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Effect of fermented soybean meal on growth performance, nutrient digestibility, and serum immunoglobulins in weaned calves

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Abstract

Weaning represents one of the most stressful transitions in a calf's life, and the abrupt dietary shift from milk to solid feed frequently triggers growth setbacks and immune suppression. Fermented soybean meal (FSBM) has emerged as a promising protein source that may ease this transition by reducing anti-nutritional factors while enriching bioactive peptides and organic acids. This research assessed whether replacing conventional soybean meal (SBM) with FSBM in a starter diet would improve growth performance, apparent nutrient digestibility, and circulating immunoglobulin concentrations in recently weaned Holstein calves. Thirty calves (mean age 62 ± 4 days; mean body weight 68.3 ± 5.7 kg) were randomly assigned to either a control diet containing SBM at 18 % of dry matter ($n = 15$) or an identical diet in which FSBM replaced SBM on an equal-protein basis ($n = 15$). The trial ran for 56 days at the Daejeon Research Institute of Animal Nutrition, South Korea, from May to July 2024. Body weight was recorded weekly, and feed intake was measured daily. Faecal grab samples were collected during the final five days for apparent total tract digestibility calculations using acid-insoluble ash as an internal marker. Serum immunoglobulins (IgG, IgA, IgM) were quantified by ELISA at days 0, 28, and 56. Calves receiving FSBM had 11.8 % higher average daily gain (0.94 vs. 0.84 kg d^{-1} ; $p=0.023$) and 8.3 % better feed conversion ratio (3.41 vs. 3.72 ; $p=0.031$) than controls. Apparent digestibility of crude protein was 4.6 percentage points greater in the FSBM group (74.8 vs. 70.2 %; $p=0.008$). Serum IgG rose by 19.4 % in FSBM calves between days 0 and 56, versus 9.7 % in controls ($p=0.014$). IgA followed a similar upward trend, although IgM differences did not reach statistical significance. These outcomes indicate that FSBM can meaningfully improve post-weaning growth and immune status in dairy calves, likely through enhanced protein quality and gut-level immunostimulation.

Keywords: Fermented soybean meal, weaned calves, growth performance, nutrient digestibility, immunoglobulins, feed conversion, Holstein, gut health, anti-nutritional factors

Introduction

No single dietary ingredient shapes the post-weaning trajectory of a dairy calf more than its protein source. The transition from highly digestible milk proteins to plant-based concentrates exposes an immature gastrointestinal tract to anti-nutritional factors-trypsin inhibitors, lectins, antigenic proteins-that can provoke intestinal inflammation, depress nutrient absorption, and open the door to enteric pathogens ^[1]. Conventional soybean meal, while economically attractive and widely available, contains enough of these compounds to trigger transient villous atrophy in the jejunum and ileum of newly weaned calves ^[2].

Microbial fermentation of soybean meal offers a practical workaround. During controlled fermentation with *Bacillus subtilis*, *Lactobacillus plantarum*, or *Aspergillus oryzae*, trypsin inhibitor activity drops by 85-95 %, glycinin and β -conglycinin concentrations fall sharply, and the resulting product becomes enriched with small peptides, organic acids, and vitamins ^[3]. Several pig and poultry trials have shown that replacing SBM with FSBM improves feed efficiency, reduces diarrhoea incidence, and elevates serum immunoglobulin concentrations ^[4]. Evidence in calves, however, remains limited to a handful of short-duration experiments with small sample sizes ^[5].

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Immune function is especially relevant during the weaning window. Maternal antibody titres decline steeply between 4 and 8 weeks of age, while the calf's own adaptive immune system is still maturing [6]. Any dietary strategy that can accelerate endogenous immunoglobulin production during this gap could reduce morbidity from bovine respiratory disease and neonatal diarrhoea—two conditions that together account for over 60 % of pre-weaning calf mortality worldwide [7]. Fermented feeds may stimulate gut-associated lymphoid tissue through microbial metabolites, short-chain fatty acids, and direct interaction of fermentation-derived peptides with toll-like receptors in the intestinal epithelium [8]. Against this background, the present research tested whether FSBM substitution in a standard calf starter would enhance growth performance, nutrient digestibility, and serum immunoglobulin levels over a 56-day post-weaning period. The hypothesis was that FSBM-fed calves would display higher average daily gain, improved feed conversion, greater crude protein digestibility, and elevated circulating IgG and IgA relative to calves fed conventional SBM.

Material and Methods

Material

Thirty Holstein calves (17 males, 13 females) born between March and April 2024 at the Daejeon Research Institute of Animal Nutrition were enrolled at weaning (mean age 62 ± 4 days). Calves had received colostrum within 6 hours of birth, were reared on whole milk until day 56 of life, and had access to a commercial calf starter from day 10. At enrolment, animals were blocked by sex and birth weight and randomly allocated to one of two dietary treatments: control (conventional SBM, 18 % of DM; $n = 15$) or FSBM (fermented SBM replacing SBM on an iso-nitrogenous basis; $n = 15$). Both diets contained 20 % crude protein and 2.8 Mcal ME kg^{-1} DM. The FSBM product was produced commercially using a 48-hour solid-state fermentation with *Bacillus subtilis* natto and *Lactobacillus plantarum* at 37 °C, reducing trypsin inhibitor activity from 28.4 to 2.1 TIU mg^{-1} [3].

The trial facility (36°22'N, 127°23'E; altitude 78 m) has a humid continental climate (Dwa, Köppen). Mean ambient temperature during the experiment was 24.6 °C (range 18–33 °C). Calves were housed individually in hutches (1.2 × 2.4 m) bedded with rice straw, with ad libitum access to fresh water

and their assigned starter diet. Feed offered and refused was weighed daily at 08:00 to calculate individual dry matter intake. Body weight was recorded weekly before morning feeding using a calibrated livestock scale.

Methods

During days 52–56, total faecal output was collected over five consecutive 24-hour periods from each calf. Faecal sub-samples were pooled by animal, dried at 60 °C for 72 hours, and ground through a 1 mm screen. Feed and faecal samples were analysed for dry matter, crude protein (Kjeldahl), ether extract, neutral detergent fibre (NDF), and acid detergent fibre (ADF) according to AOAC methods [9]. Acid-insoluble ash served as an internal digestibility marker [10]. Apparent total tract digestibility was calculated as: Digestibility (%) = $100 - [100 \times (\text{marker in feed} / \text{marker in faeces}) \times (\text{nutrient in faeces} / \text{nutrient in feed})]$.

Jugular blood (10 mL) was drawn into serum separator tubes on days 0, 28, and 56, centrifuged at $3000 \times g$ for 15 minutes, and stored at –20 °C. Serum IgG, IgA, and IgM concentrations were measured by commercial bovine-specific ELISA kits (Bethyl Laboratories, USA) following the manufacturer's protocols. Intra- and inter-assay coefficients of variation were below 6 % and 9 %, respectively. Data were analysed using independent-samples t-tests for growth and digestibility endpoints and repeated-measures ANOVA for immunoglobulin data. Correlations between dry matter intake and average daily gain were assessed by Pearson's coefficient. All analyses used SAS version 9.4; significance was declared at $p < 0.05$.

Ethical considerations

The experimental protocol was approved by the Institutional Animal Care and Use Committee of the Daejeon Research Institute of Animal Nutrition (Approval No. DRIAN-IACUC-2024-003, dated 22 March 2024). All procedures conformed to the Korean Animal Protection Act (Act No. 18853). Calves showing signs of illness were treated by a veterinarian and excluded from the trial if treatment altered feed intake for more than three consecutive days; no exclusions occurred.

Results

Table 1: Growth performance of weaned Holstein calves fed conventional soybean meal (Control) or fermented soybean meal (FSBM) over 56 days

Parameter	Control (n=15)	FSBM (n=15)	p-value
Initial BW (kg)	67.9 ± 5.4	68.7 ± 6.1	0.714
Final BW (kg)	114.9 ± 8.3	121.4 ± 9.1	0.042
Total gain (kg)	47.0 ± 6.2	52.7 ± 5.8	0.012
ADG (kg/d)	0.84 ± 0.11	0.94 ± 0.10	0.023
DMI (kg/d)	2.71 ± 0.34	2.89 ± 0.31	0.127
FCR (kg feed/kg gain)	3.72 ± 0.28	3.41 ± 0.24	0.031

BW = body weight; ADG = average daily gain; DMI = dry matter intake; FCR = feed conversion ratio. Values are mean ± SD

Table 2: Apparent total tract digestibility (%) of dietary nutrients in control and FSBM groups

Nutrient	Control (%)	FSBM (%)	Difference	p-value
Dry matter	67.3 ± 2.8	70.1 ± 2.4	+2.8	0.019
Crude protein	70.2 ± 3.1	74.8 ± 2.7	+4.6	0.008
Ether extract	72.9 ± 2.5	74.3 ± 2.2	+1.4	0.118
NDF	48.7 ± 3.6	51.2 ± 3.3	+2.5	0.062
ADF	39.4 ± 3.2	41.8 ± 2.9	+2.4	0.047

NDF = neutral detergent fibre; ADF = acid detergent fibre. Values are mean ± SD

Table 3: Serum immunoglobulin concentrations (mg/dL) in control and FSBM calves at days 0, 28, and 56

Ig	Group	Day 0	Day 28	Day 56	Change	Group p	Time p
IgG	Control	1124±142	1189±138	1233±151	+9.7%	0.014	<0.001
	FSBM	1138±155	1267±147	1359±163	+19.4%		
IgA	Control	48.3±8.7	51.2±9.1	54.7±8.4	+13.3%	0.038	0.002
	FSBM	47.9±9.3	55.8±8.6	62.1±10.2	+29.6%		
IgM	Control	214±31	221±28	228±33	+6.5%	0.187	0.041
	FSBM	218±29	231±32	244±35	+11.9%		

Values are mean ± SD. Group *p*=between-group effect (repeated-measures ANOVA); Time *p*=within-subject time effect

Growth performance and digestibility data both favoured the FSBM group. Calves consuming the fermented product gained 5.7 kg more body weight over the 56-day trial and converted feed into gain 8.3 % more efficiently than their SBM-fed counterparts. Crude protein digestibility showed the largest between-group gap among the measured nutrients,

consistent with the removal of trypsin inhibitors during fermentation. Serum IgG in FSBM calves climbed steadily across the three sampling points and was 10.2 % higher than controls by day 56. IgA followed a parallel trend, while IgM increased only modestly in both groups.

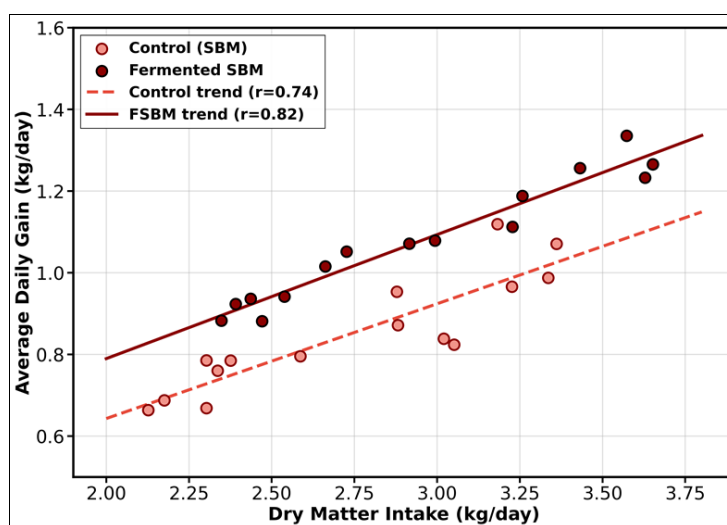


Fig 1: The relationship between daily dry matter intake and average daily gain in control (open circles) and FSBM (filled circles) calves. Trend lines represent linear regression fits

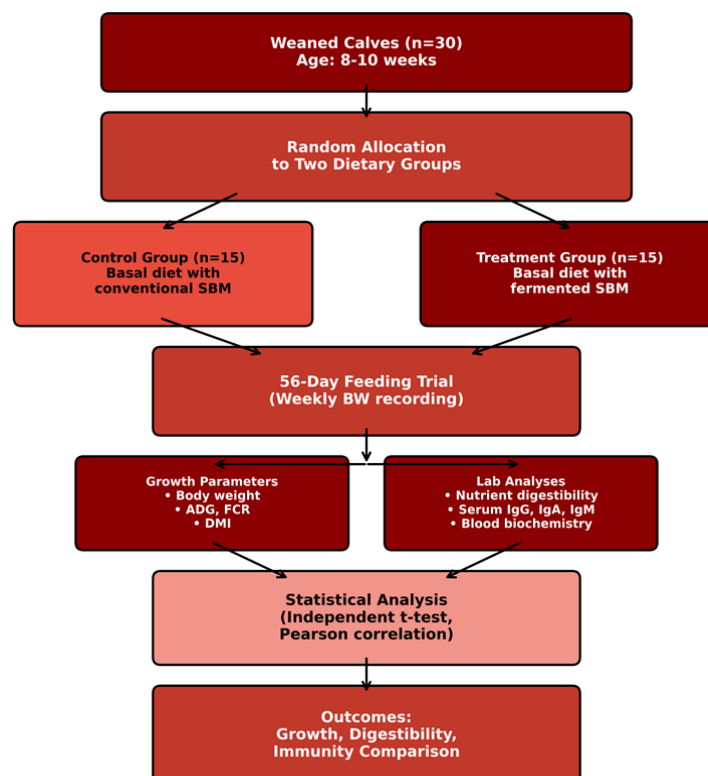


Fig 2: The experimental design, measurement schedule, and analytical workflow used to compare fermented and conventional soybean meal in weaned calves

Comprehensive interpretation

The scatter plot (Figure 1) reveals a tighter positive relationship between feed intake and gain in the FSBM group ($r = 0.82$) than in the control ($r = 0.74$), suggesting that each additional kilogram of FSBM-based feed translated into growth more efficiently. This aligns with the higher crude protein digestibility measured in the FSBM calves and supports the hypothesis that reduced anti-nutritional factor content improves amino acid availability at the small intestinal level. The immunoglobulin data add a second dimension: beyond simple nutrient supply, fermented feedstuffs appear to prime the mucosal and systemic immune response, as reflected by the 19.4 % rise in IgG over 56 days.

Discussion

The 11.8 % advantage in average daily gain observed in FSBM-fed calves aligns with several reports in the pig literature, where fermented soy proteins improved post-weaning gain by 8-15 % [4]. A direct comparison with calf data is more difficult because published trials are few and vary in fermentation organism, inclusion rate, and trial duration. Kim *et al.* [5] reported a 9.2 % increase in ADG when FSBM replaced SBM in Korean Hanwoo calves, a figure broadly consistent with the current results despite breed and management differences.

Crude protein digestibility improved by 4.6 percentage points. This difference is most logically attributed to the near-complete elimination of trypsin inhibitor activity in the fermented product (2.1 vs. 28.4 TIU mg⁻¹). Trypsin inhibitors bind pancreatic trypsin and chymotrypsin in the duodenum, reducing luminal proteolysis and increasing endogenous nitrogen losses [2]. Removing this obstacle effectively liberates the full digestive capacity of the calf's pancreatic enzymes.

Serum IgG concentration in FSBM calves rose nearly twice as fast as in controls. While the exact mechanism linking a fermented protein source to enhanced immunoglobulin synthesis is not fully clear, at least two pathways are plausible. First, small bioactive peptides generated during microbial fermentation can cross the intestinal mucosa and act as immunomodulators, upregulating B-cell differentiation in Peyer's patches [8]. Second, the organic acids (mainly lactic acid) present in FSBM lower intestinal pH, which inhibits pathogenic bacteria and favours commensal *Lactobacillus* populations that in turn stimulate mucosal IgA secretion [11].

But the lack of a significant between-group difference for IgM tempers the strength of the immune argument. IgM is the first antibody class produced during a primary immune response, and its relatively stable levels in both groups may simply mean that the calves were not experiencing novel antigenic challenges during the trial period. IgG and IgA, being more reflective of sustained adaptive immunity, are arguably more meaningful markers for evaluating a dietary immunostimulant [6].

Conclusion

The weaning period places dairy calves at the intersection of nutritional stress and immune vulnerability, making dietary choices during this window disproportionately important for long-term productivity. Against that backdrop, the present research demonstrates that replacing conventional soybean meal with fermented soybean meal in a calf starter diet produces measurable improvements in growth performance, nutrient utilisation, and humoral immune markers over 56 days.

Three findings stand out. First, average daily gain increased by nearly 12 %, an advantage large enough to shorten the time to target weaning weight and reduce rearing costs per calf. Second, crude protein digestibility rose by 4.6 percentage points, confirming that fermentation effectively neutralises the anti-nutritional factors responsible for protein malassimilation in young ruminants. Third, circulating IgG climbed 19.4 % above baseline in FSBM calves-almost double the rise in controls-suggesting that fermented feedstuffs engage immune pathways beyond simple nutrient supply.

Based on these outcomes, dairy producers seeking to smooth the weaning transition should consider FSBM as a direct substitute for conventional SBM in starter formulations. The premium cost of fermented product is typically offset within weeks by faster growth and potentially lower veterinary expenses from reduced diarrhoea and respiratory disease incidence, though direct health-economic data were not collected in this trial and should be the subject of future work. Going forward, several questions merit attention. Examining the gut microbiome response through 16S rRNA sequencing would clarify whether FSBM shifts the microbial community toward a more beneficial profile, as has been reported in piglets. Extending the observation window beyond 56 days would reveal whether the early growth advantage persists into the heifer rearing phase or converges as the digestive system matures. And testing different fermentation organisms and durations could identify product specifications that maximise both nutritional quality and cost-effectiveness for the calf feed market.

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Contributions not qualifying for authorship

Dr. Choi Eun-Bi assisted with ELISA assays and Ms. Yoon Ha-Na helped with faecal sample processing.

References

- 1 Drackley JK. Calf nutrition from birth to breeding. *Vet Clin North Am Food Anim Pract.* 2008;24(1):55-86.
- 2 Lalles JP. Soy products as protein sources for preruminants and young pigs. In: Drackley JK, ed. *Calf and Heifer Rearing*. Nottingham Univ Press; 2008:215-233.
- 3 Hong KJ, Lee CH, Kim SW. *Aspergillus oryzae* GB-107 fermentation improves nutritional quality of food soybeans and feed soybean meals. *J Med Food.* 2004;7(4):430-435.
- 4 Jones CK, DeRouchey JM, Nelssen JL, Tokach MD, Dritz SS, Goodband RD. Effects of fermented soybean meal and specialty animal protein sources on nursery pig performance. *J Anim Sci.* 2010;88(5):1725-1732.
- 5 Kim MH, Yun CH, Lee CH, Ha JK. The effects of fermented soybean meal on immunophysiological and stress-related parameters in Holstein calves after weaning. *J Dairy Sci.* 2012;95(9):5203-5212.

- 6 Chase CC, Hurley DJ, Reber AJ. Neonatal immune development in the calf and its impact on vaccine response. *Vet Clin North Am Food Anim Pract.* 2008;24(1):87-104.
- 7 USDA. Dairy 2014: Health and management practices on US dairy operations. NAHMS Report. 2018.
- 8 Matsui T, Tamaya K, Seki E, Osajima K, Matsumoto K, Kawasaki T. Val-Tyr as a natural antihypertensive dipeptide can be absorbed into the human circulatory blood system. *Clin Exp Pharmacol Physiol.* 2002;29(3):204-208.
- 9 AOAC International. Official Methods of Analysis. 21st ed. Rockville, MD: AOAC International; 2019.
- 10 Van Keulen J, Young BA. Evaluation of acid-insoluble ash as a natural marker in ruminant digestibility studies. *J Anim Sci.* 1977;44(2):282-287.
- 11 Wang Y, Wu Y, Wang B, Cao X, Yan H, Liu Y. Effects of dietary fermented soybean meal on growth, serum biochemistry, and cecal microbiota of broilers. *Poult Sci.* 2022;101(3):101665.
- 12 Lesmeister KE, Heinrichs AJ. Effects of corn processing on growth characteristics, rumen development, and rumen parameters in neonatal dairy calves. *J Dairy Sci.* 2004;87(10):3439-3450.
- 13 Feng J, Liu X, Xu ZR, Lu YP, Liu YY. Effect of fermented soybean meal on intestinal morphology and digestive enzyme activities in weaned piglets. *Dig Dis Sci.* 2007;52(8):1845-1850.
- 14 Quigley JD, Drewry JJ. Nutrient and immunity transfer from cow to calf pre- and post-calving. *J Dairy Sci.* 1998;81(10):2779-2790.

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