



초지 및 환경

착유우의 물리적, 감각적 환경 풍부화의 유형과 효과에 대한 고찰

이우도, 김찬호, 문예진, 김수미, 방한태, 양가영, 차지혜

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유제품에 대한 소비자의 인식은 안전성과 품질을 넘어 착유우의 사육 환경과 관리 방식으로 확대되면서 동물복지에 대한 관심이 증가하고 있다. 동물복지는 신체적 건강과 생리적 기능을 유지하고, 부정적 정서를 최소화하며 자연행동을 표현할 수 있는 상태를 의미한다. 이러한 복지 향상을 위해 환경적 스트레스 완화와 행동 욕구 충족, 긍정적 정서 유도를 목표로 하는 환경 풍부화(environmental enrichment)가 주목받고 있다. 본 연구는 착유우에 적용되는 물리적 및 감각적 환경 풍부화의 유형과 특성을 고찰하고, 생산성, 행동, 청결도 및 복지 측면에서의 효과를 분석하였다. 브러시, 사슬, 장난감 및 젓꼭지형 장치와 같은 물리적 풍부화와 시각, 청각 및 후각 자극을 포함한 감각적 풍부화를 구분하여 총 32편의 문헌을 분석하였다. 물리적 환경 풍부화는 털고르기 행동 증가, 활동성 향상 및 스트레스 감소와 관련이 있었으며, 일부에서는 유량 증가 등 생산성 개선 효과도 보고되었다. 감각적 환경 풍부화는 거울, 사진, 비디오 등의 시각적 자극과 음악의 종류, 템포 및 데시벨을 활용한 청각적 자극을 중심으로 연구되었으며, 청각 자극의 경우 적정 자극 수준이 제안된 바 있다. 그러나 감각 기반 풍부화 연구는 제한적이며, 효과의 일관성이 부족하거나 유의한 결과가 나타나지 않는 한계도 확인되었다. 따라서 환경 풍부화의 효과를 명확히 규명하기 위해서는 자극의 강도와 특성, 제공 기간 및 사육 환경을 고려한 체계적인 연구가 필요하다. 본 고찰은 착유우의 환경 풍부화 전략 수립과 향후 연구 방향 설정에 기초 자료를 제공할 것으로 기대된다.

Key words : dairy cattle, animal welfare, environmental enrichment, physical enrichment, sensory enrichment

Effect of negative pressure on exhaust fan performance and determination of critical ventilation rate in pig housing

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This study aimed to analyze the effects of negative pressure conditions on the performance of exhaust fans in pig housing facilities and to propose criteria for stable ventilation system design. In mechanically ventilated windowless pig houses, temperature, humidity, and harmful gases are controlled using air inlets and exhaust fans. The negative pressure environment formed during operation can cause the actual performance of exhaust fans to deviate from their rated conditions. To investigate this, a modified container-based chamber was used to establish static pressure conditions ranging from -5 to -30 Pa. The performance of a 50 cm exhaust fan was evaluated under ventilation rates from 10% to 60%. The results showed that, as static pressure increased, backflow occurred or airflow decreased. In particular, at a negative pressure of -20 Pa, backflow was observed even at a ventilation rate of 40%. Additionally, a nonlinear behavior was identified in which the fan's ability to overcome static pressure increased sharply between ventilation rates of 50% and 55%. Based on these findings, the Critical Ventilation Rate (CVR) and Safe Operating Range were defined. These results highlight the importance of considering negative pressure conditions when establishing operational criteria for the design of pig housing ventilation systems.

Key words : negative pressure, exhaust fan performance, ventilation rate, mechanical ventilation, critical ventilation rate

제주 지역에서 한·난지형 목초 및 사료작물 혼파에 따른 초지 식생 구성 및 생산성 비교

정진우, 고하늘, 박형수, 우제훈, 양승학, 정종성

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본 연구는 제주 지역을 대상으로, 한지형과 난지형 목초 및 사료작물의 혼파를 통해 초지 식생을 유지하고 연중 생산성을 극대화할 수 있는 최적의 조합을 구명하고자 수행되었다. 제주 난지축산연구센터 시험포장에서 한지형(이탈리안 라이그라스, 톨페스큐)과 난지형(바랭이, 사료피) 목초 및 사료작물을 이용해 단파 및 혼파 처리구 6개를 난괴법 3반복으로 조성하였다. 2025년 4월부터 9월까지 총 6차에 걸쳐 예취를 진행하였으며, 각 수확 시기별로 식생비율, 초장, 건물생산성 및 사료가치를 조사하였다. 식생 비율의 경우, 1차 수확 시 모든 처리구에서 한지형 목초 및 사료작물이 우점하였으나, 한지형 목초 및 사료작물 단파구는 3차 수확 이후부터 점차 식생비율이 감소하여 상대적으로 잡초 비율이 증가하였다. 반면 혼파구인 T3(이탈리안 라이그라스+바랭이)는 6차 수확 시 난지형인 바랭이가 90%를 점유하며 잡초 발생을 10%로 억제해 하절기에도 안정적인 식생을 유지하였다. 건물생산성의 경우, 혼파구인 T3(이탈리안 라이그라스+바랭이, 21,833 kg/ha)가 단파구인 T2(이탈리안 라이그라스, 14,588 kg/ha) 대비 약 49.7% 높았다. 결론적으로 제주 지역에서는 이탈리안 라이그라스에 바랭이를 혼파하는 것이 식생 유지와 건물생산성 극대화에 가장 효과적인 조합으로 확인되었다. 단, 본 연구는 제주 지역에 국한된 결과이므로, 기후 조건이 상이한 타 지역에서도 동일한 식생 유지 및 생산성 향상 결과가 도출되는지를 확인하는 후속 연구가 요구된다.

Key words : botanical composition, cool-season grass, productivity, seed mixture, warm-season grass

이유자돈 환경풍부화물 선택을 위한 문헌 기반 효과 분석

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이유자돈 시기는 어미로부터 분리된 직후 체온 조절, 모유에서 사료의 급격한 사료 전환, 환경 변화 및 개체 혼합 등 복합적인 스트레스 요인에 노출되면서 이유 스트레스를 경험한다. 이러한 급격한 환경변화는 면역 기능 저하, 공격 행동 및 이상행동의 증가로 이어질 수 있어 적절한 관리가 요구된다. 환경풍부화물은 사육 환경에서 돼지의 종 특이적 행동을 표현할 수 있도록 하는 관리 요소로 스트레스 완화 및 행동 안정화를 위한 관리 요소 중 하나이다. 본 고찰은 총 37편의 문헌을 수집하여 이유자돈의 환경풍부화물 유형을 체계적으로 검토하고 그 효과를 분석함으로써, 향후 환경풍부화물 선택을 위한 근거 마련에 기초자료로 활용하고자 한다. 최근 환경풍부화물 연구는 단일 제공에서 복합 제공으로 확장되며, 환경풍부화물 이용의 지속성과 행동 유도 유지에 초점을 두는 방향으로 발전하고 있다. 환경풍부화물의 행동학적 특성이 저작, 조작 및 탐색 행동을 유도하는 물질의 경우 탐색 행동 증가와 함께 공격 및 이상행동이 유의하게 감소하는 것으로 나타났으며, 생산성과 관련된 지표에서는 전반적으로 유의한 변화가 확인되지 않았다. 한편, 행동 및 생산성 지표에 대한 변화 분석은 활발히 이루어진 반면, 코티졸과 같은 스트레스 지표를 활용한 생리학적 측정은 상대적으로 제한적인 수준에 머물렀다. 결론적으로 본 고찰을 통해 환경풍부화물 효과 평가는 행동뿐 아니라 생리 및 생산성 지표를 포함한 다중지표 기반의 통합적 해석이 필요하며, 향후에는 돼지의 기능적 행동 유도와 환경풍부화물 이용 지속성을 함께 고려한 연구 설계가 필요할 것으로 판단된다.

Key words : weaning piglets, environmental enrichment, animal welfare

Adaptive ventilation control strategy based on heat balance modeling for improved microclimate management in broiler housing

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The rapid intensification of broiler production systems has increased the importance of precise indoor climate control. Insufficient ventilation management can lead to thermal stress, accumulation of harmful gases, and consequent declines in productivity. Despite this, many commercial broiler facilities continue to rely on manual operation or simplified rule-based control approaches, with limited availability of rigorously validated control algorithms. In this study, an adaptive ventilation control strategy grounded in heat and energy balance modeling was developed to provide a more accurate estimation of ventilation requirements. A year-long dataset obtained from an experimental broiler facility was used to evaluate performance. The conventional control approach maintained target thermal conditions for 74% of the production cycle, whereas the proposed strategy improved this to 92%. Field validation was conducted in two commercial-scale broiler houses during the finisher phase (20–34 days of age). The proposed system reduced indoor daytime temperatures by 1.5°C–2.0°C, thereby mitigating heat stress conditions. While the operation frequency of evaporative cooling pads increased substantially, the use of tunnel ventilation fans decreased by 52%, leading to an overall improvement in energy efficiency. Additionally, mortality rates were reduced by 16.5%, indicating enhanced animal welfare and production outcomes.

Key words : energy-efficient ventilation, field-scale validation, heat–energy balance analysis, poultry housing environment, thermal stress mitigation

A comprehensive framework for monitoring and enhancing animal welfare and environmental safety in livestock transport systems

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The transportation of livestock represents a vital link in Korea's agri-food supply chain, involving the daily movement of thousands of cattle, tens of thousands of pigs, and millions of poultry. During transit, animals are often subjected to challenging conditions, including thermal stress, inadequate ventilation, degraded air quality, vehicle-induced vibration, and physical injury, all of which can adversely affect welfare and production efficiency. This study proposes an integrated assessment framework designed to simultaneously evaluate animal welfare and environmental risks during livestock transportation. The framework combines a physics-based microclimate prediction model, incorporating animal heat exchange and airflow dynamics, with computational fluid dynamics simulations to characterize in-vehicle environmental conditions. Validation is conducted through field measurements using sensor-equipped commercial transport vehicles operating under a range of climatic and driving conditions. The proposed framework offers a scientifically grounded and practically applicable solution for improving transport management, enhancing animal welfare during transit, and mitigating environmental and economic risks associated with livestock transportation.

Key words : livestock transportation, animal welfare, transport microclimate, heat stress

Estimation annual nitrogen excretion from gestating and lactating sow

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The objective of the present study was to estimate the annual nitrogen (N) excretion from gestating and lactating sows in Korea. Eighteen diets (9 gestation diets and 9 lactation diets) collected from 9 commercial farms were analyzed for dry matter and crude protein. Crude protein contents in gestation and lactation diets were 13.1% and 17.7%, respectively. Daily N intake of gestating and lactating sows was calculated using daily feed intake from the literature and dietary crude protein content. The N retention of sows was calculated using the models in the literature. Daily N excretion inclusive fecal and urinary N was calculated as the difference between daily N intake and daily N retention. Annual N excretion from a sow was calculated as a weighted mean based on the duration of gestation and lactation. The daily N intake of gestating and lactating sows was 44.5 and 151.1 g/day, respectively. Daily N excretion of gestating and lactating sows was 35.9 and 89.9 g/day, respectively. The annual N excretion from a sow was 16.2 kg/year which was less ($p < 0.001$) than 26.35 kg/year suggested by the Intergovernmental Panel on Climate Change (2019). In conclusion, the annual N excretion from a sow in Korea estimated to be 16.2 kg/year.

Key words : gestating sow, Intergovernmental Panel on Climate Change, lactating sow, nitrogen excretion

저전력 엣지 환경에 최적화된 비육염소 행동 분류 Transformer-CNN 모델 개발

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가축의 반추 및 사료섭취와 같은 개체유지행동의 자동 분류는 건강 및 생산성 관리의 핵심 지표이다. 본 연구는 6축 IMU 신호 기반 Transformer-CNN 행동 분류 모델을 개발하고, 저샘플링 및 저연산 엣지 환경에서의 적용 가능성을 평가하고자 수행되었다. 경기도 소재 농장의 축사 사육(housing system) 환경에서 사육 중인 5-6개월령 거세 흑염소 19두를 공시하였으며, 2025년 9월 18일부터 26일까지 9일간 CCTV 영상과 목 부착형 6축 IMU 센서(Farmer's Hands, Bodit Inc., South Korea)를 이용하여 행동 데이터를 수집하였다. 수집된 가속도 3축 및 각속도 3축 신호를 10초 단위 윈도우로 분할하여 총 132,887개 표본을 구축하였고, Transformer Encoder와 1D CNN을 결합한 End-to-End 모델을 적용하여 사료섭취, 반추 및 기타행동에 대한 3-class 분류를 수행하였다. 모델은 5-25 Hz 조건에서 학습 및 평가되었으며 일반화 성능은 Leave-One-Subject-Out(LOSO, n = 15) 및 Stratified 5-Fold 교차검증으로 분석하였다. 그 결과 25 Hz에서 매크로 평균 F1 점수는 LOSO 82.3%, 5-Fold 86.7%를 기록하였으며, 5 Hz에서도 각각 78.6%, 84.2%로 4%p 이내의 성능 저하만 나타났다. 또한 CPU 기반 추론 지연 시간은 25 Hz에서 1.55 ms, 5 Hz에서 0.68 ms로 모든 주파수 조건에서 실시간 처리 성능을 만족하였다. 이상의 결과는 제안한 Transformer-CNN 모델이 저샘플링 및 저전력 엣지 환경에서도 안정적인 행동 분류 성능을 제공함을 시사하며, 축산 IoT 기반 실시간 모니터링 시스템에 효과적으로 활용될 수 있음을 보여준다.

Key words : artificial intelligence, deep learning, six-axis IMU, goat behavior classification, inference latency

IMU 센서 기반 젖소 혈떡임 탐지를 통한 고온 스트레스 모니터링 기술 개발

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고온 스트레스는 젖소의 생산성과 복지를 저해하는 주요 요인이며 기후변화에 따라 그 심각성이 증가하고 있다. 본 연구는 젖소의 혈떡임(panting)을 자동 탐지하여 고온 스트레스를 정량적으로 모니터링하기 위한 기술을 개발하고자 수행되었다. 2024년 8월부터 11월까지 경기도 소재 젖소 농장에서 착유우 20두를 대상으로 목걸이형 IMU 센서(Farmer's Hands, Bodit Inc., South Korea)를 부착하고 CCTV 기반 행동 라벨링을 수행하였다. 이를 토대로 가속도 신호의 정적성, 호흡 주파수 대역 에너지, 호흡 규칙성 및 스펙트럼 피크 강도를 결합한 rule-based 혈떡임 탐지 알고리즘을 설계하였다. 개발된 알고리즘은 2024-2025년 동안 총 119두의 젖소에 적용되어 혈떡임 시간을 수집하였으며, 온습도지수(THI)와의 관계를 분석하였다. 또한 혈떡임 데이터를 바탕으로 추정 호흡수(BPM)를 산출하여 THI 변화와 비교하였다. 혈떡임 탐지 성능은 개체 단위 5-fold GroupKFold 교차검증에서 F1 score 0.763을 나타냈다. 혈떡임 시간은 THI와 유의한 양의 상관관계를 보였으며($THI \geq 70$, Pearson $r = 0.671$), 추정 호흡수는 THI 82 이상에서 급격히 증가하여 THI 88에서 최대 94 BPM에 도달하는 비선형 임계 반응을 나타냈다. 이러한 결과는 행동 센서 기반 혈떡임 탐지가 젖소의 고온 스트레스를 실시간으로 모니터링할 수 있는 효과적인 기술임을 시사한다.

Key words : heat stress, dairy cattle, IMU sensor, panting detection, respiration rate, temperature-humidity index

Evaluation of methane reduction effects in swine farm slurry by application of a methane reducing agent

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Methane (CH₄) emissions from the livestock sector have recently gained increasing attention in relation to carbon neutrality and low-carbon livestock production, leading to the demand for various technologies to reduce methane generated during animal husbandry. Following the 2015 Paris Agreement and the 2019 UN Climate Action Summit, carbon neutrality by 2050 emerged as a global paradigm, and South Korea also declared its goal of achieving carbon neutrality by 2050 in October 2020. Accordingly, the Korean government revised its 2030 Nationally Determined Contribution (NDC) targets upward in October 2021 and established a 2050 carbon neutrality scenario. This study was conducted to evaluate the methane reduction effect of applying a methane-reducing agent to swine farm slurry. The experiment was carried out using slurry collected from a manure storage tank at a finishing pig farm with a capacity of 3,000 pigs located in Boseong, Jeollanam-do, Republic of Korea. *Methanotrophs* sp. were inoculated into 500 mL of slurry and incubated at 30°C in a constant-temperature water bath. Methane (CH₄) concentrations were analyzed using gas chromatography (GC; 7890A GC system, Agilent Technologies, Germany) equipped with a flame ionization detector (FID). The methane emission data obtained in this experiment were analyzed using the SAS (Statistical Analysis System) statistical package (2003). Differences among treatment means were evaluated using Duncan's multiple range test at a significance level of $p < 0.05$. The results showed that the treatment with 0.2% *Methanotrophs* sp. supplementation produced the lowest methane emissions at both 12 and 48 hours of incubation. Compared with the control group, methane emissions were reduced by 13% after 12 hours and by 23% after 48 hours of incubation.

Key words : swine, methane reduction, slurry, odor reduction

Evaluation of odor reduction effects of microorganisms isolated from swine feces, slurry, and wastewater

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This study aimed to evaluate the odor-reducing activities of microorganisms isolated from swine feces, slurry, and wastewater against ammonia, amines, and hydrogen sulfide, and to select potential microbial strains for livestock odor. Among 43 isolates, 19 strains showing proteolytic activity were selected, and *Bacillus subtilis* CACC885 was used as a positive control. Each strain was inoculated at 1% (v/v) into diluted swine slurry samples and incubated for 24 h. Based on hydrogen sulfide reduction activity, nine *Bacillus* strains and one lactic acid bacterium were selected for further evaluation of ammonia and amine reduction. Among the evaluated strains, slurry-derived *Limosilactobacillus reuteri* CACC1861 showed hydrogen sulfide and amine reduction efficiencies of 25.00% and 35.45%, respectively. Slurry-derived *Bacillus velezensis* CACC1854 exhibited the highest ammonia and amine reduction efficiencies at 85.00% and 80.00%, respectively. *Bacillus velezensis* CACC1819 also showed stable reductions against hydrogen sulfide, ammonia, and amines, with efficiencies of 18.92%, 24.48%, and 26.53%, respectively. Additionally, wastewater-derived *Bacillus subtilis* CACC1833 showed high ammonia reduction efficiency (35.68%), while swine feces-derived *Bacillus subtilis* CACC1846 exhibited broad odor-reducing activity across the tested odor compounds. Based on the overall odor reduction profiles, the slurry-derived strains *Bacillus velezensis* CACC1854, *Limosilactobacillus reuteri* CACC1861, and *Bacillus velezensis* CACC1819 were selected as promising candidates. These results suggest that the selected strains may serve as functional microbial resources for reducing livestock-derived odor.

Key words : swine slurry, livestock odor mitigation, ammonia reduction, hydrogen sulfide, *Bacillus velezensis*, *Limosilactobacillus reuteri*

한우사 내부 및 부지경계에서 악취물질 발생 조사 연구

고한종

한국방송통신대학교 농학과

한우사에서 발생하는 주요 악취물질의 농도 특성을 파악하고, 축사 내부와 부지경계에서의 악취 발생 양상을 비교하여 한우 사육시설의 악취관리 기초자료를 제시하고자 수행하였다. 현장 조사는 12개소의 한우사 내부와 부지경계를 측정지점으로 설정하여 수행하였으며, 자연환기식 개방형 바닥깔개 우사 시설을 대상으로 총 11종의 악취물질을 분석하였다. 분석 결과, 한우사 내부에서는 암모니아, 황화수소, 아민류 및 일부 지방산류가 주요 악취물질로 확인되었으며, 부지경계에서는 복합악취와 암모니아가 주요 관리지표로 활용될 수 있을 것으로 판단되었다. 한우사는 개방형 구조로 인하여 밀폐형 축사(돈사 및 계사)에 비해 악취농도는 낮은 편이나, 깔짚 상태, 분뇨 체류시간, 환기 조건, 기상조건에 따라 부지경계에서 악취 영향이 달라질 수 있다. 따라서 축산시설별 악취물질 농도뿐만 아니라 최소감지농도와 악취활동도 평가를 고려한 저감관리 기준 마련이 필요할 것으로 판단된다.

Key words : 한우사, 악취물질, 지방산, 아민류, 부지경계, 복합악취

Phylogenomic analysis of the Korean *Mycobacterium bovis* JW-1 isolate using pacbio-illumina hybrid assembly

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Bovine tuberculosis caused by *Mycobacterium bovis* remains an important infectious disease affecting livestock and public health. In this study, the Korean JW-1 isolate was assembled using PacBio long-read and Illumina short-read hybrid sequencing to generate a high-quality genome assembly. Comparative phylogenomic analysis was performed using publicly available international *M. bovis* genomes, including Chinese isolates. Core genome SNP-based phylogenetic analysis showed that JW-1 clustered closely with several East Asian isolates, suggesting possible regional evolutionary relationships. Pairwise SNP distance analysis further supported the genomic relatedness between JW-1 and selected Asian isolates. These findings provide preliminary insights into the evolutionary characteristics and molecular epidemiology of Korean *M. bovis* strains. In addition, this study demonstrates the usefulness of hybrid genome assembly and SNP-based phylogenomic analysis for high-resolution surveillance of bovine tuberculosis.

Key words : *Mycobacterium bovis*, bovine tuberculosis, hybrid assembly, phylogenomics, SNP analysis

Spatial characteristics of heat stress risk in Hanwoo cattle based on the temperature-humidity index

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Recent climate change has intensified the frequency and severity of heat waves, thereby increasing thermal stress vulnerability in the livestock industry. In particular, hot and humid summer conditions negatively affect the productivity and welfare of Hanwoo cattle. This study investigated regional patterns of heat stress risk in Hanwoo cattle across South Korea using the Temperature–Humidity Index (THI). Weather data from 167 cities and counties collected during the summer of 2024 (June–September) were used to calculate the proportions of days exceeding the warning threshold ($\text{THI} \geq 79$) and danger threshold ($\text{THI} \geq 90$).

The results revealed that warning-level exceedance rates were particularly high in the inland plains of the Honam and Chungcheong regions, where average exceedance rates exceeded 90% in several areas. In contrast, lower exceedance rates were observed in the mountainous regions of Gangwon Province and coastal areas influenced by marine climates. These findings suggest that topographic and regional climatic conditions substantially influence the thermal vulnerability of Hanwoo cattle. This study provides fundamental information for establishing climate change adaptation strategies and region-specific heatwave mitigation policies in livestock management.

Key words : heat stress, Hanwoo, temperature-humidity index

한우 거세우의 생애주기 열스트레스 노출 수준이 도축성적에 미치는 영향

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본 연구는 개체별 한우의 축산물이력제 이동정보를 기반으로 일별 기상 데이터를 연계하여 한우 거세우의 생애주기 열스트레스 누적 노출이 도체형질에 미치는 영향을 분석하였다. 공공데이터 API를 활용해 아비 및 외조부의 씨수소가 동일한 29~32개월령 한우 거세우 865마리의 축산물이력제 및 품질 데이터를 수집하였으며 개체별 이동 이력에 따라 카카오맵 API를 활용해 농장 주소지의 위도 및 경도를 매칭하고 이를 ASOS 최근접 기상관측소에 매칭하여 생애주기 전체의 기상 데이터를 획득하였다. THI 72 초과 노출일수·비율·평균 등을 산출하였으며 도체중, 근내지방도 등 9개 도체 형질과의 분석을 수행한 결과, 열스트레스 지표와 도체형질 간 유의한 연관성은 확인되지 않았다($R = 0.02-0.10$). 차후 사료공급, 사육단계별 노출, 출하계절 등 교란변수를 통제한 혼합모형을 적용함으로써 열스트레스 노출과 도체형질 간 인과관계를 보다 정밀하게 규명할 필요가 있을 것으로 보인다.

Key words : 한우, 열스트레스, THI, 생애주기, 공공데이터

Analysis of greenhouse gas emission trends in the livestock sector based on the 2023 National GHG Inventory

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To establish effective GHG reduction policies and monitor their implementation in the livestock sector, an accurate analysis of emission trends from the annual national GHG inventory is essential. This study utilized livestock category data from the '2023 National GHG Inventory Statistics' to analyze emissions from enteric fermentation and manure management in 2023. In 2023, total GHG emissions from the livestock sector were calculated at 12.7 million tons CO₂eq, accounting for approximately 56% of the agricultural sector. By specific source, emissions from enteric fermentation were 6.7 million tons CO₂eq, representing about 29.9% of agricultural emissions. In terms of emission contributions, cattle accounted for the highest proportion at 94.2%, followed by pigs (4.5%) and poultry (1.3%). Emissions from the manure management sector were estimated at 6.0 million tons CO₂eq, representing 26.5% of the agricultural sector. Direct CH₄ and N₂O emissions amounted to 4,895 thousand tons CO₂eq, with pig manure management facilities accounting for 60.4% and cattle facilities for 33.8%. Indirect N₂O emissions were 1,087 thousand tons CO₂eq, making up 18.2% of the manure management sector's emissions. Achieving NDC targets requires the active adoption of site-specific reduction technologies. These findings provide a vital foundation for advancing carbon neutrality implementation plans in the livestock sector.

Key words : livestock, greenhouse gas, methane, nitrous oxide, national inventory report

Farm-level treatment-associated odor and fecal microbiota changes in pig farms

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This study investigated farm-level treatment-associated changes in odor-related indicators, slurry physicochemical properties, short-chain fatty acid profiles, and fecal microbiota before and after treatment in pig farms. Treatment A, *Bacillus licheniformis*; Treatment B, a three-strain microbial consortium consisting of *Lactiplantibacillus plantarum*, *Pediococcus pentosaceus*, and *Saccharomyces cerevisiae*; and Treatment C, curcumin, were applied to independent pig farms. Odor-related responses differed among treatments. Treatments A and C significantly reduced major odor indicators, including ammonia, amine, hydrogen sulfide, volatile organic compounds, and complex odors, whereas Treatment B showed non-significant decreasing trends in odor gases. For short-chain fatty acid and fecal microbiota analyses, fecal samples were collected from 10 pigs per farm. Acetic, propionic, and 2-methylbutyric acids significantly decreased in Treatment A, while valeric acid significantly increased in Treatment C. Slurry physicochemical parameters, including total solids, volatile solids, suspended solids, total phosphorus, and total nitrogen, were significantly reduced in Treatment A and mostly reduced except total nitrogen in Treatment B, whereas total nitrogen increased in Treatment C. Fecal microbiota analysis showed treatment-associated shifts in gut microbial community structure, suggesting distinct farm-level environmental and microbial responses.

Key words : swine, feed additives, odor mitigation, slurry characteristics, short-chain fatty acids, fecal microbiota, farm-level variation

액티브 시니어 대상 말교감치유 융복합 프로그램 개발 및 효과 연구

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초고령사회 진입과 함께 은퇴 후 삶을 살아가는 액티브 시니어의 심리적·신체적 건강 증진에 대한 관심이 높아지고 있으며, 이러한 맥락에서 말 교감활동은 긍정적인 치유 효과를 제공하는 대안으로 주목받고 있다. 따라서 본 연구에서는 말 교감활동과 원예치유를 결합한 융복합 치유프로그램을 설계하고, 해당 프로그램이 액티브 시니어의 생리적·심리적 건강에 미치는 효과를 검증하고자 하였다. 전주시 거주 61~74세 성인 30명을 대상으로 실험군(n = 15)과 대조군(n = 15)으로 나누어 실험을 진행하였다. 실험군은 비기승 말교감치유 중심의 융복합 프로그램(주 1회, 회기당 120분, 총 8회기)에 참여하였으며, 각 회기는 말교감활동(80분)과 원예치유활동(40분)으로 구성되었다. 원예치유활동은 말교감활동 후 정서 이완 및 마무리를 목적으로 구성되었다. 대조군은 복지관의 일상 프로그램에 참여하였다. 집단 간 차이와 시계열 변화 양상을 확인하기 위해 반복측정 분산분석(Repeated Measures ANOVA)을 실시하였다. 실험군은 프로그램 참여 후 우울감과 불안감 점수가 유의적으로 감소하였으며($p < 0.05$), 긍정정서 점수는 증가하는 경향을 나타내었다. 또한 심박수는 프로그램 참여 전 대비 평균 6.3 bpm 감소한 것으로 나타났으며($p < 0.05$), 대조군에서는 유의적인 변화가 나타나지 않았다. 반복측정분산분석 결과, 집단과 시점 간 상호작용 효과가 확인되어($p < 0.05$), 말교감치유 중심 융복합 프로그램이 액티브 시니어의 스트레스 완화 및 심리적 안정 증진에 긍정적인 영향을 미치는 것으로 나타났다. 본 연구는 말교감치유 융복합 프로그램이 액티브 시니어의 심리·생리적 건강 증진을 위한 효과적인 중재 방안으로 활용될 수 있음을 시사한다. 본 연구는 농촌진흥청 국립축산과학원 축산시험연구의 노인 대상 농촌자원 융복합 치유활동 콘텐츠 개발(4_축산원, PJ01747701) 과제의 지원사업에 의해 이루어진 것임. 본 연구는 2026년도 농촌진흥청 국립축산과학원 전문연구원 과정 지원사업에 의해 이루어진 것임.

Key words : 동물교감치유, 말, 액티브 시니어, 스트레스, 융복합 치유프로그램

Evaluation of heat stress in adult Korean native black goats during summer

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This study was conducted to evaluate heat stress responses in adult Korean native black goats under hot summer conditions, to develop a respiration rate (RR) prediction model using major environmental factors, and to determine the upper critical temperature. A total of 12 clinically healthy adult goats (6 males and 6 females) were used. Temperature (T, °C), relative humidity (RH, %), radiant energy (RE, W/m²), skin temperature (ST, °C), and respiration rate (RR, breaths/min) were measured under field conditions. Pearson correlation analysis showed that T, ST, and RH were positively correlated with RR ($p < 0.001$), whereas RE was not significantly correlated with RR ($p = 0.232$). Contribution analysis indicated that T had the greatest effect on RR variation (48.5%), followed by ST (40.2%) and RH (11.3%). The regression model was derived as $RR = 8.35 - 10.05T + 0.24T^2 + 4.20ST + 0.26RH$, and the model was statistically significant ($p < 0.001$) with high explanatory power ($R^2 = 0.893$). The upper critical temperature at which RR reached 60 breaths/min in adult goats was estimated to be 27.4°C. These results indicate that heat stress responses in adult Korean native black goats are mainly influenced by temperature and surface thermal load, suggesting that preventive heat stress management should be initiated before animals reach this upper critical temperature.

Key words : Korean native black goat, heat stress, respiration rate, upper critical temperature

융복합 자원 기반 반려견 교감 치유프로그램의 효과: 활동적 은퇴자 대상 우울감 및 자기효능감 개선

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초고령사회 진입에 따라 활동적 은퇴자의 정신건강 관리 필요성이 증대되고 있다. 본 연구는 동물교감(산책·행동관찰)에 원예(허브볼), 식량자원(모시브러시), 농촌환경(라탄바구니) 등 융복합 자원을 결합한 치유프로그램(6회기, 주 1회)을 전주시 거주 61~74세 활동적 은퇴자 15명(N = 15)에게 적용하여 생리·심리적 효과를 검증하였다. 사전·사후 측정 결과, 타액 코르티솔이 32.43%($p < 0.01$) 감소하였고, 자기효능감 52.36%($p < 0.01$) 향상, 우울 37.97%($p < 0.01$) 감소, 주관적 활력 2.79%($p < 0.01$) 향상이 확인되었다. 전반적 만족도는 4.69/5점으로 높게 나타났다. 본 연구는 동물자원 융복합 치유프로그램이 활동적 은퇴자의 생리·심리적 건강 증진에 효과적임을 실증하며, 초고령사회 정신건강 정책의 기초자료로 활용될 수 있음을 시사한다.

본 연구는 농촌진흥청 국립축산과학원 축산시험연구의 노인 대상 농촌자원 융복합 치유헌동 콘텐츠 개발(4_축산원, PJ017477)과제의 지원사업에 의해 이루어진 것임.

Key words : 동물교감치유, 융복합 치유프로그램, 활동적 은퇴자, 자기효능감, 타액 코르티솔

반려견 휴식방법에 따른 심박수 및 QBA 행동 변화 분석

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본 연구는 동물교감치유 환경에서 반려견의 적정 휴식방법을 탐색하기 위한 파일럿 테스트로, 휴식 형태에 따른 생리적 및 행동적 반응을 예비적으로 비교·분석하였다. 반려견 4마리를 대상으로 △보호자와 함께 켄넬에서 휴식(보호자+켄넬) △켄넬 내 단독 휴식(켄넬) △장난감 제공 휴식(장난감) △간식 제공 휴식(간식)의 네 가지 조건을 설정하고, 각 조건을 2회 반복 적용하였다. 생리적 반응은 심박수(heart rate, HR), 행동적 반응은 QBA (qualitative behaviour assessment) 14개 항목을 활용하여 평가하였다. 분석 결과, 휴식 조건에 따라 심박수 ($F(3,20) = 5.67, p = 0.006$)와 QBA 다수 항목에서 유의한 차이가 나타났다. 특히 보호자+켄넬 조건에서 심박수는 92.4 ± 8.2 bpm으로 가장 낮았으며, 긍정 정서 항목인 content(8.31 ± 1.88)와 relaxed(8.06 ± 1.54)는 가장 높고, 부정 정서 항목인 anxious(1.75 ± 1.53)와 nervous(1.25 ± 1.68)는 가장 낮게 나타났다. 종합 웰빙 지표(Δ QBA) 또한 보호자+켄넬 조건에서 가장 높은 값을 보였다($+6.56 \pm 1.23, p < 0.001$).

이상의 결과는 보호자 동반 켄넬 휴식이 다른 조건에 비해 반려견의 생리적 안정과 긍정적 행동 반응에 보다 유리할 가능성을 시사한다. 다만 본 연구는 소규모 파일럿 테스트라는 한계가 있으므로, 향후 더 많은 개체를 대상으로 코르티솔 등 추가 생리 지표를 포함한 후속 검증이 필요하다. 이러한 결과는 동물교감치유 프로그램에서 반려견의 복지 친화적 휴식 가이드라인 마련을 위한 기초자료로 활용될 수 있다.

본 연구는 농촌진흥청 반려동물 전주기 사업의 반려동물 행동특성 평가 방법 및 시스템 개발(RS-2023-00232319)의 지원사업에 의해 이루어진 것임.

Key words : dog, behavior, QBA, HR, stress

Advances in audio classification and artificial intelligence for respiratory health and welfare monitoring in swine

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Respiratory diseases are a major challenge in pig farming and can cause serious economic losses if not detected early. Traditional diagnosis relies on visual inspection and laboratory testing, which are time-consuming and often identify problems only after disease has spread. In recent years, artificial intelligence (AI)-based sound analysis has emerged as a promising, non-invasive approach for monitoring pig health by automatically detecting changes in vocalizations such as coughing. This review summarizes recent advances in audio-based monitoring systems for respiratory disease detection and behavior monitoring in pigs, covering microphone technologies, signal processing techniques, machine learning and deep learning models, and on-farm deployment using edge and embedded devices. The strengths, limitations, and practical challenges of current systems are discussed, along with future opportunities for improving accuracy, robustness, and real-time application. AI-driven acoustic monitoring has strong potential to support early disease detection, improve animal welfare, and enhance decision making in modern pig production.

Key words : pig vocalization, respiratory disease, cough detection, audio classification, deep learning

Comparison of popular YOLO's (YOLOv5 & YOLOv8) for the detection of postures, feeding and drinking behaviors of pig

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This study comparatively evaluated two lightweight object detection architectures, YOLOv5s and YOLOv8s, for detecting pig postural (Lateral Lying, Sternal Lying, Standing, and Sitting) and nutritive (Feeding, Drinking, and Not Feeding/Drinking) behaviors. Three detection models were developed: posture detection, feeding and drinking detection, and a combined model integrating both behavior types. Grad-CAM was applied to visualize and compare the key visual features underlying model predictions. For both architectures, task formulation affected performance more strongly than model version. The nutritive model produced the best results (mAP50: 96.0%–96.9%), followed by the posture model (95.7%–96.3%), whereas the combined 10-class model was the most challenging because of greater class overlap and imbalance (78.5%–79.3%). YOLOv8 generally achieved slightly better recall and localization, including the highest average mAP50 in the posture and combined tasks, while YOLOv5 remained highly competitive and even outperformed YOLOv8 for some classes. Grad-CAM analysis confirmed that both detectors relied on biologically meaningful cues that combined global posture with localized head-resource interactions. Overall, this focused comparison shows that upgrading from YOLOv5 to YOLOv8 yields only modest gains unless dataset balance and class design are improved, especially for the integrated multi-behavior setting.

Key words : deep learning, object detection, computer vision, artificial intelligence, precision farming

Farm-scale pig posture and behavior monitoring: a critical review of vision-based technologies

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Monitoring pig behavior and posture is important for animal welfare assessment, early warning of 29 health problems, and productivity optimization in intensive farming systems. This review critically synthesizes recent advances in pig 32 posture detection and behavior analysis, with particular emphasis on digital image processing, machine 33 learning, and deep learning approaches. Current evidence shows a clear transition from conventional 34 feature-based methods to deep-learning-based detection, segmentation, tracking, and temporal analysis 35 frameworks, including CNNs, Faster R-CNN, YOLO variants, Mask R-CNN, and Deep SORT. Deep 36 learning generally provides stronger robustness in complex farm scenes, while RGB cameras remain 37 the most practical sensing option for commercial deployment. However, practical performance remains 38 strongly influenced by dataset design, environmental variability, occlusion, annotation burden, 39 computational constraints, and weak cross-farm generalization. Welfare and activity monitoring appear 40 more mature than disease-specific diagnosis and fully integrated decision-support systems. Emerging 41 directions such as multimodal sensor fusion, explainable artificial intelligence, edge AI, and digital 42 twin-based decision support are also reviewed. The review identifies key research gaps and outlines 43 future directions for scalable, reliable, and welfare-oriented monitoring in pig.

Key words : pig behavior, posture detection, precision livestock farming, computer vision, deep learning

A systematic literature review on the uses, benefits, challenges and prospects of digital twins in livestock farm management

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To facilitate the adoption and integration of Digital twin (DT) technologies in livestock farming systems, this study aims to discern and appraise the most recent advancements by assessing scientific and technological progressions. The objective of this study is to conduct a comprehensive review of the literature to determine the status of DT application in livestock farm management with its benefits, challenges, and prospects. Scientific databases, PRISMA guidelines, and systematic bibliometric methodologies were used for searching and sorting the most fit articles. This study found that DT technology is new to the livestock industry and mainly used for environmental control, feed management, farm planning, greenhouse gas reduction, and behavior monitoring. Key barriers to DT deployment include high establishment costs, risk of market monopolization, and technical knowledge gaps. The application of DT is limited in monitoring animal behavior and farm environment. However, DT technology has the potential for broader use, such as predicting growth, feed consumption, and improving the supply chain. Although these new areas are yet to be explored in real farm conditions. Along with expanding the new area of using DT in livestock farm management, future collaborative research should concentrate on creating new machine learning and/or deep learning models.

Key words : digital twin, animal behavior monitoring, environmental control, farm operation, livestock supply chain

Limitations of combined posture and nutritive behaviors for a comprehensive detection model in group-housed pigs using YOLO architectures

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This study systematically evaluated four lightweight object detection architectures—YOLOv5, YOLOv8, YOLOv9, and YOLOv10—for detecting pig postural and nutritive behaviors. Three models were developed for posture, feeding/drinking, and combined behavior detection. Task formulation influenced performance more than architectural differences. Nutritive models achieved the highest accuracy (mAP50 = 94.1%–95.4%), followed by posture models (90.6%–90.8%), while combined models showed lower performance (80.0%–80.5%) due to increased classification complexity and class imbalance. Standing, Feeding, and Not Feeding/Drinking were detected most reliably, whereas Sitting, Drinking, Sitting Drinking, and Sternal Lying Feeding remained challenging. Grad-CAM analysis confirmed that predictions relied on biologically meaningful visual features. Among the architectures, YOLOv9 achieved the highest overall accuracy, whereas YOLOv5 and YOLOv8 provided superior computational efficiency (> 130 FPS). This study establishes a benchmark for lightweight YOLO-based detectors and provides practical insights for developing reliable, real-time, and comprehensive behavioral monitoring systems in precision livestock farming.

Key words : deep learning, object detection, computer vision, artificial intelligence, precision farming

Computer vision-based detection of agonistic behaviors in pigs: advances and applications for precision livestock farming

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Agonistic behaviors remain major challenges for pig welfare, particularly during the weaning and growing periods. Computer vision (CV) technologies are emerging as scalable tools for non-invasive monitoring of agonistic behaviors. This review summarizes recent advances in CV-based detection of agonistic behaviors in pigs and identifies factors influencing their reliability and commercial adoption. Following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines, a structured search identified 42 eligible studies. Most studies employ deep learning approaches, including you only look once (YOLO)-based detectors and spatio-temporal models, achieving detection accuracy of up to 97% for behaviors such as head knocking, head-to-body pushing, and tail biting, typically evaluated under controlled conditions using mAP@0.5. Three key findings emerged: rapid progress in deep learning-based detection; methodological heterogeneity in behavioral definitions, validation strategies, and annotation protocols; and a gap between high detection accuracy and demonstrated improvements in welfare or productivity. Progress is limited by scarce cross-farm validation, inconsistent bout definitions, reliance on manual annotations, and weak integration with physiological and production indicators. Future research should prioritize multimodal integration, predictive modeling, and rigorous external validation.

Key words : agonistic behaviors, computer vision, precision livestock farming, pig welfare, deep learning

Effects of construction noise stress on growth performance and behavior in growing pigs

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Construction noise is a major environmental stressor around pig farms and may impair pig productivity and welfare. Growing pigs are particularly vulnerable to environmental disturbance because of rapid growth and high physiological demand. This study evaluated the effects of construction noise on growth performance and behavior in growing pigs under practical farm conditions. Growing pigs exposed to construction noise showed significantly reduced growth performance compared with the control group. Final body weight decreased by 5.93 kg (9.98%), average daily gain decreased by 23.08%, and feed conversion ratio worsened by 36.10% ($p < 0.05$). Behavioral analysis also indicated increased instability under noise exposure, with changes in posture, feeding activity, and aggressive behavior patterns during the noise application period. These findings indicate that construction noise can act as a substantial environmental disturbance during the growing phase, impairing both growth efficiency and behavioral stability. Therefore, construction-related noise should be carefully managed in pig production systems, particularly during the growing period when animals are more susceptible to environmental stress.

Key words : construction noise, growing pigs, noise stress, growth performance, behavior