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The Potential of High-Yielding Triticale Varieties in the Diet of Broiler Chickens

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ABSTRACT

A study was undertaken to test the nutritional potential of new high-yielding, high protein varieties of triticale developed at University of New England, Australia containing higher protein (around 20%) for their feeding value in broiler chicken. Three hundred and fifty day-old Cobb broiler chicks was randomly allocated to 10 treatments consisting of 5 cereal diets viz., one wheat and four triticale varieties (H55, H128, H431 and H261) incorporated at 40% level in diet and 5 corresponding diets supplemented with microbial enzyme. The weight gain to 22 day of age on the wheat-fed group was higher ($p<0.01$) than on H128 and H261 but not the groups raised on H55 and H418. The jejunal mucosal protein was lowest ($p<0.055$) in enzyme-supplemented groups and the activity of alkaline phosphatase was higher ($p<0.05$) in chickens on H55 and H128 than on the wheat-based or H418 diets. The ileal protein digestibility on the wheat-based diet was higher ($p<0.01$) than on H128 and H261 with lower starch digestibility in H418. It is most probable that these triticale varieties would have similar feeding values as wheat for broiler chickens, provided the diets are iso-caloric and iso-nitrogenous. Enzyme supplementation did not influence growth performance probably due to lower soluble non-starch polysaccharide levels.

Key words: Chicken, cereal, enzyme supplementation, performance, nutrient utilization

INTRODUCTION

Triticale, the result of inter-specific crosses between rye and wheat, has remained a minor cereal grain in Australia mainly due to the low volume of production. Since 1979, Australia has released several triticale varieties for farmers and most of these are used locally to feed poultry, pigs, cattle and sheep, although some of it is exported to Southeast Asia. However, its use in human food has been negligible (Andrews *et al.*, 1991). The rapid adoption of the crop was because of the high yield in some areas, notably those with acid soils, the existence of a ready market for stock feed grain and the fact that direct farmer-to-manufacturer sales are possible. Early triticale varieties were reported to have a poor feeding value relative to wheat and were not considered suitable for poultry diets. However, later studies have shown different results with positive performance of feeding triticale on broiler performance, probably due to variety differences, inclusion levels and enzyme supplementations (Jozefiak *et al.*, 2007; Santos *et al.*, 2008; Zarghi and Golian, 2009). The nutritive value of rye, wheat and triticale depends on the soluble Non Starch Polysaccharide (NSP) content which is responsible for increasing gut viscosity and in turn affecting the availability of nutrients for digestion and absorption (Bedford and Classen, 1992; Choct, 2006). However, addition of commercial enzymes to wheat/triticale based diets have overcome this problem and enhanced the feeding value for broiler chickens/turkey (Hermes and Johnson, 2004; Santos *et al.*, 2004a, b; Garipoglu *et al.*, 2006; Joaquim *et al.*, 2006; Pourreza *et al.*, 2007; Jozefiak *et al.*, 2007; Zarghi *et al.*, 2010). The behaviour of hens fed a glycanase enzyme in triticale based diet has also been studied (Habte-Micael and Glatz, 2002).

Recent breeding at the University of New England, Australia has created new varieties which are high-yielding and contain more protein (around 20%) than most other cereal grains. These varieties are being released for cultivation and the objective of the study was to investigate their feeding value for poultry.

MATERIALS AND METHODS

All experimental procedures followed were approved by the University of New England Animal Care and Ethics Committee.

Bird and housing: A total of 350-day-old Cobb broiler chicks, vaccinated against Marek's disease, infectious bronchitis and Newcastle disease obtained from a local hatchery were randomly allocated to 10 treatments of 5 replicates each (7 birds per replicate). The chicks were reared in brooder cages with wire floor in environmentally controlled experimental room. The temperature was set at 33°C for the first three days and gradually reduced to 24°C at 21 day of age. The study was conducted during August-September, 2008.

Experimental diets: The 10 diets consisted of 5 cereal diets viz., one wheat and four triticale varieties (H55, H128, H431 and H261) incorporated at 40% level in diet (Table 1) and 5 corresponding diets supplemented with a microbial enzyme, Avizyme 1302 (Danisco, Marlburough, Wiltshire, UK) at 0.5 g kg^{-1} diet. The guaranteed minimum activity of the supplemental enzyme is 5000 U g^{-1} endo-1, 4-beta-xylanase (EC 3.2.1.8) and 1600 U g^{-1} protease (EC 3.4.21.62). Celite (acid-insoluble ash, 5 g kg^{-1}) was added to the diets as a marker for digestibility measurement. Chickens had *ad libitum* access to feed and water.

Response criteria: Body weight and feed intake were recorded at weekly interval. Mortality was recorded as and when occurred. Feed conversion ratio and protein efficiency was calculated and corrected for mortality. On day 22, four chickens were selected at random from each replicate and euthanized by cervical dislocation. Each bird was dissected and the contents of the ileum were pooled within a cage and frozen immediately for digestibility measurements.

The digest samples were freeze-dried and ground for further analyses The diets and excreta were analyzed for gross energy by bomb calorimeter (IKA C7000 calorimeter, IKA-Werke, Staufen, Germany), nitrogen by nitrogen analyzer (Leco FP 2000, protein/nitrogen analyzer, Michigan, USA) and starch by Megazyme total starch assay (AOAC, 1996). The concentrations of Acid-Insoluble Ash (AIA) in the diet and digesta were measured, in line with methods described by Annison *et al.* (1996). The apparent digestibility coefficient of the nutrients was then calculated from the equation:

$$\text{Apparent digestibility} = \text{I} - \left[\frac{\text{Ileal nutrient/Ileal AIA}}{\text{Diet nutrient/Diet AIA}}\right]$$

One bird from each replicate was used for measurement of visceral organ weights. For enzyme analyses, pancreas (whole) and jejunum (around 2 g, after flushing with normal saline) from one

Table 1: Ingredient and nutrient composition of diet

Parameters	Wheat	Triticale
Ingredient (%)		
Wheat	40.00	0.00
Sorghum	22.94	29.42
Soybean meal	30.20	21.80
Triticale	0.00	40.00
Vitamin/mineral premix[a]	0.20	0.20
Choline chloride	0.05	0.05
Fat/oil	2.30	4.00
Limestone	1.30	1.30
DCP	1.70	1.70
Salt	0.40	0.40
Lysine	0.21	0.39
Methionine	0.20	0.24
Celite	0.50	0.50
Calculated nutrient composition (g kg^{-1})		
ME (kcal kg^{-1})	2985.90	2984.60
CP	220.00	220.00
Lysine	12.10	10.20
Methionine	5.00	5.10
Threonine	7.40	6.30
Ca	10.10	10.00
P, avail.	4.60	4.50

[a]Vitamin-mineral premix supplied the following per kilogram of diet: 3 mg of Vitamin A (retinyl acetate), 0.0625 mg of Vitamin D3 (cholecalciferol), 50 mg of Vitamin E (DL-α-tocopheryl acetate), 2 mg of thiamine, 10 mg of riboflavin, 50 mg of niacin, 7 mg of D-calcium pantothenate, 7 mg of pyridoxine, 25 µg of cyanocobolamin, 250 µg of biotin, 0.3 mg of Se, 1 mg of I, 0.5 mg of molybdenum 0.25 mg of Co

bird of each replicate were snap-frozen in liquid nitrogen and then stored at -20°C for later analyses of enzymes. The concentrations of protein in the pancreas and jejunal mucosa were measured using the Coomassie dye-binding method described by Bradford (1976). For the jejunum, the homogenate was prepared following the method of Shirazi-Beechey *et al.* (1991) and for pancreatic homogenate as per Nitsan *et al.* (1974). The specific activities of enzymes; maltase (EC. 3.2.1.20), sucrase (EC. 3.2.1.26), alkaline phosphatase (AP, EC. 3.1.3.1) and chymotrypsin (EC. 3.4.21.1) were measured by Iji *et al.* (2001a-c).

Non-Starch Polysaccharides (NSP) were analyzed for the wheat and triticale samples (Englyst and Hudson, 1993; Theander and Westerlund, 1993). The amino acid content of the test ingredients were analyzed at the Australian Proteome Analysis Facility Ltd, Macquarie University, Sydney, NSW, Australia, using a precolumn derivatisation method (AccQTaq, Waters, Milford, MA, USA).

Data were subjected to two-way analysis of variance for completely randomized design and tested for significance between the dietary treatment means (SPSS, 2008).

RESULTS

Chemical composition: The triticale variety H418 and H55 contained higher protein content (Table 2) but lower starch content than the other grains (Table 3). The protein of wheat, triticale H128 and H261 contained higher lysine, methionine and threonine than those of triticale H418 and H55. All the samples had low soluble NSP content.

Table 2: Analyzed crude protein (%) and amino acid contents (g kg^{-1} protein) of test ingredients

Parameters	Wheat	H418	H55	H128	H261
Crude protein					
Diet	23.90	22.60	21.70	18.80	19.40
Ingredient	15.90	20.30	19.40	10.80	11.60
Amino acid					
Lysine	4.18	2.73	2.93	3.81	4.01
Methionine	1.74	0.99	1.01	1.37	1.53
Threonine	4.26	3.08	3.11	3.27	3.49
Arginine	6.56	3.46	3.78	5.16	5.46
Glutamic acid	50.53	29.57	28.45	27.49	29.83
Histidine	3.59	2.13	2.20	2.50	2.67
Alanine	5.27	5.23	5.39	4.41	4.70
Valine	6.63	5.47	5.59	4.92	5.27
Isoleucine	5.68	4.00	4.00	3.87	4.09
Leucine	10.27	6.94	6.85	6.83	7.41
Phenylalanine	7.50	4.04	4.04	4.70	5.07

Table 3: Starch and NSP content (as such basis, g kg^{-1}) of test ingredients

Parameters	Wheat	H418	H55	H128	H261
Starch	515.00	480.00	491.00	572.00	549.00
Total NSP	92.59	107.12	101.48	89.17	88.65
Soluble NSP	11.84	10.05	10.51	12.47	10.76
Insoluble NSP	80.75	97.07	90.97	76.70	77.89
Free sugar	18.01	19.82	17.10	21.49	19.90

Table 4: Growth performance of broiler chicks

	Gain (g/b)			Feed intake (g/b)			FCR		
Parameters	0-7d	0-14d	0-22d	0-7d	0-14d	0-22d	0-7d	0-14d	0-22d
Effect of cereal type									
Wheat	85.4	327.2^{a}	773.0^{a}	109.8	446.0^{a}	1181.3^{a}	1.30^{b}	1.39	1.56
Triticale H418	75.4	281.8^{ab}	710.1^{ab}	104.9	389.5^{b}	1040.2^{b}	1.40^{ab}	1.41	1.49
Triticale H55	75.1	286.6^{ab}	733.8^{ab}	104.5	394.3^{b}	1041.5^{b}	1.40^{ab}	1.45	1.47
Triticale H128	78.8	288.2^{ab}	679.7^{b}	110.2	416.6^{ab}	1059.2^{b}	1.41^{ab}	1.48	1.58
Triticale H261	73.3	276.9^{b}	691.3^{b}	107.1	402.7^{b}	1073.2^{b}	1.48^{a}	1.51	1.58
Effect of enzyme supplementation									
Without enzyme	76.0	286.9	711.4	105.5	405.1	1067.2	1.41	1.46	1.53
With enzyme	79.2	297.4	723.8	109.1	414.5	1091.0	1.39	1.43	1.54
SEM	1.61	5.36	8.85	1.29	5.28	12.23	0.018	0.018	0.017
Significance									
Cereal	0.15	0.02	0.01	0.48	0.003	0.01	0.029	0.198	0.092
Enzyme	0.32	0.31	0.45	0.17	0.32	0.44	0.592	0.428	0.599
Cereal × enzyme	0.90	0.91	0.84	0.27	0.52	0.83	0.761	0.161	0.282

Means within the same row with no common superscript differ significantly ($p<0.05$)

Broiler performance: Feed intake was not significantly ($p>0.05$) different up to 7d of age either due to cereal type, enzyme or interaction but at 14d, feed intake in the wheat-based diet was higher ($p<0.003$) than on all the triticale varieties except H128. Feed intake up to 22d was higher ($p<0.01$) on the wheat based diet than on all triticale groups. Feed conversion ratio was not significant ($p>0.05$) during the entire phase except at 7d, whereas chicks on the wheat-based diet were less efficient ($p<0.029$) than those on triticale H261. Cereal type, enzyme or interaction (Table 4) did

Table 5: Apparent ileal digestibility of energy, protein and starch

Parameters	Energy	Protein	Starch
Effect of cereal type			
Wheat	0.770	0.824[a]	0.959[ab]
Triticale H418	0.766	0.819[ab]	0.937[c]
Triticale H55	0.775	0.816[ab]	0.940[bc]
Triticale H128	0.769	0.802[bc]	0.961[a]
Triticale H261	0.762	0.792[c]	0.957[abc]
Effect of enzyme supplementation			
Without enzyme	0.767	0.808	0.943[b]
With enzyme	0.771	0.814	0.958[a]
SEM	0.0036	0.0028	0.0034
Significance			
Cereal	0.845	0.001	0.036
Enzyme	0.550	0.194	0.018
Cereal × enzyme	0.331	0.563	0.229

Means within the same row with no common superscript differ significantly ($p<0.05$)

Table 6: Protein efficiency during different growth phases

Parameters	0-7d	0-14d	0-22d
Effect of cereal type			
Wheat	0.310[a]	0.329[a]	0.368[a]
Triticale H418	0.317[a]	0.312[ab]	0.330[b]
Triticale H55	0.304[a]	0.302[abc]	0.308[bc]
Triticale H128	0.264[b]	0.272[c]	0.293[c]
Triticale H261	0.287[b]	0.285[bc]	0.302[c]
Effect of enzyme supplementation			
Without enzyme	0.298	0.302	0.319
With enzyme	0.295	0.298	0.321
SEM	0.0043	0.0044	0.0047
Significance			
Cereal	0.001	0.001	0.001
Enzyme	0.669	0.516	0.693
Cereal × enzyme	0.752	0.537	0.315

Means within the same row with no common superscript differ significantly ($p<0.05$)

not significantly ($p>0.05$) affect the body weight gain of chicks up to 7 days of age. However, body weight gain at 14d was higher ($p<0.02$) in the wheat fed group in comparison to triticale variety H261. Weight gain at 22d of age on the wheat-fed group was higher ($p<0.01$) than on triticale H128 and H261.

Nutrient utilization: Ileal protein digestibility on the wheat-based diet was higher ($p<0.001$) than on triticale H128 and H261 (Table 5). The starch digestibility of triticale H418 was lower ($p<0.036$) than that of wheat and triticale H128.

During 0-14d of age, the chicks on triticale H128 and H261 had better ($p<0.001$) protein efficiency than those on wheat due to the difference in protein levels in the diet. However, over the entire period of study (0-22d), all triticale fed groups had better ($p<0.001$) protein efficiency than the wheat group (Table 6). Starch digestibility was improved ($p<0.018$) by enzyme supplementation.

Table 7: Tissue protein content and the activities of jejunum and pancreatic digestive enzymes

	Jejunum			Pancreas		
Parameters	Protein[a]	Maltase[c]	Alkaline phosphatase[b]	Sucrase[c]	Protein[a]	Chymotrypsin[d]
Effect of cereal type						
Wheat	30.20	0.91	2.99[b]	0.062	52.52	0.24
Triticale H418	25.99	0.97	2.77[b]	0.072	52.57	0.24
Triticale H55	24.85	0.87	3.98[a]	0.055	52.74	0.23
Triticale H128	25.21	1.07	4.06[a]	0.079	44.38	0.29
Triticale H261	28.41	0.91	3.57[ab]	0.061	49.07	0.27
Effect of enzyme supplementation						
Without enzyme	29.64	0.96	3.56	0.065	51.51	0.24
With enzyme	24.22	0.93	3.38	0.067	49.01	0.27
SEM	1.355	0.024	0.145	0.0029	1.636	0.009
Significance						
Cereal	0.694	0.082	0.013	0.074	0.435	0.216
Enzyme	0.055	0.46	0.517	0.649	0.451	0.17
Cereal × enzyme	0.805	0.86	0.889	0.1721	0.433	0.667

Means within the same row with no common superscript differ significantly ($p<0.05$) [a]Concentration in tissue (mg g^{-1} wet tissue). [b]Specific activity (μmol p-nitrophenol/mg protein/min). [c]Specific activity (ρmole glucose / mg protein / min). [d]Specific activity (μmol p-nitroaniline/mg protein/min)

Table 8: Visceral organ weight (g kg^{-1} of live weight) of broiler chicken

Parameters	Small intestine	Pancreas	Liver	Gizzard + Proventriculus	Spleen	Bursa
Effect of cereal type						
Wheat	53.50	2.87	26.10	39.40	1.17	2.04
Triticale H418	62.90	3.11	27.50	42.90	0.98	2.03
Triticale H55	58.70	3.07	28.40	39.30	0.94	2.16
Triticale H128	56.40	3.05	28.30	41.60	0.97	1.89
Triticale H261	58.10	2.88	29.20	40.10	0.98	1.95
Effect of enzyme supplementation						
Without enzyme	58.40	3.15[a]	28.00	40.80	0.97	1.94
with enzyme	57.40	2.85[b]	27.80	40.50	1.05	2.09
SEM	1.07	0.071	0.45	0.71	0.038	0.060
Significance						
Cereal	0.09	0.71	0.21	0.42	0.34	0.72
Enzyme	0.66	0.04	0.76	0.81	0.27	0.25
Cereal × enzyme	0.72	0.46	0.05	0.28	0.81	0.83

Means within the same row with no common superscript differ significantly ($p<0.05$)

Gut enzyme activities: Maltase and sucrase activities in the jejunum were not significantly ($p>0.05$) affected by cereal, enzyme or their interaction (Table 7). The activity of alkaline phosphatase was also significantly higher ($p<0.013$) in chickens fed triticale H55 and H128 than on the wheat-based or triticale H418 diets. Jejunal mucosal protein was lower ($p<0.055$) on enzyme-supplementation. Mucosal protein content and chymotrypsin activity in the pancreas were non-significant ($p>0.05$).

Carcass traits: The weight of the pancreas was lower ($p<0.05$) due to enzyme supplementation (Table 8). The weight of other visceral organs (small intestine, liver, proventriculus, gizzard, bursa) assessed was not significant ($p>0.05$).

DISCUSSION

The triticale varieties H418 and H55 contained higher protein content due to genetic improvement. It should be pointed out that the diets were formulated on the basis of nutrient specifications in existing databases. The grains were analysed again after we had analysed diets in order to measure nutrient digestibility. The results indicated a lower protein content, particularly for triticale varieties H128 and H261 than we found in the preceding harvest years. This raises the need to obtain the nutrient composition of ingredients that are still under breeding development every time prior to testing for nutritional quality. Lysine, methionine and threonine content of wheat protein were higher than those of triticale varieties which were variable. Salmon (1984) reported triticale to contain more lysine, arginine, aspartic acid and alanine than wheat.

The difference in the weight gain was probably due to the protein levels in the test ingredients and diets (H128 and H261). Feed intake up to 22d was lower on all triticale fed groups, probably due to higher palatability of wheat which is seen from 2nd week of age onwards. However, similar FCR indicates that lower feed intake accounted for lower gain. Johnson and Eason (1988), contrary to the present study, observed that growth of broiler chickens was similar whether triticale or wheat was the cereal source in diets that contained 50% cereal and were equalized for nutrient content. Similarly, Vieira *et al*. (1995) found that the graded inclusion of triticale up to 40% (substituted for corn) had no negative effect on weight gain or final weight of broilers. The use of triticale/wheat based diet in broiler chicken was dependent on the content of soluble NSP and low soluble NSP ingredients were reflected in optimum growth performance (Choct, 2006). Although wheat and triticale varieties had lower soluble NSP content, the differences in the performance were probably due to the differences in the protein quality of the diet.

Higher protein content in triticale (H418 and H55) was accompanied by improved ileal digestibility. Although, protein efficiency of all triticale-based diets was better than that of wheat, the closer performance of chicks in H128 and H261 may have been probably due to higher contents of lysine, methionine and threonine in protein. Ileal starch digestibility on H128 was higher than on H 418, indicating that the higher the starch content, the better is the digestibility similar to that with higher protein content. Enzyme supplementation improved the starch digestibility but this was not reflected in the growth performance, probably the improvement margin was not wide enough. The earlier digestibility studies with wheat revealed a starch digestibility between 0.93 and 0.98 (Annison, 1990) and Enzyme supplementation not only improved the starch digestibility in wheat with soluble NSP but also the growth performance. In the study of Boldaji *et al*. (1986) observed no significant difference in metabolizable energy values between 3 varieties of triticale and 3 varieties of wheat with almost similar protein content.

Of the endogenous enzymes assessed, maltase and sucrase activities were similar between the groups, indicating similarities in carbohydrate levels of the diets. Alkaline phosphatase activity provides a measure of intestinal maturation (Henning, 1987) and the differences in its specific activity may suggest that birds in the H55 and H128 groups had a relatively high proportion of mature enterocytes and would be better able to digest and absorb nutrients from the small intestine (Ceylan *et al*., 2003). In an earlier study, the activities of alkaline phosphatase were negatively affected by dietary protein content but this was only on diets with low protein quality (Swatson *et al*., 2002). This may probably be the reason for lower alkaline phosphatase activity in case of H418.

The similar organ weights of birds from the different cereal groups are probably due to the low levels of soluble NSP. As with antinutritive factors, organs secreting enzymes tend to increase in weight, through both hypertrophy and hyperplasia (Ikegami *et al*., 1990). However, the reason for the lower weight of pancreas in enzyme supplemented group is not clear.

It is concluded that these triticale varieties would have similar feeding values as wheat for broiler chickens, provided the diets are iso-caloric and iso-nitrogenous. The enzymes tested did not influence the growth performance probably due to lower soluble NSP levels.

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