HOW USEFUL IS TRITICALE FOR PIGS AND POULTRY?

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SUMMARY

Investigations of the nutritive value of triticale for pigs, broilers and layers are reviewed. Crude protein was from 8.3 to 17.2% and there was a significant negative correlation between crude protein and lysine content of the protein. Rat trials indicated that lysine and threonine are the limiting amino acids in triticales. Tannin levels in triticale samples were from 0.05% to 0.10%.

Digestibility of components in two samples of triticale was determined with pigs., Values found were similar to those in wheat. A series of substitution trials were conducted with pigs, broilers and layers. With one exception triticale replaced wheat effectively but one sample of triticale caused growth depression in pigs. A reduction in yolk colour in eggs was seen in triticale-based diets.

A taste panel test was conducted on meat of broilers grown on triticale-based diets. A slight difference in flavour was detected but there was no preference for or against this flavour.

INTRODUCTION

Triticale is a cereal grain which has recently gained much interest from cereal growers and stock feeders. Originally developed to combine the winter hardiness of rye and its range 'of habitat with the milling and baking qualities of wheat, it soon became apparent that triticales were frequently high in protein, lysine and other amino acids (Villegas et al. 1970). It was the prospect of a cereal with higher protein and lysine levels than those currently in use for stock feeding and one which would not besubject to legislative controls nor be so competitive for human consumption that stimulated work to evaluate triticale as a feedstuff for livestock.

This man-made cereal results from an intergeneric cross between wheat (*Triticum* spp.) and rye (*Secale cereale*). Withouth the development of the chromosome doubling technique using colchicine, triticale could not have been produced since early types were sterile, as might be expected from. an intergeneric cross. However with research programmes in many countries to develop the genetics and agronomic features of the crop; triticale now equals or out yields modern wheat varieties. It will grow in areas where many other cereals, yield poorly.

In Australia, groups at the University of New England, at the N.S.W. Department of Agriculture, the University of Sydney, the Waite Institute and the Victorian Department of Agriculture are breeding and developing, strains of triticale: The purpose of the present programme was to examine these Australian varieties and to'evaluate them as feedstuffs for pigs and poultry.

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Triticale for pigs

Studies to examine the substitution of triticale for various grains in pig diets have been conducted by several workers. This work appears to fall into two categories:

(1) those who found that triticale can be substituted for the cereal part of the ration completely without adverse effects e.g. Stothers and Shebeski (1965) using barley; Shimada et al (1971) using sorghum; Allee and Hines (1972a) using sorghum although not on an isonitrogenous basis; and Shimada et al. (1974) using maize.

(2) those who found some depression in feed intake, growth rate or feed conversion efficiency e.g. Stothers and Shebeski (1965) suggested that palatability problems caused a reduction in feed intake, Harrold et al. (1971) recommended a maximum inclusion rate of 25% of the ration for growing pigs because of reduced palatability, and Ericksen et al. (1976) who, in a series of three experiments, demonstrated a reduction in growth rate at high levels of substitution of triticale for maize. They suggested that this reduction may have been due to either a trypsin inhibitor or to poor lysine availability.

Attempts have been made to measure the energy value of triticale for pigs. Cornejo et al. (1913) reported the digestible energy, metabolisable energy (ME) and nitrogen-corrected metabolisable energy of triticale to be 15.06, 14.72 and 13.48 Mj/kg, respectively. Shimada and Cline (1974) reported a ME value of 13.67 Mj/kg, a figure which appears to agree reasonably well with the former authors and which compares favourably with other commonly used cereal grains.

Knipfel (1969) studied the protein efficiency ratio (PER) of several cereal grains and reported that triticale was equal to rye in PER but superior to wheat. He concluded that the superiority of triticale was due to higher contents of lysine and sulphur amino acids. Allee and Hines (1972b) reported that lysine was the first limiting amino acid in triticale for finishing pigs and they also suggested that the lysine in triticale may not be fully available to the pig. Shimada and Cline (1974) suggest that the two limiting amino acids in triticale for the pig are lysine and threonine in that order.

Sauer et al. (1974) investigated the availability of amino acids in triticale, wheat, barley and soybean meal and found that the limiting amino acids lysine and threonine in triticale were more available than in wheat and barley. Taverner et al. (1978) found availability values for lysine and threonine in triticale to be similar to those of wheat, sorghum, maize and barley. These results are at variance with the suggestions of Erikson et al. (1976) and Allee and Hines (1972b) that poor lysine availability may affect the performance of pigs fed triticale.

With regard to intrinsic and extrinsic toxic substances Madl and Tsen (1974) have observed that the trypsin inhibitor activity of triticale tends to lie between that of the wheat and rye parents. Nishimuta et al. (1978) suggest that a toxic substance isolated by warm water extraction of triticale, which depressed rat growth, may have been a trypsin inhibitor. These workers also isolated growth-depressing substances in ether and hexane extracts which they suggested may have been alkyl resorcinols (see also Radcliffe 1979). However, Larter (1974) discounts the presence of resorcinols in triticale as a reason for growth depression. Ergot (Claviceps purpurea) has been 'shown to depress both growth and feed intake (Harrold et al. 1971), and may explain growth depression in other trials (Larter 1974). The tannin level of triticale has also been implicated in growth depression (King 1978). Thus it would seem that the area of toxic factors remains rather unclear and further work in this area is needed.

Triticale for broilers

When substituted on a weight or energy basis triticale has been found equal or superior to wheat 'in nutritional value (Sell et al. 1962; Bragg and Sharbey, 1970; Wilson and McNab, 1975). Similarly when substituted on an energy and nitrogen basis Rao et al. (1975) 'found that triticale had a similar nutritive value to maize in broiler diets. However; Bixler et al. (1968) found that triticale was inferior to maize and wheat.

Fernandez and McGinnis (1974) suggested that lysine and threonine are the limiting amino acids in triticale for chick growth and showed no. response to methionine and tryptophan. Marquez and Avila (1973) similarly showed no response to methionine and tryptophan or to valine but showed a significant response. to threonine supplementation. These results are both in disagreement with Bragg and Sharbey (1970) who showed' an improvement with methionine supplementation but not with lysine. However, this response occurred in only one diet of one experiment and could not be repeated in a subsequent experiment. It was suggested that the explanation could be the two different strains of chickens used in the two experiments. Bragg et al. (1970) investigated the effect of ergot in triticale on growth, feed efficiency and mortality in broilers. Ergot levels above 0.8% 'were found to significantly depress growth and feed efficiency and to increase mortality. Other toxic factors appear not to have been investigated with chickens.

Triticale for layers

Sibbald (1977) and Farrell (1978) found the mean metabolisable energy level of several varieties of triticale for poultry to be 15.34 and 15.30 Mj/kg, respectively-' It would seem from these preliminary analyses that triticale should be of equivalent or better nutritive value to other cereal grains used in layer diets. In order to assess the nutritive value of triticale compared to other cereal grains, several trials have been conducted wheretriticale was substituted for the cereal component of layer diets. Guenthner and Carlson (1970) compared triticale, maize, wheat and sorghum inlaying diets which were formulated to be isonitrogenous and isocaloric. Triticale was found to depress egg production in both 12% and 14% protein diets, compared, to other grains. Cuca and Avila (1973) substituted triticale for sorghum on a protein basis and found a depression in -egg production and egg weight.

In two experiments Weber et al. (1972) compared sorghum to wheat and triticale- In the first experiment, one of two varieties of triticale was found to give' similar egg production and feed conversion to sorghum while' the other variety depressed performance. Both triticale varieties. depressed egg weight compared to sorghum. In the 'second experiment triticale and wheat gave similar performance to sorghum. In none of these experiments were diets formulated to take account of varying levels of essential amino acids in the grain samples. It is likely therefore, that in most cases replacement of soybean protein by triticale protein may have resulted in lysine and possibly threonine deficiencies which would in turn result in depressed performance.

In an experiment where diets'were formulated to make full use of the high protein content of triticale, that is, account was taken of the amino acid composition of triticale, Fernandez et al. (1973) found that hens receiving diets containing over 80% triticale had produdtion parameters that were equal to those of hens receiving more conventional layer diets.

Although Choudhary and Netke (1976) found that the quantitative substituion of triticale for maize did not adversely affect egg production and egg weight they suggested that the protein quality of a triticale-based diet was similar or inferior to that of a maize-based diet, possible because of a threonine deficiency. Similarly, Kim et al. (1976) found in two experiments that triticale was equal to maize in supporting egg production, egg weight and body weight.

In a free choice feeding experiment Karunajeewa (1978) compared triticale to wheat and found that rate of lay and egg weight were similar on either grain; Hens on triticale diets ate more grain than those'on wheat diets and it is suggested that the ME content of the triticale was lower than that of the wheat used. It is interesting to note that both groups of birds ate a similar amount of the protein concentrate offered and that their total intakes of protein were-very similar (triticale diet 21.0g/day, wheat diet 20.9g/day). It is unlikely, with these protein intakes, that either group would have suffered from an amino acid deficiency.

In a digestibility trial with laying hens McNab and Shannon (1975) concluded that triticale should be nutritionally, superior to wheat because of its higher ME value and digestible lysine content..

Thus, it would seem that where allowance is made in diet formulation for the amino acid and ME contents of triticales, they are quite capable of being substituted for'other common cereal grains in the diets of laying hens;

In this paper we provide. a preliminary report of results obtained in experiments'designed' to investigate the following:

(1) the' levels of protein and amino acids in various samples of triticale,

(2) the level of tannins'in various samples of triticale,

(3) the sequence of limiting amino acids in triticale for the growing rat,

(4) the effect of substituting triticale for wheat in the diets 'of pigs, layers and broilers,

(5) energy values of triticale for pigs and poultry.'

MATERIALS AND METHODS

Chemical analysis

Samples of ten varieties of triticale grown at four different locations were analysed for nitrogen using a micro-Kjeldahl method. The crude protein levels were obtained-by multiplying the nitrogen content by a factor of 5.76 (Tkachuk 1969). Samples of thirteen different.

varieties of triticale were analysed for tannin. content by the method of. Price and Butler (1977).

Individual amino acids were determined on the acid hydrolysates using a TSM-1 Technician amino-acid analyser. Other procedures used in the analysis of feed and faeces followed standard methods (AOAC 1960; Van Soest and Wine 1967).

Rat trials

Weanling rats of the Wistar strain were housed individually in wire cages in an air-conditioned room. The animals and feed containers were weighed at the beginning of the experiment and after 7, 10 and. 14 days. Food and'water were available ad libitum.

The triticale samples (above) analysed for proteinwere bulked to obtain three different crude protein levels. These mixtures were then left unsupplemented, or supplemented. with lysine, lysine + threonine, lysine + threonine and methionine or a high-quality protein source (soybean meal and fishmeal) to supply the various recommended allowances for the growing rat (N.R.C. 1972) and compared to a wheat-based diet similarly substituted.

Groups of six rats, 3 males and 3 females were allocated at random to each treatment.

Pig trials

(i) Digestibility Four Large White x Landrace castrated males weighing approximately 30 kg were p&aced in metabolism crates in a room kept at 20 ± 1^{o}C. The animals on a commercial grower diet were allowed to adjust to the experimental conditions for.7 days. Water was freely available from drinking nipples.

The design of the experiment was a cross over with two diets containing triticale of different crude protein levels each fed to two pigs for a 7-day adjustment period and a 5-day collection period. The diets were then crossed over and fed to the remaining two pigs for a further 7-day adjustment and 5-day collection period.

The diets consisted (g/kg) of 970 triticale, 23 bone meal, 5 vitamin/ mineral premix and 2 salt. The crude protein (N x 5.76 on a DM basis) of the two diets was 139 and 154 g/kg'. Pigs were fed once daily at a level of 3% of average live-weight, the feed being mixed with an equal weight, of' water. Any feed remaining one hour after feeding was removed and dried to constantweight in a forced-draft oven at 750C. At the commencement of each collection period, 10 g of ferric oxice was mixed with 100 g of dry feed and given to each pig followed later by the remainder of the ration. This was repeated 5 days later. Collection of faeces was commenced and ceased upon the appearance of the ferric oxide.

Faeces were collected and dried to constant weight and samples stored for analysis. Total urine output was collected daily in 10 ml of concentrated H_2SO_4. A 10% aliquot was accumulated daily and stored at - 10^{o}C for chemical analysis.

(ii) Substitution trials Three experiments were conducted at Hawkesbury and one at Armidale, to examine the effect of substituting triticale for wheat in pig diets. The first of'these involved pigs from weaning to approximately 20 kg live weight, the remaining two from approximately 45 kg to 75 kg..

In experiment I, forty two mixed sex, Large White x Landrace pigs were allocated to three treatments replicated twice. Pigs weighing from 4.0 to 6.0 kg were allocated at random within one replicate and pigs from 6.0 to 8.8 kg to the second replicate. Each group of seven pigs was housed in a weaner cage in a forced ventilation weaner shed. Feed and water were available ad libitum'. The composition of the diets used is in Table 1.

Diets were formulated to be isonitrogenous and isocaloric with triticale supplying equivalent lysine levels to wheat in diet 3. Pigs were individually weighed at weekly intervals and feed consumption was recorded on a pen basis. The duration of the trial was 47 days.

TABLE 1 Composition of pig. diets (g/kg) used in experiment 1

Ingredient	Diet		
	1	2	3
Wheat (13% CP)	730		400
Triticale (10.5% CP)		650	270
Meal meal	100	120	120
Soybean meal	120	150	140
Hipro sunflower meal	30	60	50
Mineral/vitamin premix	10	10	10
Soybean oil	10	10	10

In experiment 2, twenty four entire male Large White x Landrace pigs of approximately 45 kg body weight were randomly allocated to four treatments. 'Pigs were fed in individual feeding stalls and were housed in groups of six in a naturally ventilated grower house. Feed was offered once daily mixed with an equivalent weight of water and all feed not consumed within one hour was weighed back. The composition of the diets used in shown is Table 2. Diets were formulated to contain equal energy,' lysine, methionine and threonine levels. Diets 2, '3 and 4 contained 33.3, 66.7 and 100% of the lysine level of diet 1 contributed by triticale (var. Quickgro, -9% CP)'.

TABLE 2 Composition (g/kg) of pig diets used in experiment 2

Ingredient	Diet			
	1	2	3	4
Wheat (12% CP)	828	554	271	
Triticale		266	542	820
Soybean meal	30	30	30	30
Meat meal	80	80	80	80
Hipro sunflower meal	40	40	40	40
Soybean oil		4.5	6.3	9.4
dl-methionine		0.1	0.3	0.5
l-threonine		0.2	0.4	0.5
Shirley phosphate	12	11	10	9
Filler (ground rice hulls)		4.4	10.5	8.7
Premix	10	10	10	10

Pigs were weighed at 14 days intervals and feed allowances were adjusted accordingly based on the ARC semi-<u>ad lib</u> scale (ARC 1967). The trial was concluded when the average live weight of all pigs reached 70 kg when backfat thickness was measured using a "Meritronics" backfat tester.

TABLE 3 Composition (g/kg) of pig diets used in experiment 3

Ingredient	Diet			
	1	2	3	4
Wheat (12% CP)	828	552	276	
Triticale		238	476	715
Soybean meal	30	30	30	30
Meat meal	80	80	80	80
Hipro sunflower meal	40	40	40	40
Soybean oil		16	33	48
l-threonine	0.1	0.1		
Shirley phosphate	12.5	11.3	10	9
Filler (ground rice hulls)		23	45	68
Premix	10	10	10	10

TABLE 4 Ingredient (g/kg) and chemical composition of experimental diets offered to five groups each of six pigs in experiment 4

	1	2	3	4	5
Triticale (13.5% CP)		818	642	747	718
Wheat (13.5% CP)	818				
Soybean meal (46.6% CP)	100	100			
Meat meal (45% CP)	80	80		50	60
Sunflower meal (34.8% CP)			130	200	70
Lupinseed meal (29.3% CP)			200		150
Bone meal			25		
L-Lysine HCl			1.2	0.8	0.4
Vitamine-mineral premix	1.0	1.0	1.0	1.0	1.0
Chromic oxide	1.0	1.0	1.0	1.0	1.0
Calculated composition					
Digestible energy (MJ/kg)	14.4	14.2	14.1	13.8	14.2
Crude protein (g/kg)	186	186	186	185	186
Lysine (g/kg)	9.5	9.5	9.2	9.2	9.2
Determined composition					
Digestible energy (MJ/kg)	13.3[a*]	13.4[a]	12.7[bc]	12.5[b]	12.8[c]
Crude protein (g/kg)	191	183	191	182	178
Crude protein digestibility (g/kg)	787	803	793	767	782
Lysine (g/kg)	7.9	8.1	8.7	8.3	7.5
Arginine (g/kg)	11.7	18.3	18.8	19.6	13.6
Threonine (g/kg)	6.8	6.5	6.4	6.6	5.7
Isoleucine (g/kg)	7.1	5.8	6.5	6.7	6.2
Leucine (g/kg)	13.9	12.2	11.9	12.2	11.4
Neutral detergent fibre (g/kg)	106	118	161	166	163

*Values with the same superscript are not significantly different ($P>0.05$)

Experiment 3, shown in Table 3, was conducted in similar fashion to experiment 2 using a different triticale (var. AT6, 12.5% CP).

Experiment 4 was conducted at Armidale. Thirty Large White x . . Landrace entire male pigs (19 kg) were placed in individual pens in a temperature-controlled (22°C) piggery.' Following a short period of adjustment five pigs were allocated to each of the five diets (Table 4); these were by calculation isocaloric and isonitrogenous. Restricted amounts of each diet were offered once daily, using the formula

$$\text{feed (g/d)} = 120W(\text{kg})^{0.75}$$

Pigs were weighed each week and their daily feed allowance adjusted accordingly. The experiment was terminated when each pig weighed 45 kg, and backfat thickness was then measured using an ultrasonic instrument (Scanoprobe, Ithaca).

Apparent digestibility of feed dry matter, nitrogen and energy of each pig diet was determined using chromic oxide (0.1%) in the feed and its concentration measured incorresponding faeces to determine. faecal output.

Layer trial

Fifty White Leghorn x Australorp hens of' the Hyline strain aged 31 weeks with an average liveweight of 1.99 kg were allocated at random to single bird laying cages in an open sided gable roofed shed. Pens were then allocated at random to one of the five treatments. Birds had access to feed (in individual troughs) and water at all times and were on a 16 hour lighting programme. The composition of the diets used in shown in Table.5. Diets were formulated to contain equal amounts of energy, lysine, methionine and threonine.

TABLE 5 Composition of diets (g/kg) in the laying trial

Ingredient	Diet				
	1	2	3	4	5
Wheat (15.3% CP)	790	593	395	198	
Triticale (10.6% CP)		198	395	593	790
Meal meal (50% CP)	50	50	50	50	50
Soybean meal (46% CP)	50	50	50	50	50
Sunflower meal (38% CP)	30	30	30	30	30
Shirley phosphate	20	20	20	20	20
Limestone	50	50	50	50	50
l-lysine HCl	1.2	1.2	1.2	1.2	1.2
dl-methionine	0.5	0.5	0.7	0.9	1
Soybean oil	9	7	5	2	
Premix	10	10	10	10	10
Caraphyll orange (ppm)	250	250	250	250	250

The birds were weighed at the beginning o-f the experiment, at 31 weeks of age, and at the end of the experiment at 41 weeks of age. Egg production of each'hen was recorded daily and feed consumption was recorded over 14 days. During the last 14 days of the experiment, 5 eggs from each hen were collected and used to determine average weight, yolk colour, specific gravity and albumen quality. .

Broiler trials .

A preliminary experiment wasconducted in battery brooder cages to examine the substitution of two samples of triticale for wheat.

Four replicate groups of eight treatments, each containing six male chicks were housed in battery brooder cages at one week of age and received the test diets for 15 days. Weight gains and food conversion ratios were measured for the 15 day trial period. The diets used and their calculated composition are presented in Table 6. These diets were formulated on a Qeleq analog computer.

TABLE 6 Composition of diets (g/kg) used in chick trial (air-dry basis)

Ingredient	Diet							
	1	2	3	4	5	6	7	8
Wheat (15.3% CP)	670			505	355	175		
Triticale (10.6% CP)		635						
Triticale (14.3% CP)			700	175	350	525	700	700
Meat meal (50% CP)	105	120	125	125	125	125	125	125
Soybean meal (46% CP)	185	210	150	155	140	145	150	150
Soybean oil	30	25	15	27	20	20	15	15
l-Lysine HCl	1.2	.43	.91	1.57	1.66	1.29	1.55	1.55
Methionine	1.46	1.62	1.55	1.52	1.58	1.56	2.05	2.05
Premix	5	5	5	5	5	5	5	5
Salt	2.01	2.72	2.73	2.01	2.24	2.48	2.73	2.73
l-Threonine								.5
Calculated composition								
Metabolizable energy (Kcal/kg)	3122	3004	3181	3132	3147	3178	3818	3181
Crude protein	240	224	232	236	231	231	232	232
Lysine	12.8	12.7	12.2	12.8	12.5	12.3	12.7	12.7
Methionine	4.2	4.4	4.3	4.4	4.4	4.5	4.8	4.8
Methionine + cysteine	7.2	7.3	7.9	7.3	7.5	7.7	8.2	8.2
Threonine	7.3	7.2	7.3	7.2	7.1	7.2	7.2	7.7

A second experiment was conducted to study the effect of substitution of triticale for wheat in broiler finisher rations. Two

TABLE 7 Composition of diets (g/kg) used in broiler finished trial (28 to 43 days)

Ingredient	Diet			
	1	2	3	4
Triticale (12.6% CP)		250	500	750
Wheat (12% CP)	750	500	250	
Meat meal	100	100	100	100
Soybean meal	40	40	40	40
Hipro sunflower meal	60	60	60	60
Tallow	40	40	40	40
Premix	10	10	10	10
l-Lysine HCl	0.22	0.54	0.37	0.2
dl-Methionine	1.43	1.51	1.79	0.2

thousand mixed sex broiler chickens were allocated at random to 20 pens in a conventional style broiler shed. These. birds were fed on a commercial broiler starter ration for 28 days and the pens were randomly allocated to four treatments given 5 replicates of each treatment. The birds were weighed at this stage and feeding of the experimental diets was commenced. The birds were again weighed at the conclusion of the trial, 25 days later. Feed consumption was recorded for this period. The composition of the diets used is shown in Table 7.

'Diets were formulated to contain equal amounts of energy, lysine and methionine.

A taste panel test was conduced on representative birds from each treatment to determine any differences in flavour of cooked meat from any of the treatments. Twenty six untrained subjects were offered coded samples of meat cooked under identical conditions from each of the treatments. They were asked to determine the presence of different' flavours between the samples and the level of these differences on a graduated scale. They were also asked to rank the samples in order of preference for flavour.

RESULTS

Chemical analysis

The crude protein values obtained for the triticale samples are shown in Table 8 and the amino acid analysis of selected samples is shown in Table 9.

TABLE 8 Crude protein (N x 5.76, %) of triticale samples (air-dry basis)

Variety	Location 1	Location 2	Location 3	Location 4
AT 1	14.5	16.1	14.5	15.4
AT 2	14.3	15.8	14.5	15.7
AT 3	12.6	13.3	13.9	13.3
AT 4	14.1	15.8	13.8	15.2
AT 5	14.2	14.6	13.5	15.2
AT 6	13.5	14.7	13.3	13.9
AT 7	13.9	14.4	13.6	14.9
AT 8	12.8	14.0	13.0	13.7
AT 9	12.9	14.2	12.7	14.4
AT 10	14.1	14.6	17.2	15.0

There was a significant negative correlation between lysine content of protein and crude protein level ($r = -0.70$).

The values for tannin content in the triticale samples analysed 'are shown in Table 10.

TABLE 9 Amino acid composition of 'triticale samples ('air-dry basis) grams of amino acid per 100 grams of sample

Amino Acid	Sample							
	AT4	AT5	AT1	AT8	AT10	Quickgro		
						A	B	C
Asparatic acid	.81	.84	1.04	.78	.88	.82	.61	.56
Threonine	.44	.46	.59	.42	.48	.46	.30	.30
Serine	.64	.57	.64	.65	.72	.67	.43	.40
Glutamic acid	4.25	4.00	4.99	3.79	4.38	3.98	2.29	2.03
Proline	1.26	1.28	1.51	1.16	1.61	1.43	1.11	.70
Glycine	.61	.58	.73	.57	.60	.66	.44	.36
Alanine	.55	.56	.61	.50	.57	.57	.42	.36
Cystine	.34	.32	.39	.31	.31	.16	.17	.15
Valine	.60	.61	.71	.56	.64	.55	.40	.33
Methionine	.16	.10	.15	.10	.16	.21	.14	.11
Iso-leucine	.51	.49	.58	.46	.54	.43	.34	.24
Leucine	.94	.95	1.05	.84	1.08	.85	.64	.52
Tyrosine	.45	.45	.57	.45	.52	.36	.29	.21
Phenylalanine	.62	.64	.76	.62	.73	.58	.48	.35
Lysine	.37	.47	.50	.44	.52	.47	.39	.33
Histidine	.29	.38	.39	.33	.38	.35	.26	.17
Arginine	.77	.88	.93	.94	1.06	.83	.74	.37
Crude protein (%)	14.1	12.6	16.1	12.8	14.1	14.0	10.0	8.3
Lysine (% of protein)	2.62	3.73	3.11	3.44	3.69	3.36	3.90	3.98

TABLE 10 Tannin content (%) of Triticale samples (air-dry)

Sample	AT1	AT7	AT6	Bronco 90	32A76	48A77	T119
	.08	.098	.064	.071	.048	.071	.063
Sample	ARM1524	ARM157	17A76	58A77	Groquick	3A76	
	.058	.052	.073	.073	.058	.104	

Rat trial

'The mean values obtained for 14 day weight gain and feed conversion ratio in the rat growth trial are shown in Tables 11 and 12 respectively,

The addition of lysine to all diets increased growth rate and improved feed efficiency, significantly ($P<0.05$) in the case of growth rate on the low protein triticale and wheat, and in all cases of feed efficiency. Similarly the addition of threonine resulted in significant improvements in growth rate in all but the highest protein triticale diet with a similar but not significant trend in feed efficiency. The use of soybean meal and fishmeal as a source of essential amino acids gave no further improvement in performance over the triticale diets supplemented with lysine and threonine. There is a suggestion from the feed efficiency data that the addition of methionine to a low protein triticale diet'may give some improvement.

. TABLE 11 Mean 14 day weight gain (g) of rats fed diets based on triticales of three protein levels and wheat

	Diet base			
	Triticale	Triticale	Triticale	Wheat
Protein level (%)	15.6	14.0	13.7	14.0
Supplement				
0	43.9[ab*]	40.3[ab]	39.3[ab]	27.8[a]
+ Lysine	56.3[bcd]	54.7[bc]	60.4[cd]	45.1[bc]
+ Lysine + threonine	72.5[def]	75.8[def]	79.2[cf]	70.7[def]
+ Soybean meal + fish meal	64.4[ae]	78.7[ef]	83.8[f]	78.5[ef]
+ Lysine + threonine + methionine			78.8[ef]	

*Values with the same superscripts in rows and columns are not significantly different (P>0.05)

TABLE 12 Mean feed conversion ratios of rats fed diets based on triticales of different protein levels and wheat

	Diet base			
	Triticale	Triticale	Triticale	Wheat
Protein level (%)	15.6	14.0	13.7	14.0
Supplement				
0	4.37[ef*]	4.19[e]	4.94[f]	4.67[ef]
+ Lysine	3.19[cd]	3.27[d]	3.08[bcd]	3.40[d]
+ Lysine + threonine	2.69[abcd]	2.55[abc]	2.47[ab]	2.33[a]
+ Soybean meal + fish meal	2.70[abc]	2.35[a]	2.45[ab]	2.36[a]
+ Lysine + threonine + methionine			2.29[a]	

*Values with the same superscripts in rows and columns are not significantly different (P>0.05)

Pig trials

(i) Digestibility trial The results obtained from the digestibility trial are shown in Table 13. Each value is the mean of four individual pig values.

There appears to'be little difference between the values obtained for the two triticale samples.

TABLE 13 Means and standard errors of digestibility parameters for pigs fed diets based on triticale

	Triticale	
	13.9% CP	15.4% CP
Dry matter digestibility %	86.3 ± 0.44	85.9 ± 0.30
N digestibility %	82.5 ± 2.53	85.9 ± 0.90
Energy digestibility %	85.7 ± 0.61	85.4 ± 0.26
Gross energy kj/kg*	18660	18693
Metabolisable energy %	83.9 ± 0.50	83.6 ± 0.52
N adj. metabolisable energy %†	81.9 ± 0.40	81.4 ± 0.60
N retention %	27.5 ± 2.98	31.7 ± 2.41

* Energy values on a D.M. basis
† ME value adjusted for N retention (Diggs *et al*. 1959)

(ii) Substitution trials The mean daily weight gains and group'feed conversion ratios of pigs obtained inexperiment 1 are shown in Table 14.

TABLE 14 Mean daily weight gain (g/day) and feed conversion ratio (FCR) of pigs (Experiment 1)

	Treatment	Gain (g/d)	FCR
1	(All wheat)	300	1.87
2	(All triticale)	305	1.86
3	(Triticale + wheat)	305	1.89

There were no significant (P>0.05) treatment difference between diets when pigs (4-8 kg) were grown for 47 days on diets shown in Table 1.

The mean daily weight gains, feed conversion. ratios and backfat thickness obtained for experiment 2 are shown in Table 15.

TABLE '15 Mean daily liveweight gain (g/day), feed conversion ratios (FCR) and backfat thickness (BF mm) of groups of pigs grown from 45 to 70 kg (Experiment 2)

	Treatment	Gain (g/d)	FCR	BF (mm)
1	(All wheat)	750[a]	3.65	17.7
2	(1/3 Triticale)	780[a]	3.59	17.0
3	(2/3 Triticale)	550[b]	4.46	19.0
4	(All Triticale)	580[b]	4.47	18.0

*Values with the same superscripts are not significantly different (P>0.05)

A. significant (P<0.05) depression in growth occurred on the two diets (3 and 4) containing high levels of triticale. This' trend also appeared in FCR but it was not significant.

The values obtained for daily weight gain, feed conversion ratio and backfat thickness from experiment 3 are shown in Table 16.

TABLE16 Mean daily liveweight gain (g/day), feed conversion ratios (FCR) and backfat thickness (mm) of pigs grown from 45 to 70 kg (Experiment 3)

	Treatment	Gain (g/d)	FCR	BF (mm)
1	(All wheat)	600*	2.97	18.0
2	(1/3 triticale)	730	2.73	16.9
3	(2/3 triticale)	690	2.79	18.7
4	(All triticale)	650	3.08	19.1

*There were no significant (P>0.05) differences between treatments for any parameter

There were, no differences in growth and FCR between wheat- and triticale-based diets (1 and 2) thereby indicating that the variety of triticale (var. Quickgro) used was equal to that of wheat in nutritive value (Table 17). Analysis of diets (Table 4) showed them to be isonitrogenous but not isocaloric as calculated.. Digestible energy contents of diets 1 and 2 were higher than the remainder. Because pigs on all treatments were on the same feeding scale it was not surprising that differences in performance occurred. Had pigs on diets 3 and 4 been given amounts of feed commensurate with the actual digestible energy contents of the diets differences in performance between groups did not necessarily reflect differences in protein quality of the diets.

TABLE 17 Growth rate, feed conversion ratio and backfat thickness of groups of 6 pigs per treatment grown from 20-45 kg

	Diet				
	1	2	3	4	5
Growth rate (g/d)	620[a]	630[a]	490[b]	520[b]	600[a]
Feed conversion ratio	2.45[a]	2.44[a]	3.16[b]	2.94[c]	2.58[a]
Backfat thickness (min)	9.8[ab]	9.6[ab]	11.1[a]	8.3[b]	10.7[a]
Digestible energy intake (MJ/kg gain)	32.5[a]	32.6[a]	40.0[b]	36.7[c]	32.9[a]

Layer trials-

The results obtained for hen day production (%), daily feed intake per hen (g/day), egg weight (g), bodyweight change (kg), specific gravity, Haugh Index and yolk colour are shown in Table 18.

TABLE 18 Mean hen day production, daily feed intake, egg weight, body weight change, specific gravity, 'Haugh index and yolk colour

	Hen day production (%)	Feed intake (g/day)	Egg wt (g)	Body wt change (kg)	Specific gravity	Haugh index	Yolk colour
1 (All wheat)	78.4	122	58.7	0.12	1.071	79.7	12.1[a*]
2 (25% triticale)	80.1	127	58.3	0.07	1.075	82.5	11.8[ab]
3 (50% triticale)	78.0	124	57.5	0.14	1.076	82.7	11.8[ab]
4 (75% triticale)	81.6	133	57.8	0.16	1.075	84.3	11.7[b]
5 (All triticale)	79.6	127	59.4	0	1.075	81.6	11.3[c]

*Values with the same superscripts are not significantly different ($P<0.05$)

There were no significant differences in any parameters except yolk colour. There was a significant depression of yolk colour at high levels of triticale substitution.

Broiler trials

(i) Chick trial The values obtained for weight gains and feed conversion ratios are shown in Table 19.

TABLE 19 Mean weight gain (g) and feed conversion ratio of broiler chicks grown from 7 to 22 days .

	1	2	3	4	5	6	7	8
Gain (g)	334*	363	375	373	377	362	368	373
FCR	1.55	1.56	1.53	1.55	1.54	1.52	1.60	1.54

*An analysis of variance of these results indicated that there was no significant ($P>0.05$) difference between treatments

(ii) Broiler finisher trial The values obtained 'for weight gains and feed conversion ratios are shown in Table 20.

TABLE 20 Mean weight gain (g) and feed conversion ratios of broiler . chickens from 28 to 43 days

	Treatment	Weight gain (g)	FCR
1	(All wheat)	953*	3.00
2	(1/3 triticale)	971	2.94
3	(2/3 triticale)	974	2.95
4	(All triticale)	1006	2.97

*There was no significant ($P>0.05$) difference between treatments

(iii) Taste panel The results of the taste panel test are shown in Tables 21 and 22.

TABLE 21 Test for differences in flavour, comparing broiler meat from treatment 1 (all wheat) to meat from triticale diets (numbers of respondents)

	Treatment 2 (1/3 triticale)	Treatment 3 (2/3 triticale)	Treatment 4 (All triticale)
Extreme difference			1
Moderate difference	5	3	6
Slight difference	8	11	9
Very slight difference	8	8	3
No difference	5	4	7

TABLE 22 Flavour preferences comparing meat from treatment 1 (all wheat) to meat from triticale diets

	Treatment 2	Treatment 3	Treatment 4
Better flavour	6	4	8
Similar flavour	13	14	8
Flavour not as good	6	7	9

There were some differences in flavour between the samples of meat but there was no preference for the flavour of any meat.

DISCUSSION

The results of the chemical analysis indicate a wide variation in crude protein content betweenvarieties and in all samples tested; a range of 8.3% to 17.2% was obtained. This is a similar range to that found by Villegas et al. (1970) working on Mexican varieties. Similarly with lysine content of the 'protein, the above workers found a significant negative correlation between lysine content and crude protein level. However, it does appear that the lysine content of the protein is higher than that of wheat which have a reported maximum lysine level of 3.8 g/16 g N (Ivan 1974). Variation in these factors therefore makes it difficult to have available standard values which can be used for feed formulation.

The results of tannin estimations indicate relatively low levels of tannin present in all samples tested with only one variety (3A76) exceeding 0.1%. Since a level of approximately 0.5% is required before a growthdepressionoccurs in chicks (Vohra et al. 1966), it appears unlikely that tannins in the samples tested would cause growth depression.

The data obtained from the rat growth study seem to confirm the conclusions of Shimada and Cline (1974) to the effect thatlysine and threonine are the essential amino acids limiting to rat growth in triticale. There is also a suggestion that supplemental methionine may benefit in triticales of relatively low protein content. These results also indicate that essential amino acids other than lysine and threonine are in sufficient supply in triticales to support adequate growth since no further improvements occurred when a high quality protein source (fishmeal and soybean meal) was used to supplement the protein of the diet.

The ME values for triticale obtained from the pig measurements are somewhat higher than those of Cornejo et al. (1973) and Shimada and Cline (1974) although the digestible energy values are in closer agreement. The ME values however, do agree quite closely with those of Farrell (1978) using Australian varieties of triticale in chickens. It may be that the more recent varieties of triticale have higher energy values than the earlier varieties. It was also apparent that there was very little differences in energy values for the two samples tested. The relatively low values obtained for nitrogen retention are probably due to amino 'acid imbalance arising from the use of complete grain diets.

The data obtained from the substitution experiments indicate that for pigs from weaning to 20 kg liveweight, and from 20 to 45 kg liveweight the triticales used in experiments 1 and 4 respectively can effectively substitute for wheat on a protein and energy basis without affecting growth rate and feed efficiency. However, because of the small scale of the experiments and the fact that only two samples of triticale were tested' it is not possible to make any general feeding recommendations. Similarly, the data from experiments 2 and 3 appear to conflict since severe growth depression occurred in experiment 2 at levels of triticale inclusion above 48% of the total diet, whereas no growth depression was observed in experiments 3 and 4.Thus it would seem that there may be some factor present in the sample of triticale used in experiment 2 which led to growth depression. Since daily feed allowances were set according to Iiveweight, pigs fed on the higher triticale diets ate less due to lighter body weights. However, there was no rejection of feed by pigs on these diets which suggests that acceptability was not a problem in this case, as has been suggested by Harrold et al. (1971). King (personal communication 1980) has preliminary results which indicate that a trypsin inhibitor is probably involved. It would be desirable to establish if there is a growth inhibitor in triticale and to define it in order that firm recommendations may be made regarding inclusion level of this grain in pig diets.

The results from the layer trial show that even when there was 100% substitution for wheat, the' sample of triticale used here did not'affect laying performance. It is interesting to note that depression of yolk. colour does occur at levels of inclusion above 59% of the total diet. This observation has also been reported by Chondhary and Netke (1976) and Karunajeewa (1978); the latter author suggested an unknown factor inhibiting the utilization of xanthophyll pigments. Since the level of depression occurring in the present experiment was only 0.8 of one unit on the Roche Colour Fan, this 'is likely only to be a problem in cases where producers are just above the yolk colour level set by marketing authorities.

The results for both broiler trials indicate that the substitution of triticale for wheat in broiler rations does not depress growth or feed efficiency. The relatively poor growth rates and feedconversion ratios obtained in experiment 2 can probably be attributed to the combined effects of using a mash-type diet and the cool weather during the period of the trial.

Since allowances were made in these experiments for energy level, lysine, methionine and threonine levelsand there was no erogt . 'contamination of the samples it would appear that triticale such as used here can effectively substitute for wheat in broiler diets. It would also appear that there were no major differences in lysine availability between wheat and triticale demonstrated here., a reason advanced for poorer growth or feed efficiency by some wbrkers (Allee and Hines 1972b).

In regard to the taste panel tests on meat from birds fed on triticale-based diets, approximately 80% of testers detected some difference in flavour between meat of birds on triticale based diets and that of birds on wheat based diets. However, there was very little difference between the 'meat of birds from diets with increasing levels of triticale. Simiarly there was no definite preference exhibited for or against the flavour of the meat of triticale-fed birds compared to meat of birds fed wheat. It may be that the design of the questionnaire for the taste test influenced the response of participants in that they were actively seeking differences between samples. Although they felt they were able to detect differences, panelists were unable to determine whether these differences were preferable or not. The level of difference also illustrates these points, since approximately 60% of panelists could only detect slight or very slight differences.

CONCLUSIONS

Chemical analysis indicated a wide range in crude protein content of Australian-grown triticales with a significant negative correlation between crude protein level and lysine content of the protein. Analysis of tannin content of triticales shows a range from .048% to .104%. These levels appear unlikely to cause growth depression in chicks.

Rat growth trials indicated that lysine and threonine are limiting amino acids in triticales confirming overseas results.' It is likely therefore that these amino acids will also be limiting growth of the chick and the pig.

In combination with the results for chemical analysis and the rat 'growth trial, the digestibility trials indicate that on the basis of crude protein, amino acid and energy contents, triticale is equivalent to or better than wheat as a feed grain.

This conclusion is born out to some degree by the substitution trials with pigs, layers and broilers although some qualification must be made regarding the growth depressing effect noted in one sample of triticale and the effect on yolk colour. It is desirable that the cause for this depression is established. Acceptability and lysine availability do not appear to have been the problems reported by other authors.

The results of the taste. panel test of meat of chickens grown on triticale-based diets are fairly equivocal with some degree of flavour difference being detected, but no preference for or against this flavour difference being apparent.

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