality

Dietary treatments had no significant effects on egg weight or incidence of soiled eggs (Tables 11 and 12). In particular, there was no indication whatsoever that hens on diets containing triticale laid more soiled eggs than hens on a wheat diet. Similarly, shell quality was unaffected by dietary treatments (Tables 13 and 14), although the reduction in shell thickness with enzyme addition to the triticale diet approached significance (P = 0.07). Addition of enzyme to the wheat only diet significantly raised yolk colour (Table 14), and there was a tendency for higher yolk colour as triticale progressively replaced wheat.

Fresh excreta moisture

Addition of enzyme to wheat or triticale diets had no effect on excreta moisture (Tables 15 and 16). Progressive replacement of wheat by triticale had inconsistent effects on excreta moisture. While some differences are statistically significant, actual differences are relatively small (Table 16).

CONCLUSIONS

- Triticale is a useful alternative to wheat for inclusion in diets for laying hens but it would appear to be somewhat inferior to wheat in terms of nutritive value judging by small losses in laying performance.
- There were no indications that triticale was inferior to wheat in regards to egg weight, incidence of soiled eggs or shell thickness.
- Excreta moisture was not affected by either the type of cereal used in the diet or by enzyme supplementation.
- Use of enzyme in the triticale diet improved feed conversion to egg mass.
- The cost-effectiveness of triticale for inclusion in laying diets will depend on whether the price differential between triticale and wheat will be sufficient to cover relatively small losses in performance due to triticale.

REFERENCES

Ravindran, V., Hew, L.I. and Bryden, W.L. (1998). "Digestible Amino Acids in Poultry Feedstuffs". RIRDC Publication No. 98/9.

APPENDIX

Following is an example of the relative returns from each of the experimental diets using the following assumptions in relation to egg and feed ingredient prices. It should be noted that in practice the relative profitability of each diet will vary according to the real prices of each ingredient.

Average egg returns at farm gate : $1.05 per dozen

Ingredient prices		($/tonne)
	Wheat	150
	Triticale	135
	Soybean meal	440
	Meat and bone meal	350
	Marble	95
	Tallow	540
	Sunflower oil	1500
	Sodium bicarbonate	480
	L-lysine	2800
	DL-methionine	4500
	Vitamin/mineral premix	4000

Choline chloride (60%) 1750
Millrun 130

Yolk colour $12/tonne of feed in millrun diluent
Enzyme $40/kg added @100g/tonne of feed = $4/tonne of feed

DIET	1	2	3	4	5	6	7	8
Triticale (%)	0	20	40	60	80	100	0	100
Enzyme	No	No	No	No	No	No	Yes	Yes
Cost of feed ($/tonne)	215.61	212.73	210.03	207.15	204.44	201.56	219.61	205.56
Egg returns ($/100 hen days)	7.25	7.33	*6.90	7.25	7.05	6.90	7.07	6.93
Feed costs ($/100 hen days)	2.53	2.52	2.44	2.52	2.48	2.42	2.49	2.44
Net Returns ($/100 hen days)	4.71	4.81	4.46	4.72	4.58	4.48	4.58	4.49

* Egg production on this diet was low for unexplained reasons that were unlikely to be related to the triticale level in the diet.

In this example, where triticale was $15/tonne cheaper than wheat, replacing wheat with triticale reduced feed costs. However, at the higher levels of inclusion of triticale there was a reduction in egg output that outweighed the benefits of reduced feed costs and resulted in reduced net returns.

A price sensitivity analysis was conducted by varying the price of wheat from being the same price as triticale to $25/tonne more. This analysis showed that maximum returns would be obtained using a diet where 40% of the wheat was replaced with triticale when the price of wheat was $10/tonne or more higher than triticale. If the price of wheat was less than $10/tonne higher than triticale it was only profitable to replace 20% of the wheat with triticale. These results rely heavily on the fact that in this study there was no statistically significant difference in the egg production between birds given a diet with wheat as the only grain and birds receiving a diet where 20% of the wheat was replaced with triticale. It should also be kept in mind that hens may reduce feed intake, and therefore production, for a period when switched onto a different diet. Therefore, the savings in feed costs must be sufficient to compensate for this for a change in grain supply to be profitable.

In this example, adding enzyme to the wheat diet reduced feed costs by reducing feed intake. However, egg production was also reduced and net returns were poorer. Adding enzyme to the triticale diet resulted in equivalent increases in feed costs and egg returns so that net returns were not affected.

TABLE 15. Summary of analysis of variance of excreta moisture

Source of variation	**Degrees of freedom**	**Excreta moisture (%)**
		Probability of greater F value
Block	11	0.002

Diet	7	0.04
Square root of error mean square		2.39
Coefficient of variation		3.4
Overall mean		70.2