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Research Article

EFFECT OF EXOGENOUS ENZYMES AND HERBAL RESIDUES ON THE PERFORMANCE, NUTRIENT UTILIZATION AND BALANCE IN GROWING CROSS-BRED PIGS

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ABSTRACT
In a completely randomized design, 5 experimental diets (T_1 to T_5) were fed to 5 groups of animals with 6 animals (35 kg ± 1.3 body wt.) in each group. The diets were supplemented with or without herbal residues (turmeric, amla, ginger) and enzyme cocktail (xylanase, β-glucanase, cellulase and phytase). Thus the five diets were a standard diet (T_1), economic diet with enzyme cocktail but without herbal residue (T_2), T_2 with turmeric residue (T_3), T_2 with amla residue (T_4) and T_2 with ginger residue (T_5). CP digestibility was highest (P<0.01) for T_1. The number of days taken to reach the target weight of 70 kg and the ADG (g) was lower (P<0.01) and higher (P<0.01) respectively, for T_1. It was concluded that enzymes alone do not but in combination with herbal residues have significant effect on animals in terms of nutrient utilization, growth performance.

***Keywords**: Exogenous Enzymes, NSP, Herbal Residues, Growth, Nutrient Utilization*

INTRODUCTION
Non-starch polysaccharides (NSP) and phytic acid are some important anti nutritive components in plant based feed stuffs. Availability of exogenous enzymes for the use in livestock feed has led to increased inclusion rate of feed ingredients containing relatively high levels of NSP. Exogenous enzymes can hydrolyze these NSP into smaller units that can be utilized by pigs (Partridge and Bedford, 2000). Similarly phosphorus from plants is of low bio availability to swine and poultry as a result of phytate, the principal form of phosphorus storage in plants and is relatively indigestible by non-ruminants (NRC, 1998). Exogenous supplementation of phytase has demonstrated the ability to increase phosphorus bio availability and thus growth rates in pigs (Adeola, 1998) by cleavage of phosphorus molecule from phytate. Public concern over the use of antibiotic feed additives had lead to research on alternative substances with antimicrobial properties and thus use of phytogenic feed additives like herbs, residues, extracts, essential oils etc. are being explored. Hence in the present study an attempt is made to improve performance and nutrient utilization in finisher pigs by supplementing diets with xylanase, β-glucanase, cellulase (NSP-degrading) and phytase enzymes either alone or in combination with herbal residues

MATERIALS AND METHODS
Three pure enzymes viz-xylanase, β-glucanase and cellulase were procured and assayed for enzyme activity which was found to be 11,48,807 U, 15,72,646 U and 9, 64,579 U per gm, respectively. Phytase was obtained from Neospark laboratories, Bangalore with an assayed activity of 2500 FTU/gm.
Five experimental diets from T_1 to T_5 (table 1) were formulated (NRC, 1998) such that T_1 is a standard diet without enzyme cocktail (enzyme mixture) and herbal residues, T_2 is an economic diet with enzyme cocktail but without herbal residues, T_2 with *turmeric* residue is T_3, T_2 with *amla* residue is T_4 and T_2 with *ginger* residue is T_5.
Thirty (15 ± 1.3 kg) entire male pigs (LWY X desi) were made into five groups of 6 each. Groups 1 to 5 were fed with treatments T_1 to T_5, respectively. Fresh water was made always available at all times. The daily feed offered and leftover were recorded. The pigs were weighed at weekly intervals. A five day metabolism trial was carried out after the animals attained a body weight of about 25 kg using all animals per treatment to study the digestibility of nutrients and retention of N, Ca and P. The daily feed intake, urine and faeces voided were recorded.

Table 1: Ingredient and chemical composition (%) of experimental diets

Ingredient	T_1	T_2	T_3	T_4	T_5
Maize	42.00	20.00	20.00	20.00	20.00
Soybean meal	14.00	8.00	8.00	8.00	8.00
Sunflower Cake	-	12.00	12.00	12.00	12.00
Deioled Rice bran	41.50	57.50	55.50	55.50	55.50
Mineral mixture #	2.00	2.00	2.00	2.00	2.00
Salt	0.50	0.50	0.50	0.50	0.50
Turmeric residue	0.00	0.00	2.00	0.00	0.00
Amla residue	0.00	0.00	0.00	2.00	0.00
Ginger residue	0.00	0.00	0.00	0.00	2.00
	100	**100**	**100**	**100**	**100**
Lysine (%)	0.41	0.44	0.44	0.44	0.44
Methionine (%)	0.01	0.60	0.60	0.60	0.60
AB_2D_3	0.02	0.02	0.02	0.02	0.02
Biovital	0.02	0.02	0.02	0.02	0.02
Enzyme cocktail (xylanase 3500, β-glucanase 2500, cellulase 1250 and phytase 3000 Units / Kg)	-	+	+	+	+
Cost per 100 Kg (Rs.)	1320	1266	1266	1266	1266
Proximate composition (%) [a]					
DM	89.98	89.45	89.19	90.24	89.76
OM	87.66	87.57	88.15	86.75	87.85
CP	15.33	15.24	15.34	15.23	15.37
TA	12.34	12.43	11.85	13.25	12.15
EE	1.79	1.49	1.38	1.35	1.48
CF	10.86	17.19	17.74	17.83	17.80
NFE	59.68	53.65	53.69	52.34	53.20
Calcium	0.73	0.75	0.75	0.75	0.75
Phosphorus	1.02	1.28	1.28	1.28	1.28
Cell wall composition (%) [a]					
NDF	34.83	45.03	45.92	45.16	45.77
ADF	23.68	32.95	33.08	33.17	33.47
Hemicellulose	11.15	12.08	12.84	11.99	12.30
Cellulose	12.65	15.68	16.10	15.12	16.61
Lignin	4.75	6.23	6.18	6.01	6.32
NSP and starch content (%) of experimental diets [a]					
Pentosans	7.24	7.64	7.86	7.43	7.43
Cellulose	12.65	15.68	16.10	15.12	16.61
Pectins	4.28	5.44	5.67	5.73	5.94
Total NSP	32.85	43.62	42.42	42.87	42.79
Starch	36.65	24.67	24.86	25.43	25.37

#contained, Ca 32%; P 6%; Mn 0.27%; Zn 0.26%; Cu 100 ppm; Fe 1000 ppm, Iodine 0.01%; Fluorine (max.) 0.03%
[a] on Dry Matter basis except for DM

The samples of feed, faeces and urine were analyzed for various nutrients (AOAC, 1995) and data was analyzed statistically (Snedecor and Cochran, 1989). The digestibilities of all nutrients, Calcium, Phosphorus and Nitrogen balance were determined and average daily gain, feed: gain ratio were also calculated.

RESULTS AND DISCUSSION

The digestibility of all nutrients (table 2) except that of CP was not significantly different among treatments. The CP digestibility was highest ($P<0.01$) in T_1 than others. The digestibility of other nutrients was comparable. Lower CP digestibility in T_2 to T_5 might be due to an increase in the fibre content of the diets. The negative influence of dietary fibre on CP digestibility was attributed to the lower availability of protein added with fibre source (Kennelly and Aherne, 1980; Madhava Rao *et al*., 2004). The digestibility of DM, OM and CP was lower across treatments which might be due to lower response of older pigs to NSP degrading enzyme supplementation than in younger pigs (Olukosi *et al*., 2007).

Table 2: Effect of dietary treatments on nutrient digestibility (%)

Digestibility (%)	T_1	T_2	T_3	T_4	T_5
DM * *	83.34 ^{a} ± 0.97	76.96 ^{b} ± 1.21	78.06 ^{b} ± 1.09	80.27 ^{ab} ± 1.12	76.29 ^{b} ±1.75
OM*	79.73 ^{ab}± 0.81	78.12 ^{b}± 0.57	80.43 ^{ab} ± 0.98	80.71^{a} ± 0.86	80.66 ^{a} ± 0.97
CP **	80.31 ^{a} ±1.99	72.18 ^{bc} ± 1.83	76.73 ^{ab} ± 1.16	67.54 ^{c} ± 1.86	76.01 ^{ab} ± 2.39
CF	29.55 ± 3.86	33.13 ± 5.56	36.28±3.77	36.60±1.43	35.28±3.62
EE	57.82 ± 2.52	58.84 ± 4.30	56.50 ± 3.75	55.83 ± 3.63	55.87± 8.73
NFE	84.91 ± 1.49	80.98 ± 3.15	83.03 ± 1.50	82.46 ± 1.80	81.49 ±1.84
NDF	34.09 ± 2.99	35.00 ± 3.06	37.20 ± 2.51	34.52±2.16	36.12±3.45
ADF	21.64 ± 6.01	24.32 ± 5.08	23.23 ± 4.99	25.16 ± 6.44	22.05 ± 7.26
Hemicellulose	41.20 ± 7.14	42.46 ± 1.80	42.26 ± 5.54	38.02 ± 6.15	40.12 ± 8.09
Cellulose	25.51± 5.63	26.75 ± 6.79	24.26 ± 7.46	27.85 ± 6.75	24.84± 9.85
Calcium	68.49 ± 3.35	72.20 ± 4.14	71.79 ± 4.33	70.44 ± 2.04	71.68 ± 4.12
Phosphorus * *	56.36 ^{b}± 4.84	64.59 ^{a} ± 2.68	65.94 ^{a} ±7.31	68.89 ^{a} ± 1.79	66.74 ^{a} ± 3.37

^{abc} *values in a row not sharing common superscripts differ significantly ** (P<0.01) * (P<0.05)*

T_1 and T_5 recorded higher (P<0.05) nitrogen retention (table 3) as compared to others. Supplementation of enzymes in treatments T_2 to T_5 increased (P<0.05) calcium retention (g/d). Similar trend (P<0.05) was noticed for calcium retention (% of intake). A significant increase (P<0.01) in phosphorus retention (g/d) was observed in enzyme supplemented groups.

Table 3: Effect of dietary treatments on nitrogen, calcium and phosphorus balance

Nitrogen balance	T_1	T_2	T_3	T_4	T_5
Intake (g/d) *	50.34 ^{b}±1.79	55.19 ^{a} ±1.61	49.05 ^{c} ±1.79	54.13 ^{a} ±0.66	49.46 ^{bc} ±1.79
Outgo in faeces (g/d)**	8.55 ^{c} ±0.87	15.49 ^{a} ±1.40	11.35 ^{bc} ±0.46	17.60 ^{a} ±1.14	11.78 ^{b} ±1.05
Outgo in urine (g/d)*	11.86 ^{a} ±1.67	10.90 ^{ab} ±0.73	8.89 ^{ab} ±1.16	9.13 ^{ab} ± 0.63	7.88 ^{b} ±1.64
Total loss (g/d)**	20.41^{b} ±1.99	26.39 ^{a} ±1.61	20.25 ^{b} ±1.09	26.73 ^{a} ±1.31	19.66 ^{b} ±2.52
Retained (g/d)	29.93 ±1.25	28.79 ± 0.53	28.80 ± 2.47	27.39 ± 1.19	29.80 ± 2.64
Retained (% of intake)*	59.74^{ab} ±3.05	52.38 ^{ab} ±1.70	58.26 ^{ab} ±3.11	50.65 ^{b} ±2.18	60.23 ^{a} ±4.84
Retained (% of absorbed)	72.04 ± 3.09	72.59 ±1.66	75.86 ± 3.53	74.90 ± 1.84	78.82 ± 4.10
Calcium balance					
Intake (g/d) *	12.82 ^{b} ± 0.46	13.96 ^{a} ± 0.41	12.60 ^{c} ± 0.46	13.95 ^{a} ± 0.17	12.86 ^{b} ± 0.47
Outgo in faeces (g/d)	4.08 ± 0.46	3.82 ± 0.37	3.56 ± 0.47	4.12 ± 0.22	3.61 ± 0.40
Outgo in urine (g/d) *	3.26 ^{ab} ± 0.33	4.29 ^{a} ± 0.49	3.12 ^{b} ± 0.39	3.47^{ab} ± 0.32	3.22 ^{b} ± 0.17
Total loss (g/d)	7.32 ± 0.64	6.41 ± 0.38	6.68± 0.42	7.59± 0.18	6.84± 0.30
Retained (g/d)**	5.49 ^{b} ± 0.40	7.57^{a} ± 0.36	5.91^{b} ± 0.49	6.36 ^{b} ± 0.007	6.03 ^{b}± 0.49
Retained (% of intake)**	43.19 ^{b} ± 3.54	54.19 ^{a} ± 2.19	46.81^{ab} ± 3.39	45.60 ^{b} ± 0.72	46.59 ^{ab} ± 2.61
Retained (% of absorbed)	62.77± 3.81	64.38± 2.89	65.24 ± 3.85	64.95 ± 2.14	64.89 ± 1.25
Phosphorus balance					
Intake (g/d) **	13.68 ^{c} ± 0.49	18.93 ^{ab} ± 0.55	17.91^{b}± 0.65	19.83^{a}± 0.244	18.28^{ab}± 0.66
Outgo in faeces (g/d)**	5.93 ^{c} ± 0.009	6.71^{a} ± 0.30	6.05^{bc}± 0.21	6.57^{b}± 0.23	6.01^{bc}± 0.19
Outgo in urine (g/d)*	4.14 ^{b} ± 0.69	6.04 ^{ab} ± 0.69	5.93 ^{ab} ± 0.56	6.43 ^{a} ± 0.74	5.80 ^{ab} ± 0.71
Total loss (g/d) **	10.07 ^{b} ± 0.71	12.75 ^{a} ± 0.92	11.97^{ab} ± 0.55	12.99 ^{a} ± 0.74	11.82 ^{ab} ± 0.58
Retained (g/d)* *	3.62 ^{b} ± 0.39	6.18 ^{ab} ± 0.56	5.94 ^{ab} ± 0.69	6.83 ^{a} ± 0.76	6.47^{ab} ± 0.47
Retained (% of intake)	26.68 ± 3.21	32.94 ± 3.49	32.88± 3.19	34.45± 3.73	35.38± 2.23
Retained (% of absorbed)	47.84± 6.13	50.85± 5.05	49.74± 4.49	51.48± 5.52	53.37± 4.11

^{abc} *values in a row not sharing common superscripts differ significantly ** (P<0.01) * (P<0.05)*

It was observed that the N loss (g/d) in urine was lower inT_2 to T_5 fed pigs than T_1. Xavier (2005) reported that NSP increases the excretion of N in faeces by reducing the absorption of protein. Similarly in the present study there was an increase in NSP content of the experimental diets T_2 to T_5.

The calcium intake (g/d) was higher ($P<0.01$) in T_2 to T_5 than in T_1. Though calcium out go (g/d) in faeces and urine was not significantly different, a trend to a decrease in total calcium loss (g/d) was observed in T_2 to T_5. The phosphorus intake (g/d) was higher inT_2 to T_5 which might be due to higher DOB in those diets. The phosphorus loss in faeces and urine were not significantly higher in T_2 to T_5 and in total loss significant different ($P<0.05$) were observed. A trend to an increased retention of phosphorus (g/d) or when expressed as % intake or % absorbed was observed in T_2 to T_5 than in T_1 clearly indicating the positive impact of phytate phosphorus in T_2 to T_5. Similar to these observations, several earlier reports (Oryschak *et al*., 2002; Olukosi *et al*., 2007; Nortey *et al*., 2007; Carneiro *et al*., 2008) indicated a favourable effect of phytase in improving the digestibility and increasing the retention of calcium and phosphorus.

Though non-significant differences (table 4) were found in initial, final and total weight gain (kg) among treatments, the number of days taken and ADG (g) was lower ($P<0.01$) and higher ($P<0.01$) respectively, for T_1 than others. The ADFI (kg) and feed intake per kg gain (kg) was higher ($P<0.01$) in T_1 and T_2 respectively. The better performance of pigs fed T_1 could be attributed to the low dietary fibre components which has resulted in better digestibility of nutrients and energy. Grieshop *et al*. (2001) reported a negative correlation between dietary fibre content, metabolizable energy and digestible protein in the diets. The decrease in ADFI (kg) for T_2 to T_5 due to more fibre content could also be a probable reason for lower ADG as compared to T_1. Of the 3 herbal residues used in the present study, the order of performance of pigs was ginger > turmeric > amla.

Table 4: Effect of dietary treatments on growth performance of cross-bred pigs (15 to 35 kg body weight)

Parameter	T_1	T_2	T_3	T_4	T_5
Initial wt. (kg)	15.21 ± 0.21	15.35 ± 0.34	15.23 ± 0.23	15.18 ± 0.07	15.35 ± 0.20
Final wt. (kg)	35.65 ± 0.17	35.08 ± 0.24	35.32 ± 0.23	35.23 ± 0.23	35.07 ± 0.23
Weight gain (kg)	20.43 ± 0.22	19.73 ± 0.36	20.08 ± 0.25	20.05 ± 0.22	19.71 ± 0.21
No. of days *	$47.0^{b} \pm 2.21$	$49.0^{ab} \pm 3.06$	$48^{a} \pm 1.81$	$53^{a} \pm 0.83$	$47^{b} \pm 0.23$
ADG (g) * *	$435^{a} \pm 16$	$402^{a} \pm 19$	$413^{a} \pm 10$	$377^{b} \pm 9$	$419^{a} \pm 12$
ADFI (kg)	1.54 ± 0.05	1.57 ± 0.05	1.51 ± 0.03	1.49 ± 0.01	1.52 ± 0.03
Feed /kg gain	3.56 ± 0.11	3.89 ± 0.23	3.61 ± 0.18	3.94 ± 0.14	3.61 ± 0.15
Cost of feed /kg gain (Rs)	50.3 ± 1.40	54.1 ± 3.00	50.3 ± 2.40	54.1± 1.80	50.2 ± 2.00

^{ab} values in a row not sharing common superscripts differ significantly ** ($P<0.01$) * ($P<0.05$)

Conclusion

The results of this study demonstrated that addition of exogenous enzymes to the diets did not show much significant effect in terms of nutrient utilization, growth performance but in combination with herbal residues which are used as an alternate to antibiotic growth promoters proved better.

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