



반추영양

Effects of different dietary crude protein and energy levels on growth performance of post-weaning Hanwoo calves: sex-based differences

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This study investigated the effects of increased dietary nutrient levels on the growth performance of post-weaning Hanwoo calves, with particular emphasis on differences in growth responses between sexes. A total of 120 Hanwoo calves (3–6 months of age; 60 males and 60 females) were allocated to two treatments: a Control group (CP 18%, TDN 72%) and a Treatment group (CP 20%, TDN 73%). Formula feed was provided based on body weight, while forage (Klein grass hay) was restricted to 2 kg/day. Overall, the Treatment group tended to show higher average daily gain (ADG) and final body weight (BW) compared to the Control group. When analyzed by sex, female calves in the Treatment group showed significantly higher final BW than those in the Control group ($p < 0.05$). ADG also tended to improve in both females (1.08 vs. 1.14 kg/d) and males (1.16 vs. 1.26 kg/d) fed the high-nutrient diet. The feed conversion ratio (FCR) was numerically improved in both sexes. In conclusion, feeding a high-protein and high-energy diet (CP 20%, TDN 73%) to post-weaning Hanwoo calves significantly improved early growth performance in females and showed a tendency toward improved productivity in males, suggesting its potential application in sex-specific precision feeding strategies.

Key words : Hanwoo calves, dietary nutrients, average daily gain, female, sex difference

반추위 보호 카르니틴 급여 수준이 거세 한우 도체 성적 및 비육기간에 미치는 영향

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본 연구는 사료 내 반추위 보호 카르니틴(Rumen-Protected Carnitine; RPC) 첨가 수준이 거세 한우의 도체 성적 및 비육기간에 미치는 영향을 규명하고자 수행되었다. 거세 한우 60두를 공시하여 RPC 첨가 수준에 따라 대조구(n = 20), RPC 0.0125% 첨가구(n = 16), RPC 0.025% 첨가구(n = 24)의 3처리로 배치하고, 각 처리구가 출하 기준에 도달할 때까지 사양 실험을 실시하였다. 결과에 대한 통계 분석은 일원분산분석으로 수행하였다. 도체중, 등지방두께, 배최장근 단면적, 근내지방도, 일당증체량 및 사료요구율은 처리구 간 유의적 차이가 없었다($p > 0.05$). 반면, 비육기간은 대조구 237.5일에 비해 RPC 0.0125% 첨가구 223.4일, RPC 0.025% 첨가구 210.0일로 RPC 첨가 수준이 증가할수록 유의적으로 단축되었다($p < 0.05$). 이상의 결과를 종합하면, 사료 내 RPC 0.025% 첨가는 도체 품질을 대조구와 동등한 수준으로 유지하면서 비육기간을 약 28일 단축하는 효과가 있어, 거세 한우 비육 농가의 출하 회전율 향상 및 생산비 절감에 실질적으로 기여할 수 있을 것으로 판단된다.

Key words : Hanwoo steer, rumen-protected carnitine (RPC), carcass characteristics, finishing period, production efficiency

Effect of feeding hot-air dried alfalfa hay on the productivity of growing Holstein heifers

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This study evaluated the effects of domestically produced hot-air dried alfalfa hay on the productivity of growing Holstein heifers. Eleven heifers were assigned to a control (n = 5) or treatment group (n = 6) and fed experimental diets for 28 days (7-day adaptation, 21-day feeding trial). Animals were selected based on age (7.1 ± 0.4 months) and body weight (208.7 ± 37.7 kg), and diets were formulated by substituting imported with domestic alfalfa hay to meet target ADG (0.8 kg/day) and metabolizable energy requirements (14.1 Mcal/day). Body weight, dry matter intake (DMI), and ADG were measured weekly, and economic analysis was assessed. No significant differences in body weight, DMI, or ADG were observed between treatment groups or across weeks, indicating no adverse effects of the dietary substitution. Domestic alfalfa hay reduced feed costs by 370 KRW per head per day compared to imported hay. These results suggest that hot-air dried alfalfa hay can effectively replace imported alfalfa hay in growing heifer diets without negatively affecting growth performance or palatability, though further studies accounting for seasonal variation are warranted.

Key words : hot-air dry system, alfalfa, growing Holstein heifers

Circadian-aware and individualized activity modeling improves early estrus prediction in dairy cows

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This study developed an estrus prediction model that incorporates circadian rhythms and individualized baselines to improve early detection in dairy cows. Five-year activity data from 164 cows (about 2.3 million records) were used to construct a balanced dataset of 5,120 samples comprising 7-day windows preceding estrus or non-estrus periods. Features included time-of-day Z-score normalization using each cow's 30-day historical baseline and a moving activity index comparing recent 24-hour activity with a 6-day baseline. A Random Forest classifier was trained and evaluated at 4, 8, and 12 hours before estrus onset. The proposed model achieved 70.8% accuracy 8 hours pre-estrus, outperforming a conventional raw-activity model lacking individualized temporal normalization that reached only 51.1% and required a shorter lead time of 6 hours to achieve comparable performance. Improvements stemmed from enhanced detection of subtle nighttime activity increases and reduced misclassification during naturally high-activity daytime periods. Error analysis showed reduced false positives—by filtering normal daytime spikes—and false negatives—by accentuating early low-activity deviations. Feature importance identified maximum Z-score, absolute activity peaks, and sustained upward trends as the dominant predictors. These results demonstrate that circadian-aware, individualized feature design enables earlier and more reliable estrus alerts, providing a ≥ 2 -hour improvement in actionable lead time and contributing to more efficient reproductive management in precision dairy farming.

Key words : estrus detection, circadian rhythm, random forest, wearable sensor data, precision dairy farming

유전체 육종가 수준이 거세 한우의 성장과 도체 성적 및 육질 특성에 미치는 영향

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본 연구는 유전체 육종가 수준이 거세 한우의 성장 성적과 도체 성적 및 육질 특성에 미치는 영향을 규명하기 위해 수행하였다. 거세 한우 36두를 마블링스코어 유전체 육종가(genomic estimated breeding value of marbling score, gMS) 수준에 따라 상위그룹과 하위 그룹으로 배치하였다. 상위그룹이 마블링스코어, 도체중 및 등심단면적 유전체 육종가가 높았다($p < 0.01$). 시험축은 평균 10개월령부터 출하 시까지 육성기, 비육전기, 비육후기별로 구분하여 농후사료와 조사료를 두 그룹에 동일하게 급여하였다. Blood free fatty acid 농도는 상위그룹에서 높았으며($p < 0.01$), urea nitrogen과 glucose 농도는 차이가 없었다. 29개월령 체중은 하위그룹 대비 상위그룹에서 17% 높았다($p < 0.01$). 시험축은 30개월과 33개월 2시기로 나누어서 출하하였다. 2시기 평균 도체중은 하위그룹 대비 상위그룹에서 20% 높았다($p < 0.01$). 도체의 마블링스코어와 등심단면적은 하위그룹 대비 상위그룹에서 각각 100% 및 22% 높았다($p < 0.01$). 도체 경락 단가와 두당 지육가격은 하위그룹 대비 상위그룹에서 각각 34% 및 59% 높았다($p < 0.01$). 등심의 마블링 섬세도와 관능 평가에 의한 연도, 풍미 및 palatability가 모두 하위그룹보다 상위그룹에서 우수하였다($p < 0.05$). 결론적으로 유전능력이 우수한 개체를 선정하여 사육하는 것이 한우 농가의 소득 증대와 고품질 한우육 생산에 기여함을 확인하였다. 유전능력에 기반한 맞춤형 영양·사양을 통하여 추가적인 소득 증대가 기대된다.

Key words : 거세 한우, 유전체 육종가, 성장 성적, 도체 성적, 경락 단가, 지육 단가, 연도, 풍미

경산우 고에너지 급여에 따른 비육기간별 생산성 및 수익성 평가

박명선, 장선식, 문성진, 엄경환, 김재성, 백열창

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경산우에서 에너지 수준이 비육기간별 생산성 및 수익성에 미치는 영향을 구명하고자 본 시험을 수행하였다. 시험은 비육기간(5개월, 8개월)과 관행(TDN 75%), 고에너지(TDN 80%)에 따라 처리구를 구성하고 일당증체량, 건물섭취량 및 도체특성을 조사하였다. 결과적으로, 5개월 비육에서 고에너지 급여구는 관행에 비해 일당증체량과 육량지수가 높게 나타났으나, 도체중이 상대적으로 낮아 수익이 낮게 나타나는 경향을 보였다. 또한, 8개월 비육에서는 고에너지 급여구의 증체 효율이 낮고 사료비가 증가하는 경향을 보였다. 두당 수익 분석 결과, 관행 5개월 비육구가 가장 높은 수익을 나타냈으며, 고에너지 5개월 비육구는 가장 낮은 수익을 보였다. 이는 에너지 수준을 높일 경우 증체 효율은 향상되나, 도체중 증가로 충분히 이어지지 않아 수익성 개선으로 연결되지 않을 수 있음을 의미한다. 따라서, 경산우 비육 시 수익성은 육량지수보다 도체중과 같은 절대량에 크게 영향을 받는 것으로 사료된다.

Key words : 경산우, 고에너지 사양, 비육기간, 도체중, 수익성

Impact of palm oil supplementation on growth performance, rumen fermentation, and methane emissions in Hanwoo steers

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This study evaluated the effects of graded levels of palm oil inclusion in concentrate on growth performance, rumen fermentation, and methane emissions in Hanwoo steers. Twelve steers (571.00 ± 65.09) were assigned to a replicated 3×3 Latin square design with three 21-day periods and three dietary treatments: CON (0% palm oil), T1 (1.5% palm oil), and T2 (2.0% palm oil). Growth performance parameters were measured alongside ruminal pH, ammonia nitrogen ($\text{NH}_3\text{-N}$), volatile fatty acids (VFA), and methane emissions. Growth performance was not affected by palm oil supplementation ($p > 0.05$). Ruminal pH differed significantly among treatments ($p < 0.05$), whereas $\text{NH}_3\text{-N}$ and total VFA concentrations remained unchanged ($p > 0.05$). The molar proportion of propionate was higher in the T2 group, resulting in a reduced acetate-to-propionate ratio compared to CON and T1 ($p < 0.05$). Methane emissions decreased significantly in steers fed palm oil-supplemented diets ($p < 0.05$), with the T2 group showing the greatest reduction in methane production (13.27%), yield (10.33%), and intensity (13.43%). In conclusion, palm oil supplementation altered rumen fermentation patterns and reduced methane emissions without negatively affecting growth performance in Hanwoo steers. These findings support that palm oil can be used as a dietary strategy to improve rumen efficiency and mitigate enteric methane emissions in beef production systems.

Key words : palm oil, methane emission, Hanwoo, rumen, growth performance

Evaluation of kaolinite-based feed additive and fumarate supplementation on *in vitro* rumen fermentation and methane production

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This study evaluated the interaction of kaolinite-based feed additive (K) and disodium fumarate (F) supplementation on *in vitro* rumen fermentation and methane (CH₄) production. The experimental followed a 5 × 2 factorial arrangement design, consisting of five supplementation levels of kaolinite (0%, 1%, 1.5%, 2.0%, and 3.0%) with or without 15 mM disodium fumarate in a substrate containing a 70:30 concentrate-to-forage ratio. Rumen fluid was obtained from a ruminally cannulated Holstein cow and used as the inoculum for the *in vitro* experiment. Batch culture incubations were conducted for 12 and 24 h. Data were analyzed using the MIXED procedure of SAS, with kaolinite dose (K), fumarate (F), and their interaction (K × F) included in the model as fixed effects. For gas production parameters, the K × F interactions were significant for total gas production and CH₄ production (mL) at both 12 and 24 h of incubation ($p < 0.05$). At 12 h of incubation, CH₄ production was 32.0%, 42.8%, 46.1%, and 40.7% lower in K_{1.5}, K_{2.0}, F_{1.0} and F_{3.0}, respectively, compared with K₀ ($p < 0.05$). At 24 h, CH₄ production was 11.9%, 26.9%, 25.2% lower in K_{1.5}, F_{1.0}, and F_{1.5}, respectively, relative to K₀ ($p < 0.05$). Propionate, butyrate, and the acetate-to-propionate ratio showed significant K × F interactions at both 12 and 24 h of incubation ($p < 0.05$), whereas total volatile fatty acids (VFA) and ammonia-nitrogen exhibited significant K × F interactions only at 12 h. These findings indicate that kaolinite and disodium fumarate exert interactive effects on rumen fermentation and methane production, with both additives contributing to reductions in CH₄ production. The combination of kaolinite and fumarate modulated fermentation characteristics, particularly VFA profiles, suggesting a shift in rumen metabolic pathways. Overall, this strategy shows potential as an effective dietary approach for mitigating enteric methane emissions while influencing rumen fermentation dynamics, warranting further *in vivo* validation.

Key words : kaolinite, disodium fumarate, *in vitro*, methane, rumen

Effects of sodium sulfite on methane mitigation in goats

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This study was conducted to evaluate the effects of sodium sulfite (SS) supplementation on enteric methane emission and rumen fermentation in goats. Ten goats (58.7 ± 9.57 kg) were used in this study. The experimental design was a randomized block design, with treatments allocated to control (no supplementation) and 0.5% SS supplementation, based on body weight (BW). Tall fescue and concentrate were offered as the basal diet at 2% of BW on a dry matter basis. The adaptation period of the feed and the respiration chamber was 14 days and 3 days, respectively. CH₄ exhaled by goats was measured for 3 days using a methane analyzer (Airwell + 7) equipped with tunable diode laser absorption spectroscopy, while collecting feces for digestibility analysis. Thereby, blood and rumen fluid samples were collected after 3 h of morning feeding to assess rumen fermentation and blood biochemical parameters. Compared with the control, SS 0.5% significantly reduced CH₄ emissions by 21% ($p < 0.05$) without altering dry matter intake or nutrient digestibility. Molar proportion of propionate was significantly increased in SS 0.5%, while that of acetate was significantly decreased compared to the control ($p < 0.05$). No differences were observed in other rumen fermentation or blood biochemical parameters in goats. Collectively, supplementing sodium sulfite can mitigate enteric CH₄ in goats. Further studies are warranted to examine the effects of SS on animal performance, including carcass characteristics.

Key words : methane, sodium sulfite, goat, rumen fermentation

Effects of thiamine diphosphate (ThDP) supplementation on methane emissions and milk productivity in lactating Holstein cows

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Methane produced during the digestive process of dairy cows is not only a greenhouse gas but also represents a loss of unutilized dietary energy. Therefore, mitigating methane emissions can simultaneously reduce greenhouse gases and improve livestock growth performance. Thiamine diphosphate (ThDP), the active coenzyme form of vitamin B1, was previously found to reduce *in vitro* methane production by 32% at 720 ppm. Building on these findings, the present study investigated the effects of dietary supplementation with 720 ppm ThDP on the productivity and methane emissions of lactating Holstein cows. Supplementation did not significantly affect overall productivity ($p > 0.5$), with no statistical differences between the control and treatment groups in body weight (734.61 vs. 740.53 kg), dry matter intake (20.13 vs. 20.29 kg/d), milk yield (30.65 vs. 31.20 kg/d), milk fat (4.53% vs. 4.30%), milk protein (3.60% vs. 3.53%), and lactose (4.80% vs. 4.72%). Similarly, *in vivo* methane emissions showed no significant difference, with the control group producing 17.92 g/kg^{DMI} compared to 18.03 g/kg^{DMI} in the treatment group. The lack of *in vivo* efficacy, contrary to *in vitro* findings, is likely due to continuous ruminal saliva flow hindering ThDP's ability to regulate metabolism or compete with coenzyme M (CoM). Further research, such as modifying the feeding method or adjusting the dosage, is needed to overcome these *in vivo* limitations.

Key words : methane reduction, ruminant, ThDP, dairy cow, Holstein cow

Synergistic influence of exogenous fibrolytic enzymes and probiotics on *in vitro* rumen fiber digestion in Korean native black goats

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The use of bio-supplements to enhance fiber degradation and stabilize rumen fermentation has gained increasing attention in animal industry of South Korea. An *in vitro* experiment was conducted to evaluate the effects of a fibrolytic enzyme blend (cellulase + xylanase) with or without the probiotic *Clostridium butyricum* on rumen fermentation and selected microbial groups using rumen fluid from Korean native black goat. Four treatments were tested: control (CON), fibrolytic enzymes (FE), *C. butyricum*(CB) and a combination (FECB). Across incubation times (24 and 48 h), all treatments increased *in vitro* dry matter digestibility compared to the CON ($p < 0.05$). The treatments showed higher levels of propionic and butyric acids than CON ($p < 0.05$), its indicative of their distinct ruminal fermentation pathways that prioritize rapid energy availability and gut health. Quantitative PCR (qPCR) results ($\log_{10}$ gene copy numbers/mL) showed that the treatment groups had a notable increase in protozoa and anaerobic fungi compared to the CON ($p < 0.05$). This reflects the unique dependence on these microbes for fiber degradation and nutrient recycling. Therefore, it is considered that these shifts in the microbial community led to increased fiber degradation and improved ruminal fermentation efficiency. [This work was supported by IPET through Agriculture and Food Convergence Technologies Program for Research Manpower Development Program or Project, funded by MAFRA (grant number RS-2024-00400922)].

Key words : probiotics, cellulase, xylanase, *Clostridium butyricum*, rumen fermentation, Hanwoo

제주흑우 수소(비거세우)의 생후 초기 성장특성 연구

원미영, 신상민, 김연태, 이승은, Shokrollahi Borhan

농촌진흥청 국립축산과학원 축산자원개발부 난지축산연구센터

제주흑우는 유전적 보존 가치가 높은 재래축종이지만, 한우 대비 지육량이 적고 1등급 이상 출현율이 낮아 경제성이 낮은 품종으로 평가받고 있다. 또한 사육 두수 감소로 산업 기반이 약화되고 있으며, 특히 씨수소 개체 부족으로 우량 개체 선발과 세대교체를 위한 체계적 사양관리 및 성장 자료 확보가 시급한 실정이다. 더불어 생후 초기 성장단계의 체형 발달 특성에 대한 정량적 자료가 부족하여, 초기 성장 특성 구명과 예측모델 구축의 필요성이 제기되고 있다. 본 연구는 제주흑우 수소의 생후 초기 성장단계별 체형 변화를 조사하고, 이를 바탕으로 최적 성장 예측모델을 제시하고자 수행되었다. 난지축산연구센터 등에서 사육 중인 제주흑우 수소(비거세우)를 대상으로 생시부터 6개월령까지 매월 체중과 11개 체형 항목(체고, 체장, 흉위, 십자부고 등)을 정기 측정하였다. 수집된 데이터를 바탕으로 품종 간(제주흑우 vs 한우) 성장 양상을 비교하였으며, 선형 및 비선형(Logistic, Gompertz) 회귀모델을 적용하여 체형지표와 체중 간의 상관관계 및 성장 예측 가능성을 분석하였다. 제주흑우 수소의 평균 생시 체중은 26.0 kg이었으며, 2-3개월령에 이유 및 급이 조건 변화로 인해 일당증체량(ADG)이 일시적으로 감소(0.53 kg/일)했으나 이후 회복되는 경향을 보였다. 체형지표와 체중 간의 상관관계 분석 결과, 흉위(Chest Girth)와의 결정계수(R^2)가 0.987로 가장 높게 나타나 체중 예측을 위한 핵심 지표임을 확인하였다. 성장 모델 적용 결과, 제주흑우는 한우에 비해 초기 성장률은 높으나 성장이 일찍 안정화되는 경향을 보였다. 특히 Gompertz 모델은 생후 6개월까지의 데이터로 18개월령까지의 성장을($R^2 = 0.933$) 예측할 수 있는 것으로 나타났다. 본 연구에서 구축한 제주흑우 수소의 초기 성장자료와 예측모델은 희소축종의 효율적 사양관리 기준 수립과 씨수소 선발을 위한 기초자료로 활용될 것으로 판단된다. 향후 통계적 신뢰도 향상을 위해 공시축 두수 확대와 장기 반복측정이 필요하다.

Key words : 제주흑우, 성장특성, 영양사료, 흉위, Gompertz 모델

The effects of mixture of thiamine pyrophosphate and plant oils on the *in vitro* methane production and rumen fermentation characteristics

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The present study was conducted to evaluate the effects of a mixture of thiamine pyrophosphate (TPP) and plant oils (canola, sunflower, and soybean) on *in vitro* rumen fermentation characteristics and methane production. TPP was added at 0 or 480 ppm (DM basis), and each plant oil was added at 0 or 4 % (DM basis). The substrate used was a mixture of ground concentrate and forage in a 7:3 ratio. Rumen fluid was collected from two cannulated cows and mixed with McDougall's buffer at a ratio of 1:3. A total of 50 mL of the buffered rumen fluid and 0.5 g of the substrate were dispensed into 125 mL serum bottles, which were then incubated at 39°C for 24 h. After incubation, each gas sample was collected for methane analysis, and rumen fluid was sampled to evaluate fermentation characteristics. Methane production (% digested DM) showed a interaction effect between TPP and plant oils ($p=0.018$), with the TPP and plant oil mixture groups showing the lowest production ($p < 0.05$) compared with the single (TPP or oil) treatments. In addition, the acetate-to-propionate ratio increased in the plant oil treatments due to a decrease in propionate concentration, but the TPP and plant oil mixture improved these values through an interaction effect ($p<0.001$). *In vitro* dry matter digestibility and total volatile fatty acid concentrations did not differ significantly among all treatments ($p>0.05$). In conclusion, the mixture of TPP and plant oil was demonstrated to improve methane inhibition and the acetate-to-propionate ratio in rumen fluid.

Key words : methane, thiamine pyrophosphate, plant oils

Development of an automatic feeder-specific calf milk replacer through analysis of its physical and chemical properties

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This study was conducted to establish development criteria for calf milk replacers suitable for automatic milk feeders (AMF) by comparing the chemical and physical properties of four commercial milk replacers (A, B, C, D) with whole milk powder (WMP). Proximate analysis showed that WMP had the highest dry matter (97.13%), whereas C had the lowest (96.92%) ($p < 0.05$). Crude protein was highest in A (25.09%) and lowest in B (21.62%), while ether extract was highest in WMP (30.16%) and lowest in A (8.28%) ($p < 0.05$). Crude ash was highest in A (7.61%) and lowest in C (6.74%) ($p < 0.05$). Particle size distribution analyzed by laser diffraction showed that D had the lowest SPAN value (1.81), indicating more uniform particle size, whereas A had the highest SPAN value (2.82). SPAN is a measure of the width of particle size distribution. Accordingly, D exhibited more uniform particle size, whereas A showed greater heterogeneity. Solubility analysis revealed that D exhibited superior solubility, whereas A showed lower solubility and a higher possibility of insoluble residue formation after reconstitution ($p < 0.05$). These findings suggest that the suitability of calf milk replacers for AMF depends not only on nutritional composition but also on physical properties such as particle uniformity and solubility. Therefore, both nutritional value and rehydration stability should be considered in establishing quality criteria for AMF-specific calf milk replacers.

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Key words : calf, milk replacer, automatic feeder, particle size, solubility

Effects of dietary L-citrulline supplementation on adipogenic and arginine metabolism-related gene expression in finishing Hanwoo steers

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This study aimed to investigate the effects of dietary L-citrulline (L-Cit) supplementation on the mRNA expression of adipogenic and arginine metabolism-related genes in finishing Hanwoo steers. Thirty-four Hanwoo steers (age: 25.0 ± 0.6 mo) were assigned to two dietary treatments: a control group (0% L-Cit; $n = 17$) and an L-Cit group (0.4% L-Cit on a dry matter basis via top dressing; $n = 17$). Following a 6-mo treatment period, the steers were slaughtered. Samples of the liver, kidney, and *longissimus lumborum* (LL) muscle were collected for mRNA expression analysis. Statistical analyses were performed using the TTEST procedure in SAS 9.4. In the liver, *OTC* expression was higher ($p < 0.05$) in the L-Cit group than in the control group, whereas *ARG1*, *ASS*, *ASL*, and *GAMT* expression did not differ between groups. In the kidney, *AGAT* expression was lower ($p < 0.05$) in the L-Cit group than in the control group, whereas *ASS* and *ASL* expression did not differ between groups. In the LL muscle, *ZNF423*, *CD36*, *FABP4*, and *SNAP23* expression was higher ($p < 0.05$) in the L-Cit group than in the control group, whereas *PPARG*, *LPL*, *SCD*, *DGAT2*, and *BSCL2* expression did not differ between groups. Overall, dietary supplementation with 0.4% L-Cit in finishing Hanwoo steers induced tissue-specific transcriptional responses in renal and hepatic arginine metabolism and up-regulated intramuscular adipogenic gene expression, warranting further investigation with phenotypic measures of carcass quality.

Key words : finishing Hanwoo steer, L-citrulline, arginine metabolism, adipogenic gene expression

Growth performance, nutrient intake, and digestibility in female goats fed low versus high levels of different type of alfalfa

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This study evaluated the effects of low (1.5% of body weight) and high (2.0% of body weight) feeding levels of local and imported alfalfa on growth performance, nutrient intake, and nutrient digestibility in female crossbred goats (Boer × Korean native, *Capra hircus*). Twelve female goats with initial body weight of 38.7 ± 1.3 kg were assigned to a 4×4 Latin square design with four dietary treatments (L1: local alfalfa at 1.5% BW; L2: imported alfalfa at 1.5% BW; H1: local alfalfa at 2.0% BW; H2: imported alfalfa at 2.0% BW) over four periods of one month each period.

Final body weight was numerically higher in the high feeding level groups, reaching up to 43.17 kg, compared to the low feeding level groups. Body weight gain ranged from 1.63 kg (lowest in H1) to 3.08 kg (highest in H2), while average daily gain ranged from 58.04 g/day (lowest in H1) to 110.12 g/day (highest in H2). Dry matter intake was higher in the high alfalfa level treatments ($p < 0.0001$). Nutrient intake values for dry matter, organic matter, crude protein, crude fiber, acid detergent fiber, and neutral detergent fiber were generally higher in the high feeding level groups. In contrast, digestibility coefficients for all measured nutrients remained similar across treatments, ranging from approximately 71% to 84%.

These results indicate that both local and imported alfalfa performed similarly in female crossbred goats when fed at either 1.5% or 2.0% of body weight. Notably, the highest body weight gain (3.08 kg) and average daily gain (110.12 g/day) were observed in H2 (imported alfalfa at 2.0% BW), suggesting that the combination of imported alfalfa at the high feeding level supported the strongest numerical growth performance while maintaining comparable nutrient digestibility.

Key words : alfalfa, female goats, low feeding level, high feeding level, growth performance, nutrient intake, digestibility

Effects of feeding level on nutrient intake, digestibility and nitrogen balance in hybrid goats offered a locally produced alfalfa

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This study investigated the effects of feeding level (1.5% vs 2.0% of body weight) of locally produced alfalfa on growth performance, nutrient intake, digestibility, and nitrogen balance in hybrid goats (Boer × Korean native, *Capra hircus*). Twenty-four goats (12 females and 12 males; initial body weight 38.1 ± 1.1 kg for females and 40.3 ± 1.1 kg for males) were used in a 2-period crossover design with a 2×2 factorial arrangement (sex × feeding level) over 12 weeks (cage and diet adaptation: 4 weeks + experiment diet adaptation: 8 weeks) with four treatments: F1 (1.5% BW in female), F2 (2.0% BW in female), F3 (1.5% BW in male), and F4 (2.0% BW in male). Males exhibited higher body weight gain and ADG than females, with the highest value recorded in F4. Dry matter intake was clearly higher in the high feeding level groups (2.0% BW), particularly in males ($p < 0.05$). Nutrient intake, especially crude protein intake, was substantially higher in male goats compared to females, reaching the highest level in F4. Digestibility coefficients for most nutrients were generally similar between feeding levels. Male goats exhibited significantly higher nitrogen intake, body nitrogen retention, and nitrogen utilization efficiency than females, while feeding level (1.5% vs 2.0% BW) had limited impact on nitrogen balance parameters. Nevertheless, both sexes maintained positive nitrogen balance across all treatments. These findings suggest that male hybrid goats responded to higher feeding levels of locally produced alfalfa with greater growth and crude protein intake, while females showed relatively better nitrogen utilization efficiency despite lower overall intake.

Key words : local alfalfa, hybrid goats, feeding level, sex difference, nutrient intake, digestibility, nitrogen balance

Early growth performance, feed intake, and phenotypic traits of uncastrated Jeju black bulls

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Jeju Black cattle, a native Korean breed, possess distinct genetic and phenotypic characteristics; however, early growth in uncastrated bulls remains insufficiently characterized, and feeding standards are largely derived from Hanwoo. This study aimed to evaluate early growth performance, feed intake, and phenotypic development in uncastrated Jeju Black bull calves and generate baseline data for breed-specific management. Three uncastrated Jeju Black bull calves were monitored from birth to 12 weeks. Body weight, daily feed intake, and morphometric traits (height, body length, and heart girth) were recorded at regular intervals. Growth patterns were assessed using repeated measurements, and relationships between body weight and body-size traits were analyzed by regression. Body weight increased from approximately 20–37 kg at birth to 71–108 kg at 12 weeks, showing consistent growth with gradual acceleration. Daily feed intake rose from 0.1 to 2.5 kg/day, reflecting increasing nutritional demand. Morphometric traits increased steadily and were positively associated with body weight, indicating coordinated development. Compared with Hanwoo references, Jeju Black calves exhibited slightly lower body weights, suggesting breed-specific growth patterns. These findings provide baseline data on early growth, feed intake, and phenotypic development in uncastrated Jeju Black bulls, supporting breed-specific feeding strategies and future large-scale and genetic studies.

Key words : Jeju black cattle; early growth; feed efficiency; morphometric traits; growth dynamics

Development of a body condition score prediction algorithm for dairy cows using 3D point cloud data based on a pointpillar model

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This study aimed to develop an artificial intelligence-based model for the automatic estimation of Body Condition Score (BCS) in dairy cows using 3D point cloud data. A total of 605 3D point cloud datasets were utilized, and BCS labels were defined as the average scores from three independent observers. For datasets with temporal gaps, linear interpolation was applied assuming that changes in BCS occurred linearly over time. During preprocessing, data with insufficient point counts were excluded to ensure data quality. Data augmentation techniques, including random sampling, rotation, and noise addition, were applied. The dataset was divided into training (80%) and validation (20%) sets. The model was developed based on the PointPillar architecture, converting 3D point cloud data into a 2D grid representation. Spatial features were extracted using a convolutional neural network (CNN). This approach enabled effective learning of individual cow characteristics for BCS prediction. Model performance was evaluated using MSE, RMSE, MAPE, and SMAPE metrics. t-SNE analysis showed clear separation among individual cows, indicating effective feature extraction. Cosine similarity analysis further suggested the potential for estimating BCS across different individuals.

Key words : body condition score, 3D point cloud, PointPillar, dairy cow

Rumen protozoal and fungal community composition in Hanwoo steers with divergent residual feed intake phenotypes

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This study aimed to evaluate the association between RFI phenotype and rumen protozoal and fungal communities in early fattening Hanwoo steers. Sixty-four Hanwoo fattening steers (16 months of age; 528.5 ± 44.4 kg body weight) were divided into two extreme phenotypic groups: low RFI (L-RFI; efficient; top 10%, $n = 6$) and high RFI (H-RFI; inefficient; bottom 10%, $n = 6$). Metagenomic DNA was extracted from rumen samples ($n = 12$), and the protozoal 18S rRNA gene and fungal ITS region were amplified and sequenced on the Illumina MiSeq platform. Bioinformatic analysis was performed using QIIME 2, and differential abundance was assessed using the ANCOM-BC method. Alpha diversity metrics (observed ASVs, Shannon, and Simpson) did not differ in the protozoal community between RFI groups, whereas significant differences were observed in the fungal community ($p < 0.05$). Principal coordinate analysis based on Bray-Curtis dissimilarity revealed significant differences in both protozoal and fungal community composition between the two RFI groups. In the protozoal community, *Dasytricha*, *Polyplastron*, and *Entodinium* were significantly enriched in the H-RFI group ($q < 0.05$), whereas *Eudiplodinium* and *Ostracodinium* were predominant in the L-RFI group ($q < 0.05$). Additionally, *Anaeromyces* was the only fungal genus with higher abundance in the L-RFI group ($q < 0.05$). Taxa associated with fiber degradation, including *Eudiplodinium* and *Ostracodinium* in the protozoal community and *Anaeromyces* in the fungal community, were enriched in efficient steers, suggesting their potential association with improved energy utilization from structural carbohydrates.

Key words : Hanwoo cattle, rumen microbiota, residual feed intake

Site-specific microbiome features reveal functional specialization of fecal and vaginal microbiomes in Holstein dairy cows

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Fecal and vaginal microbiomes are closely associated with digestive and reproductive physiology in ruminants, but their site-specific ecological and predicted functional characteristics in Holstein dairy cows remain insufficiently understood. This study investigated the diversity, taxonomic composition, predicted pathway-level functions, and temporal microbial dynamics of fecal and vaginal microbiomes in Holstein dairy cows using 16S rRNA gene sequencing. Fecal samples exhibited higher alpha diversity than vaginal samples, and both taxonomic and predicted functional profiles showed clear separation according to anatomical site. The fecal microbiome showed higher predicted contributions to secondary bile acid biosynthesis, lysosome-related pathways, and sphingolipid metabolism, whereas the vaginal microbiome was characterized by the enrichment of Actinomycetota, Mycoplasmoidaceae, *Blautia*, and predicted pathways related to phosphotransferase system and ketone body metabolism. Longitudinal analysis further indicated that fecal Prevotellaceae showed an increasing trend over time, suggesting temporal taxonomic responsiveness of the fecal microbiome. These findings highlight site-specific ecological and predicted functional differentiation between fecal and vaginal microbiomes and suggest their potential as microbial indicators for nutritional management and reproductive health monitoring in dairy cows.

Key words : dairy cows, feces, metabolic pathways, microbiota, vagina

Low versus high forage levels of alfalfa: effects on growth performance and morphological characteristics of male Korean Crossbred Goats

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This study investigated the effects of low (1.5% of body weight) versus high (2.0% of body weight) forage levels of local and imported alfalfa on growth performance and morphological characteristics in male Korean crossbred goats (Boer × Korean native, *Capra hircus*). Twelve goats with an initial body weight of 39.1 ± 1.2 kg were assigned to a replicated 4×4 Latin square design with four dietary treatments: T1 (local alfalfa at 1.5% BW), T2 (imported alfalfa at 1.5% BW), T3 (local alfalfa at 2.0% BW), and T4 (imported alfalfa at 2.0% BW) over four 1-month periods.

High forage levels (2.0% BW) resulted in numerically higher total dry matter intake compared to the low forage levels ($p < 0.05$). Final body weight was higher in the high forage groups, particularly in goats fed local alfalfa at 2.0% BW. Body weight gain and average daily gain were also numerically highest in the high forage level with imported alfalfa (T4). In terms of morphological characteristics, withers height was greater in the high forage level groups, with the highest value observed under high local alfalfa feeding (T3, $p < 0.05$). Other body measurements such as body length, chest width, and chest girth showed modest numerical increases in the high forage level groups.

These results suggest that increasing the forage level from 1.5% to 2.0% of body weight with either local or imported alfalfa improved dry matter intake and supported better final body weight and withers height in male crossbred goats. High forage feeding, especially with local alfalfa, appeared advantageous for certain morphological traits, while both alfalfa types performed comparably overall in growth performance.

Key words : alfalfa, low forage, high forage, male goats, growth performance, morphological characteristics

성장단계별 육용 염소의 혈중 대사물질 및 생리적 지표 변화 분석

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국내 염소 산업은 건강식에 대한 수요 증가에 따라 전업화 및 규모화가 진행되고 있으나, 사료비 상승과 표준화된 사양관리 체계의 부재로 인해 농가 경영 부담이 심화되고 있다. 특히 성장 단계별 염소의 영양 요구량 충족 여부를 평가할 수 있는 생리적 지표에 대한 연구는 여전히 부족한 실정이다. 따라서 본 연구는 육용 염소의 주요 성장 단계 (3, 6, 9, 및 13개월령)에 따른 혈중 대사물질의 변화를 추적하여 시기별 대사적 특성을 규명하고자 수행되었다. 보어 교잡종 염소 18두를 공시하였으며, 성장 특성 조사를 위해 시험 기간 동안 체중을 매월 측정하였다. 또한 혈중 대사물질 분석을 위해 혈액은 각 성장 단계에서 경정맥을 통해 채취하였으며, 에너지·단백질·간 기능 관련 지표를 자동생화학분석기를 이용하여 분석하였다. 성장 단계에 따라 체중은 3개월령 14.97 kg에서 13개월령 51.22 kg까지 완만하게 증가하였으며, 혈중 대사물질 지표에서 유의적인 시기적 변화가 관찰되었다. 혈중 BUN 농도는 3개월령(17.30 mg/dL) 대비 13개월령(34.10 mg/dL)에서 약 2배 가까이 증가하였고, glucose 농도는 3개월령에 가장 높았으나, 이후 감소 되어(Min: 56.00–Max: 117.00) 범위를 유지하였다. 혈중 NEFA 및 cholesterol 농도는 3개월령에서 일시적으로 높게 나타난 후 6개월령에 감소하였으며, 이후 점진적으로 증가하는 경향을 보였다. 간 기능 지표인 GGT 및 AST 또한 성장 단계에 따라 유의적인 변동을 나타냈다. 본 연구 결과, 성장 단계에 따라 육용 염소의 단백질 및 지질 대사 특성이 다르게 나타났으며 혈중 대사산물의 변화 양상은 성장 단계별 적정 영양 공급 기준 마련과 생리적 이상 판정을 위한 기초 자료로 활용될 수 있을 것으로 판단된다.

Key words : 육용 염소, 보어, 성장 단계, 혈중 대사산물, 생리적 지표

Effects of nutrient levels in concentrate feed on rumen fermentation characteristics, growth performance, plasma metabolites, and carcass characteristics in Hanwoo steers

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This study evaluated the effects of concentrate feed nutrient levels on rumen fermentation characteristics, growth performance, plasma metabolites, and carcass characteristics in Hanwoosteers. A total of 157 Hanwoosteers (269.5 ± 37.5 kg; 8 months of age) were assigned to two dietary treatments differing in concentrate feed nutrient levels during the growing, early fattening, and late fattening periods: Control (CP 16.5–18.5%, TDN 81–83%) and Treatment (CP 17–19%, TDN 82–84%). Rumen pH values and $\text{NH}_3\text{-N}$ concentrations were higher in the Control group than in the Treatment group ($p < 0.05$), whereas propionate concentration was higher in the Treatment group than in the Control group ($p < 0.05$). The relative abundances of *Acetivibrio* and *Saccharofermentans* were lower in the Treatment group than in the Control group ($p < 0.05$), while no significant differences were observed in the relative abundances of other genera. Body weight did not differ between treatments at any age. During the late fattening period (22–26 months of age), average daily gain was higher and feed conversion ratio was lower in the Treatment group than in the Control group ($p < 0.01$). Plasma NEFA concentration was lower, whereas triglyceride concentration was higher, in the Treatment group than in the Control group ($p < 0.05$). Concentrate feed nutrient levels had no significant effects on carcass yield or meat quality characteristics. The results of this study suggest that raising CP and TDN levels in concentrate feed by 0.5 and 1.0 percentage points, respectively, may improve late-fattening growth performance and favorably affect energy-related plasma metabolites, although the effects on carcass characteristics were limited.

Key words : Hanwoo steers, nutrient levels in concentrate feed, rumen fermentation characteristics, growth performance, plasma metabolites, carcass characteristics

Effects of nano-formulated vitamin supplementation on milk production characteristics in lactating Holstein cows

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This study was conducted to evaluate the effects of nano vitamin supplementation on milk production characteristics in lactating Holstein cows and to assess the field applicability and feeding efficiency of nano-formulated vitamins. A total of 40 lactating Holstein cows with an average milk yield of 33.4 ± 0.5 kg/day were used and assigned to three treatment groups: T1, regular vitamin; T2, nano vitamin; and T3, regular vitamin plus organic selenium. Milk yield, somatic cell count, and milk fat content did not differ significantly among treatments. However, solids-not-fat content was higher in T1 and T3 than in T2 ($p < 0.05$), and milk urea nitrogen concentration increased in the order of T1, T2, and T3 ($p < 0.05$). Stearic acid content in milk tended to be lower in T2 and T3 than in T1, whereas lauric acid and myristic acid contents tended to be higher in T3 than in T1 and T2. Milk vitamin D₃ content tended to be higher in T2 than in T1 and T3, and vitamin A content was higher in T2 than in T3 ($p < 0.05$). The results of this study suggest that nano vitamin supplementation did not significantly affect milk yield or major milk components but may favorably affect milk vitamin D₃ and vitamin A contents, as well as some fatty acid profiles, indicating the potential field applicability of nano-formulated vitamins.

Key words : lactating Holstein cows, nano-formulated vitamin, milk production characteristics, milk fatty acids, milk vitamins

Effects of genetic potential and dietary soybean meal-to-lupin ratio on growth performance, plasma metabolites, and carcass characteristics in Hanwoo steers

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This study was conducted to evaluate the effects of genetic potential and dietary ingredient ratios on growth performance, plasma metabolites, and carcass characteristics in Hanwoo steers under identical TDN and CP levels. A total of 22 Hanwoo steers (314.5 ± 49.2 kg, 10.4 ± 1.8 months of age) were assigned to four groups: YC, yield-type control; QC, quality-type control; YT, yield-type treatment; and QT, quality-type treatment. The control diet contained soybean meal (SBM) and lupin at 3% and 6%, respectively, during the growing period and at 0% and 5%, respectively, during the fattening period. The treatment diet contained SBM and lupin at 6.5% and 2%, respectively, during the growing period and at 6% and 2%, respectively, during the fattening period. Average daily gain tended to be higher in the yield-type group than in the quality-type group. A significant interaction effect between genetic potential and dietary ingredient ratio was observed for feed conversion ratio, with the lowest value observed in the QT group ($p < 0.05$). Most plasma metabolite concentrations did not differ significantly among treatments throughout the experimental period; however, plasma BUN and cholesterol concentrations at 13, 16, and 28 months of age were higher in the control diet groups than in the treatment diet groups ($p < 0.05$). Carcass weight was higher in the YT group, whereas rib-eye area, marbling score, and the proportion of carcasses graded 1⁺ or higher for meat quality tended to be higher in the control diet groups than in the treatment diet groups. In conclusion, although the effects of genetic potential and dietary ingredient ratios on plasma metabolites and carcass characteristics were limited under identical TDN and CP levels, adjusting soybean meal and lupin ratios may partially improve growth performance and carcass weight, particularly in yield-type Hanwoo steers.

Key words : Hanwoo steers, soybean meal, lupin flakes, genetic potential, growth performance, carcass characteristics

Effects of genetic potential on growth performance, plasma metabolites, and carcass characteristics in Hanwoo steers under a 28-month production system

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This study was conducted to evaluate the effects of genetic potential, classified as yield-type and quality-type, on growth performance, plasma metabolites, and carcass characteristics in Hanwoo steers raised under a 28-month rearing system from birth to slaughter. A total of 157 Hanwoo steers (269.5 ± 44.3 kg; 8 months of age) were used, and SNP genotyping was performed using hair follicle samples to classify the animals into yield-type and quality-type groups. Body weights at 21 and 28 months of age and average daily gain during the overall experimental period were higher in the yield-type group than in the quality-type group ($p < 0.05$). Plasma albumin and calcium concentrations at 8 months of age and magnesium concentration at 21 months of age were higher in the yield-type group, whereas plasma phosphorus concentration at 12 months of age was higher in the quality-type group ($p < 0.05$). Carcass weight and rib-eye area were higher in the yield-type group than in the quality-type group ($p < 0.01$), but yield grade distribution did not differ between groups. Marbling score and the proportion of carcasses graded 1⁺ or higher for meat quality were numerically higher in the quality-type group than in the yield-type group, although the differences were not significant. The results of this study suggest that yield-type Hanwoo steers may have advantages in growth performance and carcass yield-related characteristics, whereas quality-type Hanwoo steers may have relative advantages in marbling score and producing high-quality meat-quality grade carcasses under a 28-month rearing system from birth to slaughter.

Key words : Hanwoo steers, genetic potential, growth performance, plasma metabolites, carcass characteristics

Effects of genetic potential on growth performance, plasma metabolites, and carcass characteristics in Hanwoo Steers under a 26-month short-term fattening system

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This study investigated the effects of genetic potential (yield-type vs. quality-type) on growth performance, plasma metabolites, and carcass characteristics in Hanwoo steers slaughtered at 26 months of age under a shortened fattening system. A total of 157 Hanwoo calves (269.5 ± 37.5 kg; 7 months of age) were classified into yield-type ($n = 84$) and quality-type ($n = 73$) groups and raised until slaughter at 26 months of age. Body weights at 12, 21, and 26 months of age, as well as average daily gain during the overall experimental period and dry matter intake, were higher in the yield-type group than in the quality-type group ($p < 0.05$), whereas feed conversion ratio was higher in the quality-type group than in the yield-type group ($p < 0.05$). At 21 months of age, plasma NEFA concentration was higher in the yield-type group than in the quality-type group, whereas insulin concentration was higher in the quality-type group than in the yield-type group ($p < 0.05$). At 26 months of age, plasma BUN concentration was higher in the quality-type group than in the yield-type group ($p < 0.01$). Carcass weight, rib-eye area, and the proportion of carcasses with yield grade A were higher in the yield-type group than in the quality-type group ($p < 0.01$). Marbling score and the proportion of carcasses graded 1+ or higher for meat quality tended to be higher in the quality-type group than in the yield-type group. In conclusion, yield-type Hanwoo steers showed greater growth performance and carcass yield characteristics, whereas quality-type Hanwoo steers showed a higher marbling score and greater potential for producing high meat-quality grade carcasses under a shortened fattening system with slaughter at 26 months of age.

Key words : Hanwoo steers, genetic potential, growth performance, carcass characteristics, short-term fattening system

Effects of dietary soybean protein by-product meal supplementation levels on rumen fermentation characteristics, growth performance, and carcass characteristics in Hanwoo steers

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This study was conducted to evaluate the effects of soybean protein by-product meal (SPM) supplementation levels on rumen fermentation characteristics, growth performance, and carcass characteristics in Hanwoo steers. A total of 16 Hanwoo steers (488.6 ± 48.5 kg; 16.5 ± 1.6 months of age) were assigned to four treatments: control (no SPM supplementation), T1 (1% SPM), T2 (2% SPM), and T3 (3% SPM). *In vitro* rumen pH values and $\text{NH}_3\text{-N}$ concentrations at 8, 12, 24, and 48 h of incubation were higher in T1, T2, and T3 than in the control group ($p < 0.01$). Acetic acid concentration was higher in T2 than in the control group and T1 at 24 h ($p < 0.05$), and was higher in T2 and T3 than in the control group and T1 at 48 h ($p < 0.05$). Butyric acid concentration was highest in the control group at all incubation times ($p < 0.01$). At 4 h, total VFA concentration was higher in the control group, T1, and T2 than in T3 ($p < 0.01$), whereas at 8, 12, and 24 h, total VFA concentration was lower in T1, T2, and T3 than in the control group ($p < 0.05$). Average daily gain was higher in T1 than in the control group and T2 ($p < 0.01$), and feed conversion ratio was numerically lowest in T1. Marbling score was higher in T3 than in the control group ($p < 0.05$), whereas meat texture was lower in T3 than in the control group ($p < 0.05$). The proportion of carcasses with meat quality grade 1+ or higher was numerically highest in T3. The results of this study suggest that dietary supplementation with 3% SPM may contribute to increasing the proportion of carcasses with meat quality grade 1+ or higher by increasing marbling score in Hanwoo steers.

Key words : Hanwoo steers, soybean protein by-product meal, rumen fermentation characteristics, growth performance, carcass characteristics

Effects of thiamine diphosphate and soybean oil supplementation on rumen fermentation and methane production in Hanwoo steers

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This study investigated the effects of thiamine diphosphate (ThDP) and soybean oil (SBO) supplementation on rumen fermentation and methane production in Hanwoo steers. Eight Hanwoo steers (average body weight 740.18 kg; 31 month olds) were used in a 2×2 crossover design consisting of two treatments and two experimental periods. Each period lasted three weeks. The treatments were: a control diet without a supplementation (CON) and a diet supplemented with 480 ppm of ThDP and 4% of SBO (TRT) on a dry matter (DM) basis. Diets were formulated with a concentrate-to-forage ratio of 7:3, and offered level equivalent to 2% of body weight (DM basis) and provided twice daily at 10:00 and 15:00. Methane production was monitored using the GreenFeed system, and end of each experimental period, rumen fluid and blood samples were collected four hours after morning feeding. All data were analyzed using the GLIMMIX procedure in SAS. The results showed that, average daily gain, body weight^{0.75} and dry matter intake were not significantly affected ($p > 0.05$). In addition, methane production were significantly lower in the TRT group than in the CON group ($p < 0.05$). These results demonstrate that a dietary supplementation with 480 ppm of ThDP and 4% of SBO effectively reduced methane production without negatively affecting rumen fermentation in Hanwoo steers.

Key words : Hanwoo, methane production, rumen fermentation, soybean oil, thiamine diphosphate

Effects of genomic estimated breeding values and sucrose supplementation on growth performance, rumen fermentation, blood profiles, and meat quality traits in Hanwoo steers

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This study evaluated the effects of genomic estimated breeding value (gEBV) and sucrose supplementation on growth performance, rumen fermentation characteristics, blood metabolites, hormones, and meat quality traits in 34 Hanwoo steers (26 months, 725 kg) over 24-week period. Animals were assigned to a 2 × 2 factorial design: gEBV for marbling score (gMS; high vs. low) and sucrose supplementation (control vs. treatment). The animals were fed a basal diet consisting of concentrate (1.1% of body weight/day) and oat hay (1 kg/day) on an as-fed basis. The treatment group received an additional 150 g/day of sucrose on an as-fed basis. High gMS groups exhibited greater ($p < 0.01$) body weight than low gMS groups, whereas sucrose had no effect. Average daily gain, dry matter intake, and feed efficiency remained unaffected by either factor. Sucrose treatment tended ($p = 0.05$) to decrease ruminal iso-butyric acid, while other VFAs and ammonia were not influenced. While the high gMS groups exhibited higher ($p < 0.01$) plasma free fatty acid, other plasma metabolites and hormones were not affected by gMS or sucrose. Most meat quality traits were influenced ($P < 0.05$) by gMS. Notably, a tendency for an interaction ($p = 0.06$) and a significant ($p < 0.01$) gMS effect were observed for eye muscle area. These findings confirm genetic potential as the primary driver of economically important traits in Hanwoo.

Key words : Hanwoo, genomic estimated breeding value (gEBV), sucrose, growth performance, carcass trait

Distinct effects of oleic and palmitic acid on intramyocellular lipid accumulation in bovine myotubes under heat stress

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Intramyocellular lipid (IMCL) in skeletal muscle serves as an energy reservoir and contributes to intramuscular fat deposition and metabolic flexibility. This study evaluated the effects of oleic acid (OA) and palmitic acid (PA) on IMCL accumulation, and on myogenic and lipogenic responses, in bovine myotubes under thermoneutral (TN; 38°C) and HS (41°C) conditions. We hypothesized that OA would promote greater IMCL accumulation than PA under HS. Myotubes were treated with 100 µM OA, PA, or BSA (vehicle control) under TN or HS for 48 h. Gene expression (RT-qPCR), protein abundance (Western blot), IMCL content (immunofluorescence), and mtDNA copy number were analyzed by two-way ANOVA with Šidák post hoc correction ($p < 0.05$). *MYH7*, *PGC-1α*, *PPARγ*, *FAS*, and *SCD* mRNA showed treatment × temperature interactions ($p < 0.05$); PA upregulated these genes under TN, but the responses were attenuated under HS. *MYOD* and *MYOG* mRNA increased under HS as a main effect ($p < 0.01$). At the protein level, PA did not increase FAS or PPARγ, and mtDNA copy number was unaffected. SCD protein was greatest in OA- and PA-treated cells under TN and decreased under HS ($p = 0.01$). IMCL accumulation showed main effects of treatment and temperature ($p < 0.01$) without an interaction ($p = 0.15$); OA-treated cells accumulated more IMCL than PA-treated cells at both temperatures, despite the elevated lipogenic mRNA in PA-treated cells. Although PA activated lipogenic transcription, OA more effectively promoted IMCL accumulation in bovine myotubes, indicating that OA is a more effective substrate for intramuscular lipid deposition, including under heat stress.

Key words : bovine myotube, heat stress, intramyocellular lipid, oleic acid, palmitic acid

Effects of glycerol monolaurate supplementation on growth performance, blood metabolites, and disease incidence in Hanwoo and Holstein calves

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This study was conducted to evaluate the effects of glycerol monolaurate (GML) supplementation on growth performance, blood metabolites, and disease incidence in Hanwoo and dairy calves. A total of 49 Hanwoo calves (27 calves without artificial colostrum, 10 calves fed artificial colostrum, and 12 calves fed artificial colostrum supplemented with 0.1% GML) and 40 dairy calves (20 calves fed milk replacer and 20 calves fed milk replacer supplemented with 0.1% GML) were used in the experiment. Although no significant differences were observed in average daily gain (ADG) of Hanwoo calves, ADG tended to increase numerically with artificial colostrum and GML supplementation. In dairy calves, body weight and ADG were significantly increased in the milk replacer+GML treatment group ($p < 0.05$). No significant effects of treatment were observed on blood metabolites in Hanwoo calves; however, most parameters were significantly affected by sampling time ($p < 0.05$). Immunoglobulin concentrations were not significantly different among treatments at any sampling time, but numerically increased in response to GML supplementation. The proportion of prolonged diarrhea was lower in the GML-supplemented groups. Therefore, GML supplementation may improve immune status in young calves, thereby reducing the persistence of diarrhea and improving growth performance.

Key words : Hanwoo calf, Holstein calf, glycerol monolaurate, immune status, blood metabolites, IgG, growth performance, diarrhea

Effects of different injection levels of vitamins A, D₃, and E on blood metabolites and growth- and adipogenesis-related gene expression in Hanwoo calves

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This study investigated the effects of different injection levels of vitamins A, D₃, and E on growth performance, blood metabolites, and growth- and adipogenesis-related gene expression in Hanwoo calves. Twenty-two calves were assigned to four groups: control (no injection, n = 6), T1 (vitamin A 300,000 IU, vitamin D₃ 100,000 IU, vitamin E 50 mg; n = 6), T2 (vitamin A 600,000 IU, vitamin D₃ 200,000 IU, vitamin E 100 mg; n = 5), and T3 (vitamin A 900,000 IU, vitamin D₃ 300,000 IU, vitamin E 150 mg; n = 5). Vitamin injections did not significantly affect growth performance. Total protein concentration at 1 month was lower in T3 than in the control group ($p < 0.05$), while triglyceride concentration at 3 months was higher in T2 ($p < 0.05$). Serum leptin concentration at 6 months decreased as vitamin A injection levels increased ($p < 0.05$), whereas insulin concentration was not affected. Gene expression analysis showed that MYOG and PAX7 expression levels were lower in T3 and T2, respectively ($p < 0.05$). FABP3 and PDGFRA expression levels were higher in the treatment groups, whereas KLF2, STAT6, and VEGFA expression levels were lower compared with the control group ($p < 0.05$). These results suggest that early administration of vitamins A, D₃, and E may influence lipid metabolism and energy metabolism-related physiological mechanisms in Hanwoo calves.

Key words : vitamin A, D₃, and E administration, growth performance, fat-related genes, Hanwoo calves.

Effects of vitamins A, D₃, and E injection at birth on growth and expression of genes related to adipogenesis and angiogenesis across different feeding stages in Hanwoo steers

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This study investigated the effects of neonatal injection of vitamins A, D₃, and E on the expression of growth-, adipogenesis-, and angiogenesis-related genes during different growth stages in Hanwoo steers. Eighteen calves were assigned to either a control group (n = 9) or a treatment group injected with vitamin A (300,000 IU), vitamin D₃ (100,000 IU), and vitamin E (50 mg) at birth (n = 9). In the treatment group, the expression of growth-related genes, including MYF5, MYOG, PAX3, and PGC1A, and adipogenesis-related genes, including ACACA, FABP3, SREBF1, and ZNF423, significantly changed according to growth stage ($p < 0.05$). In particular, MYF5, MYOG, ACACA, and FABP3 expression levels were higher during the early and late fattening stages than during the growing stage, whereas PAX3 expression gradually increased as growth stage progressed ($p < 0.001$). In addition, PPARA expression was significantly higher in the treatment group than in the control group during the growing stage ($p < 0.05$). Overall, the expression of growth-, adipogenesis-, and angiogenesis-related genes changed according to growth stage, whereas treatment effects were limited. These findings suggest that neonatal vitamin administration may be associated with stage-dependent metabolic and developmental regulation in Hanwoo steers.

Key words : vitamin A, D₃, and E administration, growth stage, adipogenesis-related genes, Hanwoo calves.

한우 미경산우의 성성숙 개시 시기 및 생리적 변화 평가

조현진, 정신용, 강계원, 전서영, 이민경, 강하민, 서성원

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본 연구는 한우 미경산우의 성성숙 개시 시기와 이와 관련된 체중, 체형, 호르몬(에스트로겐, 프로게스테론, IGF-1, 렙틴)의 변화를 평가하고자 수행되었다. 육성기 한우 미경산우 30두(281 ± 23.2 kg; 9개월령)를 공시하고, 체중이 유사한 2두씩 1개 우방($5\text{ m} \times 5\text{ m}$)에 배치하였다. 모든 동물에게 9개월령부터 한달간 동일한 섬유질배합 사료를 급여하였으며, 10개월 이후에는 조사료와 배합사료의 비율 및 증성세제불용섬유소의 사료원에 차이가 있는 3종류의 완전혼합사료 중 하나를 급여하였다. 사료는 개체별 섭취량을 측정할 수 있는 사료조에 1일 2회(0800, 1800) 직접 급여하여 자유채식토록 하였다. 섭취량은 매일 수집하였으며, 체중 및 체형 측정과 혈액 채취는 4주 간격으로 실시하였다. 채취한 혈액에서 혈청을 분리하여 효소결합면역흡착검사를 통해 호르몬 농도를 분석하였다. 성성숙은 초음파로 측정한 난소 크기 및 구조물(난포 크기 및 황체 유무)을 기반으로 산출한 생식기 점수(reproductive tract score, RTS)를 통해 매주 평가하였다. 체고를 제외한 체중 및 체형(흉위, 배둘레, 체장)은 월령이 지남에 따라 유의적으로 증가하였다($p < 0.05$). 에스트로겐 및 IGF-1의 농도는 월령이 증가함에 따라 유의적으로 감소하였으며($p < 0.05$), 프로게스테론 농도는 월령에 따른 유의적인 차이가 없었다($p > 0.05$). 렙틴 농도는 월령이 증가함에 따라 유의적으로 증가하였다($p < 0.05$). RTS는 9개월령 3.2점에서 10개월령 4.3점, 11개월령 4.7점으로 유의하게 증가하였으며($p < 0.05$), 10개월령에 성성숙 도달 기준인 4점 이상을 충족하였다. 결론적으로 한우 미경산우는 10개월령 이전, 체중 282–298 kg 정도에서 성성숙에 도달하였다.

Key words : 성성숙, 체중, 체형, IGF-1, 렙틴, 한우

Effects of alfalfa produced in Korea at different inclusion levels in TMR on rumen fermentation and methane production *in vitro*

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This study was conducted to evaluate the effects of different inclusion levels of domestically produced alfalfa in total mixed ration (TMR) (0%, 13%, and 27% on a dry matter basis) on rumen fermentation characteristics *in vitro*. Total gas production (TGP) differed significantly among treatments at all incubation times (12, 24, and 48 h; $p < 0.05$), with values of 110.66, 144.66, and 171.94 mL/g DM, respectively. Methane production in the 27% alfalfa treatment was 17.51, 25.56, and 36.33 mL/g DM at 12, 24, and 48 h, respectively, representing an increase of 28–51% compared to the 0% alfalfa treatment. At the end of incubation (48 h), ruminal pH was 6.59 across all treatments, indicating that a stable environment for microbial activity was maintained. Ammonia nitrogen (NH₃-N) concentrations were 173.8, 149.3, and 217.4 mg/dL for the 0%, 13%, and 27% alfalfa treatments, respectively, with no significant differences among treatments. *In vitro* dry matter digestibility (IVDMD) increased significantly ($p < 0.05$) with increasing alfalfa inclusion levels, with values of 71.88%, 76.00%, and 79.66% for the 0%, 13%, and 27% treatments, respectively. The increases in TGP and IVDMD with higher alfalfa inclusion levels suggest enhanced availability of fermentable substrates for rumen microbes. The relatively high digestibility and readily fermentable components of alfalfa may have contributed to the increased fermentation rate.

Key words : Hanwoo, alfalfa, total mixed ration (TMR), rumen fermentation, *in vitro* dry matter digestibility (IVDMD)

Comparison of DNA, PMA-treated DNA, and RNA-based rumen microbial profiles in Hanwoo steers fed low-protein diets

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This study evaluated the effects of a low-protein diet during the late fattening period of Hanwoo steers and compared rumen microbial profiles derived from total DNA (tDNA), Propidium monoazide-treated DNA (vDNA), and RNA. Hanwoo steers (n = 6; 26 months of age) were assigned to either a control diet (CON, 17.2% CP; n = 3; 793 ± 91 kg) or a low-protein treatment diet (TRT, 14.9% CP; n = 3; 748 ± 56 kg) and were fed under the same housing and management conditions until 30 months of age. Growth performance, carcass characteristics, and rumen microbial communities were assessed to evaluate the effects of dietary protein level and nucleic acid source. Feeding a low-protein diet did not markedly affect growth performance or carcass characteristics. Although dietary treatment influenced overall rumen microbial community structure, its effects on individual genera were limited, suggesting a modest impact on taxonomic composition under the present conditions. In contrast, differences according to nucleic acid type were more apparent, indicating that the choice of nucleic acid source can influence the interpretation of rumen microbiota. These findings suggest that a low-protein diet during late fattening may be feasible in Hanwoo steers, while nucleic acid source should be carefully considered in rumen microbiome analysis.

Key words : Hanwoo steer, low-protein, average daily gain, feed conversion ratio, carcass traits, propidium monoazide, deoxyribonucleic acid, ribonucleic acid, microbiome, alpha diversity, beta diversity

Imported alfalfa at two feeding levels: impacts on nutrient utilization and body conformation in female and male crossbred goats

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This study evaluated the effects of two feeding levels (1.5 and 2.0% BW) of alfalfa from abroad on growth performance, nutrient utilization, and body conformation in female and male crossbred goats (Boer × Korean native, *Capra hircus*). Twenty-four goats (12 females and 12 males; initial body weight 39.4 ± 1.1 kg for females and 38.0 ± 1.4 kg for males) were used in a 4×4 Latin square design with four dietary treatments over four 4-week periods (total 16 weeks).

Males showed higher dry matter intake at the high feeding level (2.0% BW), reaching the highest value among all groups ($p = 0.0003$). Females recorded higher final body weight and body weight gain at the low feeding level (1.5% BW), with the highest body weight gain observed in females fed 1.5% imported alfalfa. Nutrient intake (dry matter, organic matter, crude protein, crude fiber, ADF, and NDF) was generally higher in the high feeding level groups, particularly in males. Digestibility of most nutrients tended to be higher in females at the low feeding level, with crude protein digestibility reaching its highest value in females fed 2.0% BW.

Body conformation measurements, including body length, withers height, chest width, and chest girth, were numerically higher in the high feeding level groups for both genders, though differences remained modest.

Therefore, the results indicate that imported alfalfa at 1.5–2.0% of body weight supported good growth and nutrient utilization in both female and male crossbred goats. However, females performed better in body weight gain and nutrient digestibility at lower feeding levels, while males showed higher nutrient intake at the high feeding level, suggesting gender-specific responses to imported alfalfa feeding levels.

Key words : imported alfalfa, crossbred goats, feeding level, gender difference, nutrient utilization, body conformation

Effect of TMR feeding compared to conventional feeding during the performance testing period of growing Hanwoo bull

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Residual Feed Intake (RFI) is a key economic trait in Hanwoo. However, measuring intake in ruminants is often challenging when concentrate and forage are fed separately, as it requires individual monitoring of both components. This study was conducted to compare the effects of conventional feeding (separate supply of concentrate and forage) and Total Mixed Ration (TMR) feeding on feed efficiency and performance during the growing period. Twenty growing Hanwoo bulls were assigned to either a conventional feeding group ($n = 10$) or a TMR feeding group ($n = 10$). Initial body weights for the conventional and TMR groups were 250.7 ± 29.0 kg and 259.6 ± 18.3 kg, respectively. The Total Digestible Nutrients (TDN) content was 73.99% for concentrate, 55.71% for forage, and 63.25% for TMR. The results showed that metabolic body weight was 69.9 ± 5.9 kg for the conventional group and 73.3 ± 4.0 kg for the TMR group, while TDN intake was 358.1 ± 40.1 kg and 406.5 ± 33.1 kg, respectively. No significant differences were observed between the two groups in actual feed intake (5.190 ± 0.581 vs. 5.891 ± 0.480 kg) or predicted feed intake (5.362 ± 0.565 vs. 5.712 ± 0.337 kg). The RFI values were analyzed as -0.172 ± 0.350 kg for the conventional group and 0.173 ± 0.347 kg for the TMR group. Overall, no statistical significance was found across all traits ($p > 0.05$). These findings suggest that TMR feeding provides a level of testing accuracy equivalent to conventional methods while significantly enhancing the convenience and efficiency of intake data collection during Hanwoo performance testing.

Key words : feed efficiency, residual feed intake (RFI), conventional feeding, total mixed ration (TMR) feeding, Hanwoo

Evaluation of carcass and meat quality traits under methane-mitigation feeding strategies

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This study was conducted to evaluate the effects of methane-mitigation feeding strategies on carcass characteristics and meat quality traits in beef cattle under commercial production conditions. A total of 542 animals were analyzed after excluding cattle older than 45 months at slaughter. Animals were classified into three feeding groups: conventional feeding ($n = 109$), synthetic compound-based methane-mitigating feed additive supplementation ($n = 145$), and plant-based methane-mitigating feed additive supplementation ($n = 288$). In addition, exploratory analyses were performed according to supplementation duration within methane-mitigating feeding groups. The evaluated traits included carcass weight, backfat thickness, loin area, yield index, and marbling score. The synthetic compound-based methane-mitigating feed additive group showed average marbling score, loin area, and carcass weight values of 6.90, 98.71 cm², and 464.57 kg, respectively, whereas the plant-based methane-mitigating feed additive group showed values of 6.28, 93.66 cm², and 435.81 kg, and the conventional feeding group showed values of 5.71, 91.44 cm², and 427.61 kg, respectively ($p < 0.05$). In contrast, yield index did not show substantial differences among feeding groups. Furthermore, long-term supplementation of methane-mitigating feed additives did not show detrimental effects on carcass or meat quality traits under field production conditions.

Key words : beef cattle, low-carbon livestock production, meat quality, methane-mitigating feed

Effects of hot water-extracted plant materials on *in vitro* ruminal fermentation and methane production

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This study investigated the effects of hot water-extracted plant materials on *in vitro* ruminal fermentation and methane (CH₄) production. Hot water extract was prepared by extracting 10 g of plants sample with 200 mL distilled water at 90°C for 2 h while stirring at 400 rpm. The extract was cooled for 5 min, centrifuged at 4,500 rpm for 22 min at 4°C, and concentrated using a rotary evaporator at 65°C and 100 rpm. The substrate was prepared at a 3:7 concentrate-to-forage ratio on a dry matter (DM) basis and incubated with rumen fluid and McDougall's buffer at 39°C and 110 rpm for 24 and 48 h. Treatments consisted of CON (control), turmeric at 0.5% and 1.0%, chrysanthemum at 0.5% and 1.0%, deodeok at 0.5% and 1.0%, and Dunggulle at 1.0%. At 24 h, total gas production did not differ among treatments ($p = 0.0612$), although Dunggulle 1.0% showed a was numerically lower than that of CON (44.25 and 52.00 mL, respectively). *In vitro* dry matter digestibility (IVDMD), CH₄ concentration, and CH₄ production did not differ among treatments at 24 h ($p > 0.05$). However, CH₄ production per g digested DM was significantly lower in Dunggulle 1.0% than in CON ($p = 0.0305$). The values were 15.40 and 17.56 mL/g digested DM, respectively, corresponding to a 12.3% reduction. These results indicate that Dunggulle 1.0% reduced methane production per g digested DM after 24 h of *in vitro* ruminal incubation without decreasing IVDMD, but this effect was not observed after 48 h.

Key words : hot water-extract, *in vitro*, methane, plant, rumen fermentation

Impact of heat stress on metabolic changes and the effects of heat-treated fermented soybean meal supplementation on lactation performance in Holstein cows under heat stress environmental condition

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Heat stress induces abnormal metabolism and impairs lactation performance in dairy cows. This study aimed to understand heat stress-induced metabolic alterations and evaluate a potential dietary mitigation strategy. The metabolomic analysis revealed severe disruptions in both carbohydrate and amino acid metabolism by heat stress. We evaluated heat-treated fermented soybean meal (HFSBM) as a targeted nutritional intervention to recover protein metabolism in heat stressed dairy cows. HFSBM was produced by fermenting soybean meal (SBM) with *Enterococcus faecium* (EF) and *Lactobacillus plantarum* (LP), followed by heating at 130°C. Nutritional evaluation confirmed that HFSBM possessed higher crude protein and amino acid contents than raw SBM. *In vitro* rumen fermentation assays demonstrated that HFSBM significantly enhanced digestibility and propionate production while decreasing ammonia nitrogen levels compared to SBM. To assess *in vivo* efficacy, a field trial was conducted where heat-stressed dairy cows were fed a TMR supplemented with 0.1% HFSBM for two weeks. Although heat stress dramatically depressed overall milk production, dietary supplementation with HFSBM significantly increased the average daily milk yield by 1.3 kg/day. In conclusion, HFSBM supplementation is an effective nutritional management strategy to counteract metabolic abnormalities and improve productivity in heat-stressed dairy cows.

Key words : by-pass protein, fermented soybean meal, heat stress, Holsteins, metabolites

Effects of creatinolfosfate supplementation level on *in vitro* rumen fermentation characteristics and methane production

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This study evaluated the effects of different inclusion levels of Creatinolfosfate (CRE) on *in vitro* ruminal fermentation characteristics and methane production. An *in vitro* batch culture system was used in which rumen fluid was incubated for 24 and 48 h with the following treatments: a negative control without additives, a positive control containing 120 ppm of 3-nitrooxypropanol, and CRE supplemented at 480, 600, and 720 ppm. After 48 h of incubation, total gas production and methane production decreased linearly with increasing CRE supplementation levels. In addition, acetate concentration decreased, whereas propionate concentration increased linearly as CRE inclusion levels increased, suggesting a shift in ruminal fermentation patterns. The greatest reduction in methane production was observed at 720 ppm, indicating a dose-dependent inhibitory effect on methanogenesis. However, dry matter digestibility and ammonia nitrogen concentration were not affected by CRE supplementation. These results suggest that CRE has the potential to mitigate ruminal methane emissions without negatively affecting nutrient digestibility under the conditions of the present study. Further *in vivo* studies are required to evaluate the efficacy, safety, and long-term applicability of CRE supplementation in practical ruminant production systems.

Key words : ruminant, methane, rumen fermentation, creatinolfosfate

Effects of synbiotics-based FTMR on rumen fermentation and host metabolism in ruminants

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Methane emissions from ruminants are a major environmental concern. In this study, a synbiotics-based fermented total mixed ration (FTMR) was developed using *Komagataeibacter intermedius* and *Zygosaccharomyces parabailii* (KZ). Genome-scale metabolic model analysis identified selective prebiotic candidates that enhanced KZ growth and showed methane-reducing potential. To evaluate its effects, in vitro rumen fermentation and in vivo feeding were conducted. Although methane reduction was not statistically significant, FTMR improved digestibility and reduced ammonia production. qNMR-based metabolomic analyses revealed distinct metabolic alterations in rumen fluid and blood after FTMR feeding. In rumen fluid, methanogenesis-associated metabolites including formate and methylamine-related compounds decreased, whereas metabolites related to substrate utilization and microbial activity increased. Blood metabolomic profiles showed increased creatine, creatinine and antioxidant-related metabolites, indicating improved energy metabolism and physiological stability. In contrast, trimethylamine N-oxide, associated metabolic imbalance, decreased following FTMR supplementation. Overall, synbiotics-based FTMR modulated rumen microbial metabolism and host metabolic responses, suggesting its potential as a strategy through coordinated modulation of rumen microbial metabolism and host metabolic responses.

Key words : synbiotics, FTMR, metabolomics

Effects of *Bjerkandera adusta* on *in vitro* rumen fermentation and methane production

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Methane produced during enteric fermentation in ruminants is recognized as a major contributor to agricultural greenhouse gas emissions and represents a loss of dietary energy. This study aimed to evaluate the effects of *Bjerkandera adusta* on *in vitro* rumen fermentation and methane production. Rumen fluid was collected from three Hanwoo cattle for the *in vitro* incubation. To prepare the incubation medium, rumen fluid was mixed with McDougall's buffer at a 1:2 ratio. A diet with a concentrate-to-forage ratio of 8:2 was used as the basic substrate. *B. adusta* were supplemented at 0% (control), 1%, 3%, and 5% of the substrate. After 24 h incubation at 39°C, *in vitro* dry matter digestibility was significantly greater in all supplementation groups than in the control group ($p < 0.05$), whereas pH was not affected by supplementation ($p > 0.05$). Methane production (mL/g DM) was significantly reduced in both the 3% and 5% supplemented groups compared with the control group ($p < 0.05$). These findings suggest that the supplementation of *B. adusta* may serve as a potential feed additive for methane mitigation in ruminants while maintaining stable rumen fermentation and improving feed digestibility.

Key words : Hanwoo cattle, rumen fermentation, methane production, *Bjerkandera adusta*

The effects of additional pressure processing of lupin flake on protein degradation characteristics

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Lupin imports have shown an increasing trend over the past decade in Korea. Lupin has high crude protein (CP) and energy content, it can be used in livestock diets. However, lupin contains a high proportion of rumen degradable protein (RDP), resulting in rapid degradation within the rumen and reduced protein utilization by the host animal. The processing methods like heat and flaking were applied to modulate protein degradability of grain, also physical press affects protein denaturation. This study aimed to evaluate the effects of *in situ* degradability of additional pressure processing of lupin flake. In the experiment, three treatments were evaluated: CON (control, no processing), lupin flake (LF, heated at 110°C for 900 s), lupin flake with press (LFP, heated at 110°C for 900 s, pressurized). All *in situ* experiments were conducted using two cannulated Hanwoo cattle for 120 h. Degradability was measured at 0, 3, 6, 12, 24, 48, 72, 96, and 120 h. In the dry matter fractional value, soluble fraction (A fraction) was higher in LF than CON ($p < 0.05$). The potentially degradable fraction (B fraction; % CP) was lower in the LF than CON ($p < 0.05$). There was no significant difference between CON and LF in rumen undegradable protein (RUP; % CP) ($p > 0.05$). As a result of additional pressure treatment, B fraction (% CP) was highest in LFP ($p < 0.0001$). RUP (% CP) was higher in LFP than LF ($p < 0.05$), also MP_{feed} (% CP) was higher in LFP than LF ($p < 0.05$). In conclusion, an additional pressure treatment of lupin flake can increase the proportion of MP_{feed} by increasing RUP proportion of lupin thereby improving protein availability of the ruminant.

Key words : feed evaluation, lupin flake, rumen degradability, metabolizable protein, *in situ*

Analysis of genomic estimated breeding value (GEBV) application based on growth traits in Hanwoo steers

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This study was conducted to evaluate the potential of Genomic Estimated Breeding Values (GEBV) for predicting growth and carcass traits using genomic and feeding management data from Hanwoo farms. Genomic information from 199 newborn calves raised on three Hanwoo farms was analyzed. Hanwoo 50K SNP markers were used for individual identification and estimation of carcass weight (CW)-related GEBV. The results showed that birth weight ($p < 0.05$) and carcass weight ($p > 0.05$) were higher in the high-GEBV group, indicating the potential of genomic information for predicting growth-related traits. These differences became more distinct when comparing the upper and lower 25% groups ($p > 0.05$). In contrast, weaning weight and several carcass traits were strongly influenced by farm-specific feeding environments and management systems. Furthermore, genomic prediction accuracy was higher in integrated breeding farms with well-established genetic improvement programs, whereas lower accuracy was observed in feedlot farms with limited pedigree information. In conclusion, CW-related GEBV showed considerable potential for predicting growth traits in Hanwoo cattle and could be effectively applied to farm-level precision breeding programs.

Key words : genomic estimated breeding value (GEBV), carcass weight, Hanwoo steers

Integrative metagenomic characterization of the bovine colostrum virome and candidate bacteria-virus interactions

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Bovine colostrum is essential for neonatal calf adaptation, yet its viral community and host-associated interactions remain poorly understood. This study characterized the colostrum-associated virome and candidate host-virus linkages using shotgun metagenomic data from 44 postpartum colostrum samples collected from 7 Holstein and 4 Jersey cows at 0 h, 12 h, 24 h, and 5 d postpartum. Host-unmapped reads were co-assembled, and viral contigs were identified using VirSorter2, followed by CheckV-based quality assessment and geNomad, VIBRANT, and DRAM-v annotation. Bacterial metagenome-assembled genomes (MAGs) were reconstructed, classified using GTDB-Tk, and quantified with viral contigs using CoverM. Candidate host-virus association were evaluated by integrating iPHoP-based host prediction, MAG taxonomy, and co-variation analysis. Among 1,315 candidate viral contigs, six core *Caudoviricetes* contigs were selected, including one *Enterococcus*-linked contig that showed a nominally significant positive co-variation with an *Enterococcus* B lactis MAG (Spearman $p < 0.05$). Functional annotation detected putative nucleotide metabolism-related genes, including dUTPase and thymidylate synthase, in two core contigs. Temporal patterns were more pronounced in viral or integrated MAG-viral profiles, particularly in Holstein samples, whereas Holstein-Jersey differences were mainly reflected in MAG abundance profiles. These findings provide a framework for bovine colostrum virome analysis and suggest that phage-bacterial host interactions may be associated with temporal restructuring of the colostrum microbial ecosystem.

Key words : bovine colostrum, virome, metagenomics, host-virus linkage, MAG, *Caudoviricetes*, dairy cow

Effects of enzyme, probiotic supplementation and fermentation period on the fermentation characteristics and quality of total mixed ration under summer temperature conditions

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This study investigated the effects of fermentation conditions on the quality of the fermented total mixed ration (TMRf) at 27°C, simulating summer conditions on a farm in South Korea. A 3 (probiotics level: Low 0.05%, Medium 0.1% and High 0.2%) × 2 (enzyme supplementation: 0.05% or non-supplemented) × 4 (fermentation period: 3, 7, 14 and 28 days) factorial design with 3 replicates per treatment was used in this study. The probiotic complex consisted of *Lactobacillus plantarum* and *Saccharomyces cerevisiae* (10⁸ colony-forming units (CFU)/mL). The enzyme treatment included a commercial mixture (cellulase, amylase and protease). As fermentation progressed, pH and ammonia-N decreased, while total volatile fatty acids (VFA) and acetate increased ($p < 0.001$). Lactic acid bacteria enumeration significantly declined from 9.07 log CFU/mL at day 3 to 6.68 log CFU/mL at day 28. In addition to time-dependent effects, probiotic concentration and enzyme treatment showed significant main effects and two-way interactions on pH, ammonia-N and total VFA ($p < 0.05$). Probiotics significantly influenced dry matter, crude ash (CA) and neutral detergent fiber (NDF), while enzymes affected CA, crude fiber and NDF ($p < 0.05$). Notably, butyrate was not detected in any treatment, indicating stable fermentation without clostridial putrefaction. These findings suggest that probiotic concentration, enzyme application and fermentation period are critical factors for optimizing TMRf production.

Key words : TMRf, probiotics, enzyme, fermentation period, summer conditions

Effects of carcass weight genomic estimated breeding values (GEBV) on productivity and carbon reduction in Hanwoo steers

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This study evaluated the effects of carcass weight-related Genomic Estimated Breeding Values (GEBV) on productivity, carcass traits, and carbon reduction potential in Hanwoo steers. Genomic information from Hanwoo cattle raised on five farms was analyzed using the Hanwoo 50K SNP chip, and animals were classified into high (Bv H) and low (Bv L) GEBV groups. Growth performance, carcass characteristics, and economic traits were compared according to farm and GEBV group.

The high-GEBV group showed greater carcass weight than the low-GEBV group across most farms, indicating the usefulness of GEBV for predicting growth performance ($p > 0.05$). However, marbling score tended to decrease in the high-growth group, suggesting a trade-off between growth and meat quality traits. Despite lower carcass prices associated with reduced marbling, total income was maintained due to increased carcass weight. Furthermore, the high genomic breeding value group demonstrated a 4.6% reduction in carbon emissions per unit of production, showing positive results in terms of production efficiency and environmental sustainability. In conclusion, carcass weight-related GEBV may be effectively applied to improve growth performance and reduce carbon emissions in Hanwoo production systems. However, balanced breeding strategies considering both growth and meat quality traits are necessary to maximize farm profitability.

Key words : genomic estimated breeding value (GEBV), carcass weight, carbon reduction effects, Hanwoo steer

Storage stability of glucose and ketone in blood samples from Korean native cattle

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Accurate measurement of blood glucose and ketone concentrations is important for evaluating energy metabolism and diagnosing metabolic disorders in cattle. However, delayed sample processing after blood collection may affect analytical results due to ongoing cellular metabolism and changes in sample stability. Under field conditions, there is often a delay between blood sample collection and laboratory analysis, and storage conditions during this period may affect the measured values. This study evaluated the storage stability of glucose and ketone concentrations in serum and whole blood samples from Hanwoo cattle. **Materials and Methods:** Blood samples were collected from clinically healthy Hanwoo cattle and divided into serum and whole blood samples using serum separator tubes and anticoagulant tubes. Samples were stored under room-temperature (20–25°C) and refrigerated (4°C) conditions. Glucose and ketone concentrations were measured at 0, 1, 2, 4, 6, 8, 12, and 24 h after blood collection. The measured values were statistically analyzed to evaluate the effects of sample type and storage condition over time. **Results:** Glucose concentrations in serum samples stored at room temperature decreased from 74.5 mg/dL at 0 h to 39.2 mg/dL at 6 h, whereas refrigerated samples showed a smaller decrease from 74.5 mg/dL to 62.8 mg/dL during the same period. In contrast, there were no significant differences in ketone concentrations between room-temperature and refrigerated storage conditions. **Conclusions:** The results of this study indicate that storage conditions and elapsed time after blood collection significantly affect glucose concentrations in Hanwoo blood samples, whereas ketone concentrations remain relatively stable. Immediate refrigeration and rapid serum separation following blood collection are recommended to minimize analytical errors. These findings provide useful information for establishing standardized sample handling procedures for metabolic profile testing in Hanwoo cattle.

Key words : Korean native cattle, blood glucose, ketone

Effects of a microcurrent-generating mineral mixture on ruminal nitrogen utilization and microbial composition *in vitro*

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This study evaluated the effects of a microcurrent-generating mineral mixture (MC) on ruminal fermentation, nitrogen utilization, and microbial composition *in vitro*. Batch cultures were incubated for 6 h ($n = 5$), and microbial crude protein (MCP), $\text{NH}_3\text{-N}$, total gas production, volatile fatty acids (VFA), and pH were measured. Microbial composition was analyzed by 16S rRNA gene V3–V4 region sequencing. MC increased MCP and decreased $\text{NH}_3\text{-N}$ concentrations ($p = 0.001$ and $p = 0.049$, respectively), with no significant changes in VFA profiles, total gas production, or pH ($p > 0.05$). Richness and overall diversity were unchanged, whereas Pielou's evenness and Simpson diversity increased with MC ($p = 0.010$ and $p = 0.028$, respectively). Weighted and unweighted UniFrac distances showed significant community separation ($p = 0.036$ and $p = 0.019$, respectively), whereas Bray–Curtis dissimilarity was unchanged. Differential abundance analysis showed enrichment of Prevotellaceae_UCG.003 ($q = 0.033$) and depletion of *Olsenella* and *Anaerobutyricum* ($q = 0.022$ for both) under MC. Functional beta diversity of predicted pathways was unchanged, but differential pathway abundance analysis indicated reduced upstream carbohydrate metabolism and enrichment of downstream carbon-routing, cofactor-, and vitamin-related pathways. These results suggest that MC may shift ruminal nitrogen utilization toward microbial biomass formation without increasing overall fermentation output or inducing broad community turnover.

Key words : rumen, microcurrent, nitrogen utilization, microbial crude protein, 16S rRNA sequencing

Longitudinal fecal microbiota dynamics in Holstein calves and comparative analysis between Holstein and Jersey breeds

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This study investigated the developmental dynamics of the fecal microbiota in calves, focusing on age-related succession, weaning-associated transitions, and breed-related differences between Holstein and Jersey calves. In Holstein calves, both richness and evenness increased with age, and the overall microbial community underwent marked temporal shifts before 12 weeks, followed by relative stabilization. Multivariable association analysis showed that age was associated with increases in putatively plant polysaccharide-associated genera including *Treponema*, *Monoglobus*, and *Alistipes*, whereas early-life-associated genera such as *Bifidobacterium*, *Parabacteroides*, and *Faecalibacterium* decreased. Weaning was linked to additional taxonomic reorganization, with postweaning increases in Spirochaetaceae, Monoglobaceae, *Akkermansia*, and *Monoglobus* and decreases in Bacteroidaceae, Enterobacteriaceae, Bifidobacteriaceae, *Parabacteroides*, *Megasphaera*, and *Faecalibacterium*. Functional prediction suggested that postweaning microbial communities were enriched in pathways related to bacterial chemotaxis, flagellar assembly, and genetic information processing. Breed-related differences were comparatively limited, although Holstein calves showed higher richness and evenness than Jersey calves at several postweaning time points and distinct temporal developmental patterns in beta diversity. Together, Holstein calves showed pronounced age-dependent microbial maturation and marked transition across weaning toward a more mature, fermentation-oriented intestinal ecosystem, whereas breed-related differences mainly involved specific microbial groups rather than broad taxonomic differences.

Key words : dairy cows, breed differences, fecal microbiota, early-life microbiota, weaning, temporal microbial succession

대용유 급여 횟수가 한우 송아지의 성장성적에 미치는 영향

김호연, 신지호, 강유진, 임진현, 김태호, 김동연, 권원서, 최한빈, 최용준*

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본 연구는 대용유 급여 횟수가 한우 송아지의 성장 성적, 설사발생률 및 혈액 성상에 미치는 영향을 규명하기 위해 수행하였다. 본 연구에서는 한우 송아지 18두(30.51 ± 3.31 kg; 암수 각 9두)를 공시하여 개별 팬에서 사육하였으며, 30일간 실험을 진행하였다. 본 연구는 15% 농도로 희석한 대용유를 모든 송아지에게 체중의 30%를 처리구별로 2회, 4회, 6회로 분할하여 30일간 급여하였다. 2회 급여 처리구는 06시와 18시에 4회급여 처리구는 6, 11, 16 및 21시에 6회 급여 처리구는 6, 9, 12, 15 18 및 21시에 대용유를 급여하였다. 실험 기간 동안 10일 간격으로 체중, 흉위를 측정하였고, 혈액을 채취하여 일반혈액성분 및 혈중 대사물질을 분석하였으며, 사료 섭취량은 매일 1회 측정하였다. 실험 결과, 총 건물 섭취량, 사료 요구율, 일반 혈액 성분 및 대사 지표는 급여 횟수에 따른 유의적인 차이를 나타내지 않았다. 반면, 증체량과 일당증체량은 대용유 급여 횟수가 증가함에 따라 유의하게 증가하였으며($p = 0.001$), 설사 발생 빈도는 1일 6회 처리구에서 2회 및 4회 급여 처리구 대비 증가하는 경향이 나타났다($p = 0.097$). 결과적으로 한우 송아지에게 다량의 대용유를 급여할 경우, 급여횟수를 늘릴수록 성장에 긍정적인 효과가 있으나, 설사발생률을 고려할 때 1일 4회 급여가 성장성적과 설사 예방 측면에서 가장 적합한 것으로 판단된다. 본 연구의 결과는 송아지에서 자동포유기를 활용한 대용유 인공포유시 일일 급여횟수를 설정하는데 기초자료로 활용할 수 있을 것으로 사료된다.

Key words : 한우 송아지, 대용유 급여 횟수, 성장성적, 설사발생률, 인공포유

Effects of feeding system on growth performance and velvet antler productivity in deer

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This study was conducted to evaluate the effects of feeding systems on growth performance and velvet antler productivity in deer during the antler growth period. Ten deer were assigned to two dietary treatments: conventional feeding (concentrate and hay) or total mixed ration (TMR), with five animals per treatment. Animals were allocated to treatments considering age, previous velvet antler production, and initial body weight to minimize baseline variation between groups. The experiment was conducted from March to June 2026, from antler casting to velvet antler harvest. Experimental periods were standardized based on the day after completion of antler casting (Day 0). Body weight was measured weekly throughout the experimental period, and feed intake, behavioral characteristics, blood parameters, and velvet antler productivity were monitored. Preliminary results showed that body weight gradually increased during the antler growth period in all animals, although individual variation was observed. In the conventional feeding group, body weight gain during the currently monitored period ranged from 9 to 23 kg, whereas the TMR group showed gains ranging from 14 to 22 kg. Body weight fluctuations were observed in several individuals during the experimental period. Further analyses, including feed intake, behavioral responses, blood metabolites, and velvet antler productivity, are currently ongoing. These results may serve as preliminary data for future studies on feeding management and velvet antler productivity in deer.

Key words : deer, velvet antler, growth performance, feeding system

Evaluating milk protein conversion efficiency in Holstein dairy cows across lactation stages as a function of dietary crude protein level

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This study was conducted to investigate the milk protein conversion efficiency of Holstein dairy cows according to their lactation stages and dietary crude protein (CP) supply levels. Fifteen Holstein dairy cows were assigned to three groups based on lactation stage: early lactation ($n = 5$; parity: 3.3 ± 1.9 , DIM: 53 ± 11.9 d, milk yield: 29.1 ± 5.67 kg/d), mid-lactation ($n = 5$; parity: 2.4 ± 1.7 , DIM: 114 ± 11.0 d, milk yield: 32.7 ± 3.96 kg/d), and late lactation ($n = 5$; parity: 2.2 ± 1.4 , DIM: 272 ± 17.1 d, milk yield: 29.9 ± 3.10 kg/d). The experimental diets were formulated by adjusting the soybean meal content to provide 80%, 100%, and 120% of the CP requirements specified in the Korean Feeding Standard for Dairy Cattle. The results showed that milk protein conversion efficiency was highest in the early lactation stage across all CP levels and decreased linearly as lactation progressed. However, the 80% CP level resulted in lower milk protein conversion efficiency compared to the 100% level. At the 120% CP level, the highest conversion efficiency during early lactation, the inefficiency caused by excess protein became more pronounced as lactation advanced. In conclusion, to optimize milk protein conversion efficiency in Holstein dairy cows, it is recommended to increase the dietary protein level during early lactation and maintain appropriate protein levels as lactation progresses.

Key words : Holstein dairy cows, lactation stage, dietary crude protein level, milk protein conversion efficiency

Evaluation of physiological and biochemical parameters according to different roughage sources in Hanwoo heifers

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Feed resources used in Hanwoo breeding farms can influence metabolic status and reproductive performance due to differences in nutrient composition. Hanwoo heifers were assigned to four dietary treatment groups according to roughage source: rice straw, corn silage, triticale, and Italian ryegrass (IRG). Body weight and body condition score (BCS) were measured to evaluate physiological responses to different feeding treatments. Blood samples were collected for the analysis of blood urea nitrogen (BUN), albumin (ALB), total protein (TP), and triglyceride concentrations. All collected data were statistically analyzed to compare differences among treatment groups. There were no significant differences in BCS among the feeding groups. BUN concentration was lowest in the IRG group at 11.14 mg/dL, whereas the triticale group showed the highest concentration at 16.89 mg/dL. Blood triglyceride concentration was significantly higher ($p < 0.05$) in the triticale-fed group at 154.21 mg/dL. Albumin and total protein concentrations were significantly lower in the IRG-fed group compared with the other feeding groups. Physiological indicators influenced by feed resources are important not only for evaluating growth performance but also for a comprehensive assessment of metabolic health. These indicators may provide fundamental information to improve productivity and economic efficiency in Hanwoo cattle breeding.

Key words : Hanwoo, roughage source, blood biochemical parameters, heifer, metabolic status

Major revisions in the 5th edition of Korean feeding standards for dairy cattle

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The Korean Feeding Standards for Dairy Cattle have been revised on a 5-year cycle since their initial publication in 2002, with the 5th edition scheduled for release in 2027. This edition goes beyond improving productivity to address the dual challenges of achieving carbon neutrality and reducing environmental pollution, incorporating domestic empirical data into the revision process. Energy requirements have been adjusted upward to reflect the increasing milk yield and body weight trends of Korean dairy cattle, while maintaining the NE framework to ensure alignment with international standards such as NASEM (2021) and INRA (2019). In addition, Chapter 10 (Environmental Improvement) has been newly established to refine emission factors based on the IPCC Tier 2 methodology; application of the updated emission factors is projected to reduce greenhouse gas emissions from the Korean dairy sector by approximately 97,000 tonnes CO₂eq annually (an 8% reduction). For nitrogen emission reduction, the combined use of low-CP diets with rumen-protected amino acids has been presented as a core strategy, with evidence indicating that precision feeding utilizing ICT-based feeders can reduce nitrogen emissions by 10–20%. The 5th edition provides a scientific basis for simultaneously achieving the dual goals of maintaining productivity and reducing the environmental burden of Korean dairy cattle through the integration of precision nutrition design and greenhouse gas mitigation technologies.

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Key words : Korean feeding standards, dairy cattle, methane, nitrogen, greenhouse gas

Effects of pectin-rich by-products (citrus pulp and apple pomace) on *in vitro* rumen fermentation: a meta-analysis

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This study evaluated the effects of pectin-rich by-products, citrus pulp and apple pomace, on *in vitro* rumen fermentation through a meta-analysis. Following the PRISMA 2020 guidelines, 17 studies investigating citrus pulp and apple pomace as alternative carbohydrate sources were included from 419 articles in PubMed, Scopus, and Web of Science, yielding 10–30 comparisons per outcome after standardizing incubation time to 24 h. Standardized mean differences (SMD, Hedges' *g*) were calculated using a random-effects model, with subgroup analyses by type of by-product. Both by-products promoted fermentation: pH remained stable ($k = 17$, $SMD = -2.840$, $p = 0.109$), while ammonia-nitrogen decreased ($k = 10$, $SMD = -1.093$, $p = 0.010$), and gas production ($k = 30$, $SMD = 0.932$, $p < 0.001$) and propionate concentration ($k = 24$, $SMD = 0.415$, $p < 0.001$) significantly increased. Citrus pulp induced an acetate-enhancing pattern ($k = 12$, $SMD = 0.728$, $p < 0.001$), whereas apple pomace induced a propionate-enhancing pattern with increased propionate proportion ($k = 12$, $SMD = 0.784$, $p < 0.001$) and decreased acetate-to-propionate ratio ($k = 12$, $SMD = -0.783$, $p < 0.001$). Methane reduction was significant only with apple pomace ($k = 11$, $SMD = -1.248$, p -subgroup = 0.003). Pectin-rich by-products could partially replace corn grain in ruminant diets, promote acetate-centered fermentation without negative effects on ruminal fermentation.

Key words: citrus pulp, apple pomace, alternative carbohydrate source, rumen fermentation, meta-analysis

축산 분야 AI 자율 생성 논문의 학술적 활용 가능성 및 검증: 6개 연구 사례를 중심으로

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최근 생성형 인공지능(Artificial Intelligence, AI)의 급속한 발전에 따라 국내 축산학계에서도 연구 전반에 걸쳐 이를 적용하려는 노력이 지속되고 있으나, AI 활용 방법 및 결과물의 신뢰성에 대한 명확한 기준과 윤리적 가이드라인은 미비한 실정이다. 본 연구는 인간의 개입을 최소화하고 실제 실험 없이 AI 도구만을 활용해 축산 분야 학술논문을 작성하고, AI 기반 연구의 가능성과 한계를 검토하였으며, 표절 검사를 통해 연구 결과의 신뢰성을 검증하고자 하였다. ChatGPT, Google Gemini, Claude, Perplexity 등 다양한 AI 플랫폼을 교차 활용하여 연구 주제 선정, 실험 설계, 데이터 분석 및 최종 논문 작성의 전 과정을 포함한 6편의 연구가 수행되었다. 표절률은 표절 검사 도구(CopyKiller) 및 AI 생성물 탐지 도구(GPT Killer)를 통해 검증하였다. 연구 유형은 (1) 문헌 기반형(반추위 마이크로바이옴, 한우 관능 품질, 착유우 유기산 급여 효과, 반추동물 스트레스 관련 메타분석 등 4편)과 (2) 데이터 기반형(합성 데이터 가상 실험, 공공데이터 기반 메탄 발생량 산정 등 2편)으로 분류하였다. 신뢰성 검증 결과, 프롬프트 반복 수정을 통해 문헌 표절률을 10% 이하 수준으로 유지할 수 있었으나, 초기 AI 생성물 탐지율은 60% 이상으로 나타나 추가적인 개선이 필요한 것으로 판단되었다. 결과적으로 AI는 축산 분야 학술 연구 및 문헌 작성의 보조 도구로서 실질적인 적용이 가능할 것으로 판단되나, 수집 및 합성 데이터의 투명한 공개, 인용 정확성 확보 및 연구 윤리 준수가 반드시 전제되어야 할 것으로 사료된다.

Key words : 생성형 인공지능, 축산학, 표절률, 연구 윤리

Effects of dietary crude protein levels and carcass weight GEBV groups on Hanwoo calves under summer heat stress

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This study evaluated the effects of dietary crude protein (CP) and carcass weight genomic estimated breeding value (CW GEBV) on growth performance and stress-related responses in Hanwoo calves under summer heat stress. Thirty-six Hanwoo calves (initial BW 117.9 ± 24.3 kg; 3.9 ± 0.6 months of age) were assigned to a 2×2 factorial arrangement with initial BW as a blocking factor. Treatments comprised two CP levels (BCP, 15.0%; HCP, 17.5%) and two CW GEBV groups (LG, low; HG, high), yielding four groups: BCP-LG, BCP-HG, HCP-LG, and HCP-HG. Body weight and blood samples were collected at the start (initial), and after one (middle) and two (final) months of feeding. ADG tended to be greater in HCP than in BCP and in HG than in LG (both $p = 0.077$), whereas rectal temperature and respiration rate were unaffected. Blood urea nitrogen was higher in HCP than in BCP ($p < 0.05$). Lymphocyte counts were higher in LG than in HG at the middle time point and higher in HCP than in BCP at the final time point ($p < 0.05$). Granulocyte counts showed a CP $\times$ GEBV interaction at the final time point ($p = 0.009$); BCP-LG was lower than the other three groups ($p < 0.05$). In peripheral blood mononuclear cells (PBMCs), HSP27 expression showed a CP $\times$ GEBV interaction at the middle time point ($p < 0.05$), although means did not differ. HSP70 tended to be higher in HG than in LG at the middle time point ($p = 0.074$). In conclusion, increasing dietary CP to 17.5% tended to improve ADG in Hanwoo calves under summer heat stress, while immune and cellular stress responses to dietary CP appeared to be modulated by CW GEBV.

Key words : heat stress, Hanwoo calves, dietary protein level, heat shock protein

Effects of dietary metabolizable energy, protein and essential amino acids on nitrogen utilization efficiency and milk production in dairy cows: a meta-analytic ensemble classifier

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This study developed a machine-learning ensemble to classify nitrogen utilization efficiency (NUE) in lactating dairy cows from dietary metabolizable energy (ME), metabolizable protein (MP) and metabolizable-protein essential amino acids (MP-EAA), and interpreted it with shapley additive explanations (SHAP). Following PRISMA 2020, control records were extracted from 1,175 peer-reviewed papers and standardized with the NASEM DairyFeed Library (2021); after quality screening, 1,217 records (1,142 studies) with NUE entered the analysis. NUE was dichotomized at 26.7%, the mean reported by Huhtanen and Hristov (2009). A soft-voting ensemble of logistic regression, random forest, and XGBoost validated by repeated stratified group 5-fold cross-validation (3 repeats; group = Study_ID) and cluster bootstrap resampling (1,000 study-level resamples) achieved ROC AUC = 0.840 (95% CI 0.809–0.886). In SHAP analysis, MP was the strongest negative contributor, whereas histidine retained a consistently leading positive contribution in both low- and high-CP diets, identifying it as a limiting amino acid independent of dietary crude protein level. High-NUE records further exhibited significantly greater milk yield (Hedges' $g = 0.56$), ECM ($g = 0.69$), milk protein ($g = 0.26$), and milk fat ($g = 0.30$) than low-NUE counterparts in linear mixed-effects models adjusting for between-study heterogeneity (Holm-adjusted $p < 0.001$). Together, these findings indicate that ME and MP-EAA profiles can identify lactating cows that are simultaneously higher in NUE and superior in lactational performance, contributing to sustainable dairy production.

Key words : nitrogen utilization efficiency, metabolizable energy, metabolizable amino acid, ensemble machine learning, dairy cows

Implication of combined vitamin supplementation on reproductive capacity during the growing period in Holstein heifers under summer heat-stress conditions

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This study investigated whether combined vitamin supplementation alleviates physiological stress and sustains reproductive capacity in growing Holstein heifers under summer heat-stress conditions. We hypothesized that elevated summer Temperature-Humidity Index (THI) induces metabolic acceleration for homeostasis, triggers excessive ROS production, and leads to oxidative damage and inflammation that impairs reproductive capacity. Based on this hypothesis, vitamin C and E were selected for their expected role in alleviating oxidative stress, and vitamin A and D for immune function regulation. Sixteen heifers were assigned to four groups (RCBD, n = 4 per group). From June 5, moderate heat stress was induced in the heifers as the THI reached 72 or higher. The control group received 100% of vitamin A, D, and E according to the Korean Feeding Standard. T1 received vitamin A and D at 200%. T2 received vitamin E at 300% with vitamin C at 5 g/day. T3 combined both approaches, providing vitamin A and D at 200%, vitamin E at 300%, and vitamin C at 5 g/day. Multiple parameters of growth, physiology, reproduction, and behavior were analyzed. The T3 treatment effectively preserved SOD activity to mitigate final MDA accumulation, and stabilized key endocrine indicators including hair cortisol and estrogen. Multi-parameter integrated Z-score analysis showed that the synergistic T3 group scored the highest (12.22/20), followed by T2 (9.48), quantitatively confirming superior stability. In conclusion, combined supplementation of vitamins A, C, D, and E provides a meaningful nutritional intervention to maintain physiological homeostasis and reproductive capacity in heifers under summer heat stress.

Key words : heat stress, temperature-humidity index (THI), reactive oxygen species (ROS), vitamin, reproductive capacity

서방형 유기산 및 에센셜오일이 반추위 발효 특성에 미치는 영향 조사

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본 연구는 서방형 유기산 제제(slow-release organic acid, SROA; 사과산·푸마르산)와 서방형 에센셜오일 제제(slow-release essential oil, SREO; 티몰·카바크롤)의 첨가가 반추위 발효 성상에 미치는 영향을 조사하고자 수행되었다. 시험군은 첨가 수준과 종류에 따라 기초사료(CON), SROA(0.20%, 0.40%: DM 기준) 및 SREO(0.20%, 0.40%: DM 기준)으로 설정하였다. 배양 9시간 및 24시간에 반추위 pH, 암모니아태질소(NH₃-N), 휘발성 지방산(VFA) 조성 및 발효 가스 발생량을 분석하였다. 반추위 발효 pH와 암모니아태질소 생성 수준을 통해 서방형 제제 첨가가 반추위 발효 안정성에 부정적인 영향을 미치지 않음을 확인하였다. 그러나 총 VFA 생성량은 SREO 첨가구가 대조구 대비 최대 37% 유의적으로 증가하였다($p < 0.001$). 또한 메탄 발생량은 배양 24시간에서 SROA 0.4% 첨가구가 대조구 대비 약 11% 유의적으로 감소하였다($p < 0.05$). 일련의 결과를 통해 서방형 에센셜오일 첨가가 반추위 미생물의 발효 활성을 촉진하는 것으로 나타났으며, 반추동물의 에너지 공급 개선 효과가 관찰되었다. 특히 서방형 유기산제제의 반추위 메탄 저감에 효과가 관찰되었다.

Key words : 서방형 유기산, 서방형 에센셜오일, 반추위 *in vitro* 발효, 휘발성지방산, 메탄

Effects of hydrogen supplementation on protozoa-associated prokaryotic communities in rumen protozoal cultures

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Rumen ciliate protozoa harbor diverse prokaryotic communities, including bacteria and methanogenic archaea. These symbionts play a central role in ruminal hydrogen (H₂) metabolism and methanogenesis, yet it remains poorly understood how elevated H₂ partial pressure influences the stability of these associations. Therefore, this study investigated whether H₂ supplementation (500 mbar) induces the redistribution or detachment of microbes from the protozoal fraction (PF) to the free-living fraction (FLF). Monoxenic *Epidinium ecaudatum* and meroxenic *Entodinium* spp. cultures, established via single-cell isolation, were incubated for 24 h with H₂ or N₂ (control) in a completely randomized design. Results showed that H₂ supplementation did not significantly affect overall fermentation characteristics, including VFA profiles, protozoal cell counts, and NH₃-N concentrations. Although H₂ supplementation successfully stimulated methanogenesis, evidenced by increased CH₄ proportions and reduced CO₂, 16S rRNA gene sequencing (V3-V4 region) revealed that the prokaryotic community structure was primarily stratified by niche fraction (PF vs. FLF) rather than gas supplementation in both the protozoal cultures. The absence of distinct redistribution patterns between fractions suggests that these microbial communities remain relatively stable under elevated H₂ conditions. These findings provide insight into the structural stability of protozoa-prokaryote associations. Ongoing analyses using fluorescence *in situ* hybridization (FISH) will further evaluate the spatial localization of associated prokaryotes across the separated fractions.

Key words : rumen protozoa, hydrogen partial pressure, symbiotic association

Effects of coconut oil supplementation on methane emissions and feed intake in ruminants: a meta-analysis

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Coconut oil, rich in medium-chain fatty acids (MCFA), has been proposed as a natural lipid additive for reducing enteric methane emissions in ruminants. However, whether its methane-reducing effects are accompanied by negative impacts on feed intake and fiber utilization remains unclear. This meta-analysis evaluated the effects of dietary coconut oil supplementation on methane yield (g/kg of dry matter intake [DMI]), methane production (g/day), DMI, and neutral detergent fiber digestibility (NDFD) in ruminants, based on 20 *in vivo* studies identified through a systematic search following PRISMA 2020 guidelines. Coconut oil supplementation significantly reduced methane production (SMD = -1.82 , $p < 0.001$) and methane yield (SMD = -1.51 , $p < 0.001$) across both cattle and small ruminants. However, it also significantly decreased DMI (SMD = -1.39 , $p < 0.001$) and NDFD (SMD = -1.47 , $p < 0.001$). Paired-effect analysis further indicated that the reduction in NDFD remained positively associated with decreased DMI, suggesting that MCFA-induced impairment of rumen fiber digestion may partly underlie reduced feed intake. These findings highlight the biological trade-offs associated with coconut oil use, and its practical application should carefully consider the balance between methane mitigation and adverse effects on rumen fermentation.

Key words : coconut oil, methane emission, dry matter intake, ruminants, fiber digestibility, meta-analysis

복합 미생물 처리가 TMR 발효 품질 및 반추위 *in vitro* 발효 특성에 미치는 영향

전무궁, 천인혁, 문예진, 정은경, 채병호, 이숙경, 조상범, 최낙진

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본 연구는 복합 미생물 제제의 첨가가 섬유질 완전 배합사료(TMR, total mixed ration)의 발효 품질과, *in vitro* 반추위 발효 특성에 미치는 영향을 평가하고자 수행하였다. *Pediacoccus pentosaceus*, *Saccharomyces cerevisiae*, *Bacillus coagulans*를 동일한 비율로 혼합하여 복합 미생물 제제를 제작하였다. 실험 1에서는 복합 미생물 제제를 첨가한 TMR을 10일간 발효시킨 후 발효 전 TMR 대비 pH, 유기산 및 미생물 군집의 변화를 분석하였다. 실험 2에서는 복합 미생물제제를 분말 제형으로 가공한 후에 그 첨가 수준(건물 기준 0.5%, 1.0%) 이 반추위 발효 특성에 미치는 영향을 조사하였다. 발효 가스 조성(CH_4 , H_2), pH, 휘발성 지방산 및 암모니아태 질소를 발효 지표로 분석하였다. 실험 1에서는 복합 미생물제 적용으로 TMR의 pH가 유의적으로 감소하였다(5.15 vs. 4.37)($p < 0.001$). TMR 내 젖산 함량도 15.4mM에서 53.2mM로 약 3.5배가 증가하였고($p < 0.001$), 초산은 1.70 mM에서 17.31 mM로 약 10.1배 증가하였다($p < 0.01$). 특히 mold와 대장균 군 및 살모넬라군의 검출은 관찰되지 않았다. 실험 2의 반추위 발효 특성에서는 총 휘발성 생산량, 초산 및 프로피온산 생성량이 유의적으로 증가하였다($p < 0.001$). 반면, 다른 발효 특성에서는 유의적인 차이가 관찰되지 않았다. 본 연구 결과, 복합 미생물 제제의 첨가는 TMR 발효 시 pH를 낮추고 젖산 및 초산 생성을 촉진하였으며, 곰팡이, 대장균 군 및 살모넬라의 증식을 억제하여 사료의 발효 품질과 위생적 안정성을 향상시키는 것으로 나타났다. 또한 반추위 *in vitro* 발효에서는 총 휘발성 지방산과 초산, 프로피온산 생성을 증가시켰다. 따라서 본 복합 미생물 제제는 TMR의 발효 품질 개선과 반추위 발효 효율에 기여할 수 있는 첨가제로서 활용 가능성이 있는 것으로 판단된다.

Key words : mixed microbial inoculant, fermented total mixed ration, fermentation quality, *in vitro* rumen fermentation, methane mitigation

Effects of dietary energy and *Lactiplantibacillus plantarum* LM1001 culture on fermentation characteristics and greenhouse gas emissions in the rumen

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This study estimated the effects of dietary energy and *Lactiplantibacillus plantarum* LM1001 culture (LPC) on rumen fermentation characteristics and greenhouse gas (GHG) emissions of fermented total mixed ration. A 2 (dietary energy = low (LE) vs. high (HE)) × 3 (LPC = 0 vs. 10 vs. 20%) factorial design was used. Each diet (5 kg) was ensiled for 21 days. After that, the experimental diet (0.3 g) was incubated with rumen buffer (30 mL) (n = 4) for 24 h. After incubation, total gas emission was measured and sub-sampled for GHG analysis. The rumen buffer was centrifuged to separate the residue and the supernatant for nutrient digestibility and rumen fermentation characteristics. The HE group showed higher crude protein and *in vitro* digestibilities of dry matter (IVDMD) and organic matter (IVOMD) than the LE group. And these parameters in the HE group increased ($p < 0.05$) by increasing LPC supplementation levels. The HE group showed lower ($p < 0.01$) total gas, CH₄, and CO₂ than the LE group. These gases showed interaction ($p < 0.001$) between dietary energy and LPC, which increased in the LE group but decreased in the HE group by increasing LPC supplementation levels. Notably, the HE group with 20% LPC showed the highest crude protein and IVOMD, along with the lowest GHG emissions. Therefore, the HE with 20% of LPC supplementation could be a promising approach to enhance feed value and methane mitigation in Hanwoo.

Key words : dietary energy, fermentation characteristics, greenhouse gas emissions, *Lactiplantibacillus plantarum* LM1001 culture

Evaluation of physiological and metabolic responses of goats under cold stress conditions

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The objective of this study was to evaluate the effects of winter ambient temperature on productivity, physiological indicators, and blood parameters (hematology, metabolite, and amino acids) in goats. This study was conducted using 16 goats (Korean native black × Boer crossbred, 8 months of age, initial body weight 29.0 ± 3.1 kg, $\geq 20\%$ Korean native black) over a 30-day period with repeated sampling every 5 days (temperatures: 3.78, 2.13, 0.52, -1.47, -2.31, 1.00, and -3.67°C). The data were analyzed using repeated-measure Mixed procedure of SAS. Rectal and ear temperatures remained stable throughout the experimental period ($p < 0.01$); however, rectal temperature decreased at d30, and ear temperature reached the highest value at d25 and then decreased. Respiratory rate increased after d15, whereas water intake and average daily gain decreased, with the lowest values observed at d30 ($p < 0.01$). Hematological responses showed a decrease in granulocyte count and proportion and an increase in lymphocyte proportion at d25 ($p < 0.05$). Red blood cell indices (hemoglobin, and hematocrit) decreased from d15 to d25 and recovered by d30 ($p < 0.01$). Blood metabolites showed that blood urea nitrogen decreased during d10 to d20 and increased again at d30, whereas creatinine reached the lowest value at d10 and increased gradually ($p < 0.05$). These results indicate that cold exposure affected physiological indicators, blood parameters, and productivity in goats, as reflected by reduced water intake and growth performance. Meanwhile, the recovery of several blood parameters by d30, together with stable rectal temperature, suggests adaptation to prolonged winter conditions accompanied by the activation of physiological homeostatic mechanisms.

Key words : cold stress, growth performance, hematological parameters, metabolic and physiological response

Feed values of ground corn and ramen by-products as the dietary energy sources for ruminant

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This study aimed to evaluate the feed value of corn meal and ramen by-products as the dietary energy sources for ruminants based on rumen fermentation characteristics and greenhouse gas emissions. Corn meal was used as a control (CON), while 4 ramen by-products (Shinramyun (SHR), Chapagetti (CPT), Anseongtangmyun (AST), and Neoguri (NGR) were assigned as the new energy sources. Each feed source (0.5 g) was incubated with rumen buffer (40 mL) in quadruplicate for 24 h. During the incubation period, gas pressure was measured every 5 min to generate the fermentation kinetics in the rumen. After incubation, gas samples were collected for CO₂ and CH₄. The bottle contents were centrifuged to collect the supernatant for fermentation characteristics. The AST had the highest crude protein ($p < 0.05$), while CON had the lowest ether extract ($p < 0.05$). All ramen by-product treatments had lower ($p < 0.05$) rumen pH, ammonia-N, acetate, and A:P ratio than CON. However, the total VFA and propionate were higher ($p < 0.05$) in CPT, AST, and NGR than in the other feed sources. The NGR showed the highest immediately degradable fraction (A) ($p < 0.05$), while the AST had the lowest total gas and CH₄ ($p < 0.05$, per DMD) among the feed sources. Therefore, ramen by-products, particularly AST, showed potential as an alternative dietary energy source for CH₄ mitigation without negative effects on rumen fermentation characteristics.

Key words : corn meal, rumen fermentation characteristics, methane emissions, ramen by-product

Effects of plant extract mixture and extruded linseed supplementation on enteric methane emissions in mid lactation Holstein cows

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This study investigated the effects of dietary supplementation with a plant extract mixture (PEM) additive and extruded linseed (EL) on enteric methane (CH₄) emissions, productivity, milk composition, and hematological characteristics of mid- to late-lactating Holstein cows. Nine multiparous cows were assigned to a 3 × 3 Latin square design consisting of three treatments: control, PEM (50 g/head/day), and EL (500 g/head/day). Cows were blocked according to CH₄ emission (300.8 ± 38.7 g/day), parity (1.67 ± 0.86), and milk yield (28.2 ± 5.08 kg/day). Cows were offered a total mixed ration (TMR) ad libitum and were additionally fed 2 kg of concentrate daily. CH₄ production was monitored using a GreenFeed system and calculated as CH₄ emission (g/day), CH₄ yield (g/kg of dry matter intake (DMI)), and CH₄ intensity (g/kg of milk yield). Statistical analysis was performed using the MIXED procedure of SAS 9.4. The statistical model included treatment as a fixed effect and cow and period as random effects. Dietary supplementation did not affect CH₄ emission, CH₄ yield, or CH₄ intensity ($p > 0.05$). Mean CH₄ emissions for the control, PEM, and EL treatments were 354.7, 369.9, and 368.9 g/day, respectively. No overall differences in DMI and milk yield were observed among treatments ($p > 0.05$). Milk composition and hematological parameters were unaffected by treatment. These findings suggest that fixed additive inclusion levels and ad libitum TMR feeding may have contributed to the lack of detectable supplementation effects.

Key words : GreenFeed system, Holstein, linseed, methane mitigation, plant extract

Effects of maternal L-citrulline supplementation on growth performance and gene expression in Hanwoo calves

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This study aimed to evaluate the effects of maternal L-citrulline (L-cit) supplementation on blood metabolites in Hanwoo cows, as well as growth performance and gene expression in offspring calves. Forty-eight pregnant Hanwoo cows were stratified by experimental start date, sire, and parity, and randomly assigned to three groups: control (no supplementation, $n = 15$), T1 (0.5% L-cit of DM from mid-gestation until calving, $n = 16$), and T2 (0.5% L-cit of DM from late gestation until calving, $n = 17$). Maternal blood metabolites and postpartum interval to estrus were measured after calving. Calf birth weight, body weight at 60 days, and average daily gain (ADG), as well as postpartum interval to estrus in cows, were recorded. At 75 days of age, longissimus lumborum muscle and liver biopsies were collected from male calves, and mRNA expression was quantified by RT-qPCR. Data were analyzed using the GLM procedure of SAS 9.4, with Tukey's test. L-cit supplementation did not affect postpartum blood concentrations of aspartate aminotransferase, alanine aminotransferase, glucose, total cholesterol, total protein, triglycerides, or blood urea nitrogen in cows, nor postpartum interval to estrus. In calves, no significant effects were observed for birth weight, body weight at 60 days, or ADG. Similarly, mRNA expression of myogenic (*MYF5*, *MYOD*, *MYOG*, *MYF6*) and adipogenic (*PREF1*, *ZNF423*, *PPARG*, *CEBPA*, *CEBPB*, *FABP4*) genes in skeletal muscle, as well as hepatic *ASS1*, *OTC*, *ASL*, and *GAMT* expression, were not affected. However, hepatic *ARG1* expression was lower in T1 than in the control and T2 ($p = 0.006$). In conclusion, maternal L-cit supplementation initiated in mid-gestation, but not in late gestation, may influence hepatic arginine metabolism-related gene expression in Hanwoo offspring. Long-term follow-up is warranted to determine whether these molecular changes translate into differences in growth performance and carcass traits in Hanwoo cattle.

Key words : Hanwoo cattle, L-citrulline, maternal nutrition, offspring calves, arginine metabolism

Efficacy of a synbiotics complex on dairy cow productivity and calf gut health under Uzbekistan farming conditions

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This study was conducted to investigate a synbiotics complex (Syner-win plus®; *Bacillus licheniformis*, dietary fiber, benzoic acid) on early-lactation performance and calf growth and gut health in Uzbekistan. For lactating cows, the basal diet was formulated with a 50:50 forage-to-concentrate ratio on a dry matter (DM) basis. The treatment group received synbiotics supplemented at 0.1% of the DM, targeting a daily provision of 20 g/cow based on a target DMI of 20 kg/d. Over the first 105 days in milk, the daily average milk yield significantly increased by approximately 7% in the treatment group 33.6 kg/d compared to the control group 31.3 kg/d ($p < 0.05$). Milk fat 3.63% and milk protein 3.25% contents were maintained, indicating that the synbiotics improved absolute milk yield without negative effect on milk components. Furthermore, synbiotics supplementation in newborn calves significantly increased cumulative weight gain at 11 weeks of age by 6% (61.98 kg vs. 58.34 kg; $p < 0.05$). During the weaning transition period around 2 months of age, the average fecal score was maintained lower in the treatment group 0.11 compared to the control 0.20, suggesting improved gut health in diarrhea incidence. In conclusion, dietary supplementation with Syner-win plus® is a showed positive effects to enhance milk production in lactating cows and improve initial growth and gut health in calves.

Key words : calf performance, early lactation, fecal score, milk yield, synbiotics

Effects of methanotroph-based probiotic (NC52PC) on milk production performance and milk composition in Holstein dairy cows

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This study evaluated the effects of a rumen-derived bacterial consortium (NC52PC) on milk production and composition in Holstein dairy cows. Sixty lactating cows were assigned to control (CON) and treatment (TRT) groups in a randomized complete block design based on milk yield, parity, days in milk, and milk composition. The TRT group received NC52PC at 0.5% of dry matter as a top-dressing on the total mixed ration for 35 days, including a 7-day adaptation period. Overall milk yield was not significantly affected, although significant effects of time and treatment $\times$ time interaction were observed ($p < 0.05$). Milk yield temporarily decreased during full-dose transition but recovered thereafter. Major milk composition traits were not significantly affected by NC52PC supplementation. However, fat percentage tended to be higher in the TRT group than in the CON group throughout the experimental period ($p < 0.1$), while milk urea nitrogen (MUN), C18:1, and long-chain fatty acids (LCFA) increased in the TRT group ($p < 0.05$). Monounsaturated fatty acids (MUFA), saturated fatty acids (SFA), differential somatic cell count (DSCC), medium-chain fatty acids (MCFA), and short-chain fatty acids (SCFA) tended to increase in the TRT group compared with the CON group ($p < 0.1$). Rumen fermentation characteristics remained stable throughout the experimental period, and ruminal bacterial diversity and community structure were not significantly affected by NC52PC supplementation. In conclusion, NC52PC supplementation did not compromise milk yield or major milk composition traits but influenced selected metabolic indicators and fatty acid profiles, suggesting its potential as a functional feed additive in lactating dairy cows.

Key words : rumen-derived bacterial consortium, feed additive, Holstein dairy cow, milk production, milk composition

Chemical composition and methane production of total mixed fermentation for different Hanwoo growth stages

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This study evaluated the chemical composition and *in vitro* methane (CH₄) production of 26 total mixed fermentation (TMF) diets formulated for different Hanwoo production stages, including calves, growing, early fattening, late fattening, and breeding cattle. Chemical composition analysis revealed no significant differences ($p > 0.05$) in major nutritional components, such as crude protein, neutral detergent fiber, acid detergent fiber, ethanol-soluble carbohydrates, and total digestible nutrients, among TMF diets within each production stage. Principal component analysis (PCA) indicated that digestibility-related parameters and fatty acid content were the primary factors distinguishing the TMF diets. Among the evaluated diets, TMF16, TMF23, TMF24, TMF25, and TMF26 were identified as the most suitable TMFs for calves, growing, early fattening, late fattening, and breeding cattle, respectively, based on their chemical composition profiles. Several TMF diets also showed reduced CH₄ production after 24 h incubation, with particularly significant reductions ($p < 0.05$) observed in breeding TMFs. Overall, although the nutritional compositions of the TMF diets were generally similar, specific TMF diets demonstrated potential for mitigating methane production in Hanwoo cattle.

Key words : total mixed fermentation (TMF), methane production, Hanwoo

Citrus peel-based *Bacillus subtilis* fermentation and surfactin: impacts on *in vitro* rumen fermentation characteristics and methane emissions

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Citrus peel is a valuable by-product, yet its application in ruminant diets remains limited. This study evaluated the effects of *Bacillus subtilis* cultured in a citrus peel-based medium specifically its liquid/solid fermentation products and the metabolite surfactin on *in vitro* rumen fermentation and methane (CH₄) production. Four batch culture experiments were conducted with graded inclusion levels of each component. Results showed that while *B. subtilis* and its fermentation products generally improved fermentability and nitrogen turnover (increasing volatile fatty acids and ammonia nitrogen), they had minimal impact on methane mitigation. In contrast, surfactin demonstrated a clear dose-dependent effect: at 0.01% of substrate DM, it reduced CH₄ production by 6.9% and shifted fermentation toward propionate without suppressing overall efficiency. However, a higher dose (0.02%) abolished these benefits. In conclusion, a citrus peel-*B. subtilis* platform serves as a viable strategy for value-added feed additives, with 0.01% surfactin identified as the optimal level for balancing methane reduction and rumen fermentation efficiency.

Key words : *Bacillus subtilis*, citrus peel, methane, rumen fermentation, surfactin

Effects of processing methods on ruminal fermentation characteristics and protein utilization of palm kernel meal

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Palm kernel by-products are potential alternative protein sources for ruminants. However, their nutrient composition and protein availability may differ depending on the oil-extraction and processing method. Comparative information integrating ruminal fermentation characteristics, ruminal protein degradation, intestinal digestibility of rumen-undegraded protein (RUP), and metabolizable protein (MP) supply among different palm kernel by-products remains limited. Therefore, this study evaluated the ruminal fermentation characteristics and protein utilization of three palm kernel by-products: palm kernel meal (PKM), palm kernel expeller (PKE), and palm kernel extraction in bulk (PKEB). *In vitro* fermentation was conducted to determine dry matter degradability (IVDMD), pH, ammonia-N, volatile fatty acid (VFA), and gas production, which was measured at 6, 12, and 24 h. *In situ* was conducted using two rumen-cannulated Hanwoo heifers (BW: 450 ± 10 kg) to determine dry matter and crude protein degradability and to calculate rumen degradable protein (RDP) and RUP. After 12 h of ruminal *in situ* incubation, the residual samples were subjected to a separate *in vitro* intestinal digestibility assay to determine intestinal digestibility (ID) of rumen undegradable protein (RUP) and to calculate metabolizable protein from feed (MP_{feed}). *In vitro*, PKEB showed lower IVDMD than PKM and PKE ($p = 0.0002$) but a greater molar proportion of propionate and a lower acetate-to-propionate ratio ($p < 0.05$). *In situ*, PKM had higher soluble CP and RDP, whereas PKE and PKEB had higher RUP than PKM ($p < 0.0001$). Intestinal digestibility of RUP was greatest in PKEB, and MP_{feed} was higher in PKE and PKEB than in PKM ($p < 0.0001$). Considering both *in vitro* and *in situ* results, PKE appears to be the most effective palm kernel by-product for improving utilizable protein supply, owing to its relatively high IVDMD, greatest RUP, and greatest MP_{feed} supply. PKEB showed an advantage in intestinal digestibility of RUP and fermentation profile, but further *in vivo* studies are needed to confirm their practical feeding value.

Key words: palm kernel by-products, palm kernel by-products, palm kernel expeller, rumen undegradable protein, intestinal digestibility, metabolizable protein