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Synergistic effects of mannan oligosaccharides and beta-glucans on growth performance and economic efficiency of early weaned piglets[#]

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Abstract

This study evaluated the synergistic effects of a mannan oligosaccharide (MOS) and beta-glucan (BG) blend on growth performance and economic efficiency in early-weaned piglets. Eighteen sows and their litters were randomly assigned to one of three treatments: T1 (weaned at 42 days + basal diet), T2 (weaned at 35 days + basal diet) and T3 (weaned at 35 days + basal diet supplemented with 0.5 g/kg MOS+BG). Body weight and feed intake were monitored until 18 weeks of age. Results indicated no significant differences (P>0.05) among treatments for final body weight, total weight gain, average daily gain, or overall feed conversion efficiency. However, a significant post-weaning growth check was observed in T2 piglets at weeks 6-8, which was mitigated in the supplemented T3 group, whose performance was comparable to the later-weaned T1 group during this critical period. Although total feed intake and cost were similar, the cost of feed per kg of weight gain was marginally lower in T3 (Rs.84.96) compared to T1 (Rs.87.73) and T2 (Rs.85.28). In conclusion, supplementation with MOS and BG helped early-weaned piglets overcome the immediate post-weaning growth lag, demonstrating a beneficial trend towards improved resilience and economic efficiency without significant overall performance differences.

Keywords: *Early weaning, mannan oligosaccharide, beta-glucan, growth performance*

Early weaning is a key management strategy to maximise sow productivity, as it reduces lactation length, facilitates an earlier return to estrus and thereby optimises overall herd efficiency. However, this practice poses significant challenges for piglets, leading to gut immaturity, reduced feed intake and increased susceptibility to enteric pathogens. The post-weaning period is commonly associated with impaired growth performance and a higher incidence of diarrhoea, which can lead to morbidity and mortality, ultimately causing economic losses to farmers (Mohan *et al*., 2023). Furthermore, the global restriction of antibiotic growth promoters (AGPs) has intensified the search for effective alternatives to sustain piglet health and performance during this critical phase.

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Functional carbohydrates such as mannan oligosaccharide (MOS) and beta-glucan (BG) are promising alternatives to antibiotic growth promoters. They play an important role in gut health by enhancing intestinal integrity, modulating the gut microbiota, reducing pathogenic load and stimulating the immune system, thereby improving the overall health and performance of piglets. Mannan oligosaccharide, derived from yeast cell walls, functions as a pathogen-binding decoy, preventing the adhesion of harmful bacteria such as *E. coli* to the gut mucosa (Spring *et al.,* 2000). Beta-glucan, obtained from yeast and cereals, are potent immunomodulators that enhance innate immunity by priming macrophages and neutrophils (De Marco Castro *et al.,* 2020). Importantly, their mechanisms of action are complementary; MOS reduces the pathogenic load in the intestinal lumen, while BG enhances systemic immune responsiveness. This suggests their combined use may produce synergistic effects, improving outcomes more effectively than either additive used alone (Fadl *et al.,* 2020). Despite extensive research on early weaning and individual supplementation of MOS or BG, studies evaluating the combined effect of MOS and BG on early-weaned Large White Yorkshire piglets under Indian conditions are limited. Therefore, this study was conducted to evaluate the synergistic effects of combined MOS and BG supplementation on the growth performance and economic efficiency of early-weaned piglets.

Materials and methods

Eighteen Large White Yorkshire (LWY) sows at last week of gestation were selected from the Centre for Pig Production and Research (CPPR), Mannuthy. Sows and their piglets were randomly divided into three treatments groups having six sows and their litters. The piglets were fed with one of the following diets (ICAR, 2013) throughout the experimental period of 90 days post-weaning. T1- Piglets weaned at 42 days of age + Basal diet, T2- Piglets weaned at 35 days of age + basal diet and T3- Piglets weaned at 35 days of age + Basal diet supplemented with a mixture of MOS and BG at 0.5 g/kg of feed. Basal diet consisted of a creep ration containing 21 per cent crude protein and 2750 kcal ME/kg of feed. All animals were maintained under uniform management conditions and were fed twice daily at 10:00 h and 15:00 h. *Ad libitum* feeding was practised throughout the experimental period and the residual feed, if any, was collected and weighed daily to determine moisture content and calculate dry matter intake. Fresh drinking water was provided *ad libitum* in all the pens throughout the experiment

The weekly body weight of piglets was recorded throughout the experimental period. To ensure uniformity across treatments, the piglets' age of 18 weeks (126 days) in T1, T2 and T3 was taken as the final experimental period. Proximate composition of feed was estimated (AOAC, 2016). Cost of production per kg weight gain was calculated based on body weight gain, total feed intake on dry matter basis, cost of feed and supplements.

The statistical analysis of data on various parameters was done by one way ANOVA method as described by Snedecor and Cochran (1994). Means were compared by Duncan multiple range test (DMRT). The data obtained were statistically analysed by using SPSS Version 24.0.

Results and discussion

Average weekly body weight and growth performance of piglets

The average weekly body weight and growth performance of different treatment groups are presented in Table 2 and 3. Birth weight of piglets in T1, T2 and T3 were 1.30, 1.31 and 1.34 kg, respectively, which exhibited an increase over the period of study to reach final body weight at 18 weeks of age was 36.90, 37.19 and 38.24 kg, respectively. There was no significant difference between the treatment groups in birth weight, final body weight, total weight gain and average daily gain (ADG) of piglets at 18 weeks of age. The present results align with the findings of Montsho *et al.* (2016), who concluded that weaning age of 35 and 28 days had no impact on the final body weight and ADG of piglets reared up to 70 days of age. Kalita *et al.* (2015) reported that weaning at 42 days and 35 days had no difference in body weight at 77days of age. In contrast, Faccin *et al.* (2020) reported that increasing weaning age enhances overall performance in commercial pig production systems, particularly in the nursery and finishing phases. Although early-weaned piglets supplemented with MOS and BG showed numerically higher final body weight compared to late weaned and unsupplemented early weaned groups, the difference was not statistically significant. Similarly, Tuoi *et al.* (2016) reported that supplementation of MOS and BG had higher body weight and ADG and Valpotić *et al.* (2016) observed higher body

The proximate composition of the experimental feeds on dry matter basis is presented in Table 1.

Table 1. Proximate composition of experimental feed, %

Parameters	Creep ration*
Dry matter	88.25 ± 0.31
Crude protein	21.23 ± 0.28
Crude fibre	5.86 ± 0.34
Ether extract	4.90 ± 1.01
Total Ash	9.64 ± 0.13
Nitrogen free extract	58.37 ± 1.51
Acid insoluble ash	2.05 ± 0.07
Calcium	0.93 ± 0.05
Phosphorus	1.33 ± 0.02

*On dry matter basis except DM

weight gain than the non-supplemented groups, but not significantly. However, Zhao *et al.* (2011) and Ficagna *et al.* (2025) reported that significantly better body weight, higher average daily weight gain and feed intake in MOS and BG supplemented group than the control group.

Significant difference ($P < 0.05$) in average weekly BW was observed in the 6th, 7th and 8th week of age, with higher body weight in T1 and T3 compared to T2 at week 6th and lower BW in T2 than in T1 and T3 at 7th and 8th week of age. The significant difference with markedly lower body weight in T2 piglets compared to T1 was a classic demonstration of weaning stress. This finding is strongly supported by Campbell *et al*. (2013), who opined that the immediate post-weaning period is characterised by reduced feed intake, gut barrier dysfunction and inflammation, leading to a growth check. Our results confirm that weaning at 35 days, without any supportive measures, presents a greater immediate challenge to the piglet than weaning at the later age of 42 days.

However, the T3 group, weaned at the same early age of 35 days, exhibited significantly higher body weight at the 7th and 8th weeks of age compared to T2. This aligns with the findings of Lee *et al.* (2016) and Tuoi *et al.* (2016), who demonstrated that BG and MOS supplementation improved the growth performance in piglets, particularly during the first 2-3 weeks post-weaning. Huting *et al.* (2021) further suggested that although early nutrition and health status set the initial growth trajectory, pigs often possess a remarkable capacity for compensatory growth if early challenges are overcome.

The weaning weight (kg) was significantly ($P < 0.01$) higher in T1 (7.46 ± 0.14) than T2 (6.43) and T3 (6.73). Body weight at weaning was significantly higher in T1 than T2 and T3, possibly due to the later weaning of piglets (42 days) in the T1 group. Valentim *et al.* (2021) similarly found that piglets weaned at older ages tend to have higher body weights at weaning than those weaned earlier.

Feed conversion efficiency in T1, T2 and T3 was 2.22, 2.16 and 2.10, respectively. No significant differences were observed among treatments. Kalita *et al.* (2015) reported feed conversion efficiency of 2.44 and 2.48 in piglets weaned at 35 and 42 days of age, suggesting that early weaning may improve feed conversion efficiency, although the differences is not statistically significant. Furthermore, supplementation of 0.05 per cent BG or a combination of 0.05 per cent BG and 0.05 per cent mannans improved the feed efficiency and growth performance (Szuba-Trznadel *et al.,* 2018). However, Assis *et al.* (2014) reported that supplementation produced no differences in feed conversion efficiency.

Table 2. Weekly average body weight of piglets maintained in different treatments, kg

Week	Treatments			F value	P value
	T1	T2	T3		
0	1.30 ± 0.02	1.31 ± 0.02	1.34 ± 0.01	2.43	0.091^{ns}
1	2.20 ± 0.04	2.25 ± 0.04	2.32 ± 0.02	2.89	0.058^{ns}
2	3.25 ± 0.07	3.23 ± 0.07	3.40 ± 0.03	2.66	0.073^{ns}
3	4.32 ± 0.06	4.33 ± 0.08	4.52 ± 0.04	2.95	0.055^{ns}
4	5.59 ± 0.07	5.60 ± 0.13	5.88 ± 0.09	2.76	0.067^{ns}
5	6.33 ± 0.07	6.43 ± 0.13	6.73 ± 0.17	2.51	0.085^{ns}
6	7.46 ± 0.14^{a}	6.78 ± 0.16^{b}	7.10 ± 0.18^{ab}	4.58	0.012*
7	8.16 ± 0.16^{a}	7.49 ± 0.18^{b}	8.06 ± 0.19^{a}	4.21	0.017*
8	9.46 ± 0.22^{a}	8.76 ± 0.21^{b}	9.55 ± 0.25^{a}	3.67	0.028*
9	11.07 ± 0.28	10.88 ± 0.28	11.66 ± 0.31	1.95	0.147^{ns}
10	13.17 ± 0.34	13.34 ± 0.34	14.29 ± 0.36	3.03	0.052^{ns}
11	15.94 ± 0.39	15.88 ± 0.36	17.04 ± 0.38	2.99	0.054^{ns}
12	18.81 ± 0.43	18.90 ± 0.43	20.12 ± 0.41	2.99	0.054^{ns}
13	21.71 ± 0.44	22.26 ± 0.54	23.12 ± 0.47	2.06	0.132^{ns}
14	24.98 ± 0.51	24.96 ± 0.50	25.86 ± 0.49	1.07	0.346^{ns}
15	27.93 ± 0.49	28.45 ± 0.51	29.26 ± 0.56	1.59	0.209^{ns}
16	31.12 ± 0.55	31.25 ± 0.53	32.34 ± 0.62	1.39	0.252^{ns}
17	34.22 ± 0.57	35.12 ± 0.56	35.09 ± 0.68	0.70	0.500^{ns}
18	36.90 ± 0.60	37.19 ± 0.53	38.24 ± 0.71	1.30	0.277^{ns}

ns – Non significant ($P > 0.05$); *significant at 0.05 level
Means having different letters as superscript within the same row differs significantly

Table 3. Growth performance of piglets in different treatments

Parameters	Treatments			F value	P value
	T1	T2	T3		
Initial body weight (kg)	1.3 ± 0.02	1.31 ± 0.02	1.34 ± 0.01	2.43	0.091^{ns}
Weaning weight (kg)	7.46 ± 0.14^{a}	6.43 ± 0.13^{b}	6.73 ± 0.17^{b}	13.05	0.001**
Final body weight at 18 weeks of age (kg)	36.90 ± 0.60	37.19 ± 0.53	38.24 ± 0.71	1.30	0.277^{ns}
Total body weight gain (kg)	35.63 ± 0.60	35.87 ± 0.53	36.90 ± 0.71	1.19	0.309^{ns}
Average daily gain (kg)	0.283 ± 0.01	0.285 ± 0.01	0.293 ± 0.01	1.17	0.313^{ns}
Average daily FI on DM basis (kg)	0.621 ± 0.01	0.608 ± 0.01	0.617 ± 0.01	0.378	0.687^{ns}
Total FI on DM basis (kg)	78.28 ± 1.54	76.60 ± 1.12	77.67 ± 1.50	0.38	0.686^{ns}
Feed conversion efficiency	2.22 ± 0.04	2.16 ± 0.03	2.11 ± 0.04	1.301	0.276^{ns}

ns – Non significant (P > 0.05); **significant at 0.01 level
Means having different letters as superscript within the same row differs significantly

Table 4. Average weekly feed intake of piglets in different treatments on DM basis, kg

Week	Treatments			F value	P value
	T1	T2	T3		
5	-	1.99 ± 0.03	1.57 ± 0.03	-	-
6	2.13 ± 0.14	1.89 ± 0.12	2.03 ± 0.06	1.25	0.40^{ns}
7	3.00 ± 0.58	2.74 ± 0.10	2.74 ± 0.08	0.19	0.84^{ns}
8	3.79 ± 0.19	3.59 ± 0.12	3.45 ± 0.06	1.62	0.33^{ns}
9	4.36 ± 0.40	4.85 ± 0.24	4.78 ± 0.06	0.99	0.47^{ns}
10	5.50 ± 0.39	5.43 ± 0.01	5.76 ± 0.25	0.42	0.69^{ns}
11	6.39 ± 0.23	5.99 ± 0.13	6.38 ± 0.41	0.65	0.58^{ns}
12	7.13 ± 0.01^{a}	6.77 ± 0.01^{b}	6.68 ± 0.07^{b}	29.67	0.011*
13	7.58 ± 0.36	7.21 ± 0.05	7.12 ± 0.06	1.32	0.39^{ns}
14	8.18 ± 0.03	7.88 ± 0.29	7.92 ± 0.23	0.60	0.60^{ns}
15	9.61 ± 0.18	8.53 ± 0.33	8.73 ± 0.01	7.25	0.07^{ns}
16	9.67 ± 0.71	9.58 ± 0.09	10.21 ± 0.09	0.69	0.57^{ns}
17	10.83 ± 0.27	10.53 ± 0.07	10.31 ± 0.23	1.62	0.33^{ns}

ns – Non significant (P > 0.05); *significant at 0.05 level
Means having different letters as superscript within the same row differs significantly

Table 5. Techno-economic analysis of piglets maintained in different treatments

Parameters	Treatments		
	T1	T2	T3
Total feed intake per piglet (kg)	88.70	86.80	87.89
Cost of creep feed (Rs/kg)	35.24	35.24	35.67
Total feed cost (Rs.)	3,125.79	3,058.83	3,135.04
Total weight gain from birth to 90 days post weaning (kg)	35.63	35.87	36.90
Cost of feed per kg weight gain (Rs.)	87.73	85.28	84.96

Average weekly feed intake

The average weekly feed consumption on dry matter basis is presented in Table 4. The average feed consumption (kg) on the 12th week was significantly ($P < 0.05$) higher in T1 (7.13) than in T2 (6.77) and T3 (6.68). However, there was no significant difference in feed consumption during other weeks of age. The significantly higher feed intake in T1 at week 12 may reflect a compensatory adjustment, where the later-weaned pigs consumed more feed during the growing-finishing phase to meet increased nutrient needs, aligning with the concept of non-linear growth (Huting *et al.,* 2021). However, no significant differences in feed intake or average daily feed intake (ADFI) were observed during other weeks. This is consistent with Assis *et al.* (2014) and Luna *et al.* (2015), who reported that MOS and BG supplementation did not alter feed intake in piglets. Leliveld *et al.* (2013) found late weaning improves ADFI and ADG in piglets up to 10 weeks post-weaning. Conversely, these findings contrast with those of Sulabo *et al.* (2010) and Ficagna *et al.* (2025), who observed a trend of increased feed intake in piglets exposed earlier to creep ration and MOS and BG-supplemented feed.

Techno-economics of production

Data on techno-economics of production are presented in Table 5. Cost of feed per kg weight gain was 87.73, 85.28 and 84.96 in T1, T2 and T3, respectively. However, the cost of feed per kg of body weight gain was slightly lower in T2 and T3 compared to T1, although the differences were marginal. The results of the present study are consistent with previous reports. Vikas (2014) reported feed costs of Rs. 79.80–85.66 per kg weight gain in pigs supplemented with probiotics, prebiotics or synbiotics, while Saseendran *et al.* (2017) observed costs of Rs. 75.03–80.00 per kg weight gain with lecithin and carnitine supplementation. In contrast, Keyho (2017) reported that feed costs were Rs. 57.55 per kg of body weight gain for 42-day weaned piglets and Rs.51.24 for 35-day weaned piglets, without and with lactose supplementation, respectively.

Conclusion

The findings of the present study indicate that early weaning at 35 days of age, even without supplementation in piglets, did not adversely affect the overall growth performance, compared with conventional weaning at 42 days. Although early-weaned piglets without supplementation experienced a temporary reduction in growth during the early post-weaning stage, their overall performance remained comparable to the other groups by the end of the study period. Notably, supplementation with MOS and BG in early-weaned piglets facilitated faster recovery from weaning stress, with marginal improvements in growth performance and feed efficiency. Although these benefits were not statistically significant, they indicate a potential biological advantage of MOS and BG supplementation in enhancing resilience during the early post-weaning phase and overall growth. From a techno-economic perspective, supplementation with MOS and BG did not markedly alter the feed cost per kilogram of body weight gain but demonstrated a marginal improvement in production efficiency compared to the control group, suggesting its economic feasibility for practical swine production.

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Conflicts of interest

The authors declare that they have no conflict of interest.

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