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2023 Annual International Conference of KSAST

"저탄소 친환경 축산"
Low Carbon to become environment-friendly Animal Industry

광주 김대중컨벤션센터
2023년 7월 5일(수)~7일(금)

- 주 최 : (사)한국축산학회
- 공동주관 : (사)한국축산학회, 국립축산과학원, 서울대학교 축산과학기술연구소
- 후 원 : 한국과학기술단체총연합회, (재)광주관광재단, 한국관광공사
- 협 찬 : (주)카길애그리퓨리나, (주)이지홀딩스, (주)정농바이오, 농협경제지주 축산경제, (주)hy, 김유용 교수, (주)우진B&G, 일동바이오사이언스(주), 축산환경관리원, (주)에이피엠엔지니어링, 한우자조금관리위원회, CJ BIO, CJ Feed&Care(주), 지더블유바이테크(주), (주)동곡기정, (사)대한한돈협회, (주)농심, 풀무원다논(주)

(사) 한 국 축 산 학 회
Korean Society of Animal Science and Technology

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- 후 원 : 한국과학기술단체총연합회, (재)광주관광재단, 한국관광공사
- 협 찬 : (주)카길애그리퓨리나, (주)이지홀딩스, (주)정농바이오, 농협경제지주 축산경제, (주)hy, 김유용 교수, (주)우진B&G, 일동바이오사이언스(주), 축산환경관리원, (주)에이피엠엔지니어링, 한우자조금관리위원회, CJ BIO, CJ Feed&Care(주), 지더블유바이텍(주), (주)동곡기정, (사)대한한돈협회, (주)농심, 풀무원다논(주)

(사) 한 국 축 산 학 회
Korean Society of Animal Science and Technology

인 사 말 씀

안녕하십니까?

2023년 한국축산학회 정기학술대회에 오신것을 환영합니다. 한국축산학회는 지난 2022년 코로나 펜데믹이 끝나지 않았음에도 불구하고 제19차 아세아태평양축산학회를 성공적으로 개최하여 우리나라의 앞선 축산 연구와 기술을 재확인하였습니다. 그동안의 정기학술대회는 매년 전국 대학을 순회하며 개최하였으나, 이제 규모가 확장된 시설과 학술발표로 빛고을 광주 김대중컨벤션센터에서 여러분을 맞이합니다.

이번 정기학술대회의 키워드는 탄소저감 입니다. 기조강연을 맡아주신 연사님들이 이 주제와 관련된 내용을 발표해 주실 것입니다. 현재 축산에 대하여 잘못되고 과장된 탄소 배출 문제가 금번 학술대회를 통하여 바로 잡아 축산이 환경을 살리면서 나아가 국민 먹거리에 기여한다는 점이 올바르게 알려지길 희망합니다. 우리 축산분야 학자들과 학문 후속 세대들이 탄소저감에 대한 과학적인 실마리를 찾는데 도움이 될 것이라 생각됩니다.

학술대회에 적극적으로 참여해주신 학회 회원님들과 이사님, 그리고 학회 실무진 여러분께 감사드립니다. 또한 이번 학술대회를 전폭적으로 지원해 주시고 후원해 주신 광주관광재단과 강기정 광주광역시장님, 축산과학원 박범영 원장님, 그리고 학회 후원을 해주신 많은 분들께 감사의 말씀을 드립니다.

Greetings and welcome to the 2023 International Symposium & Annual Meeting of Korean Society of Animal Sciences & Technology (KSAST).

Despite the hard conditions we had the past 3 years of Covid-19, Korea's advanced animal science research remains stronger than ever and successfully hosted the 19th AAAP Animal Science Congress in 2022. We proudly welcome you to the expanded facilities venue of academic presentations at the Gwangju Kim Dae-jung Convention Center. In the past, the annual meetings were hosted by a diverse network of universities within Korea.

Given this years theme keyword, "Low Carbon," the keynote speakers will give presentations on this subject. Through this KSAST Annual Meeting, we hope to dispel myths and exaggerations about carbon emissions in animal husbandry and inform the public that the animal industry can contribute to the preservation of the environment while also providing produce for the nation. Additionally, we believe that this meeting will assist the members of the Korean Society of Animal Sciences and future generations of scholars in discovering scientific clues for carbon reduction.

This KSAST Annual Meeting would not have been possible without the extraordinary efforts of the Program Committee, volunteers, and sponsors. Also, many thanks to the GJTO and Kang Ki-jung, the Mayor of Gwangju City, for their assistance in creating a successful meeting and extended thanks to all our session chairs, speakers, presenters, and exhibitors.

2023년 7월

(사)한국축산학회 회장

오 세 종

환 영 사

2023년 한국축산학회 학술발표회가 우리 광주에서 열리게 된 것을 매우 뜻깊게 생각하며 축하드립니다.

광주를 찾아주신 모든 분께 감사와 환영의 인사를 드립니다. 더불어 행사준비에 애써주신 한국축산학회 오세종 회장님을 비롯한 학회원과 관계자 여러분께도 감사의 마음을 전합니다.

우리 광주는 지난해 말부터 최근까지 유례없는 가뭄위기를 겪으면서 기후위기의 심각성과 탄소중립사회로의 전환에 대한 필요성을 절감했습니다. 그래서 이번 학술발표회의 주제인 '저탄소 친환경 축산'에 대한 논의에 많은 관심을 갖고 이를 정책적으로 담아낼 방법을 깊게 고민할 것입니다.

우리 광주의 축산업 규모는 그리 크지 않지만, 육류 소비가 증가하면서 전국적으로 축산업이 확대되고 있습니다. 장점도 있지만, 그에 따른 위생과 환경문제에 대한 대책도 필요해 보입니다.

소 한 마리에서 발생하는 연 평균 메탄가스 배출량이 소형차 1대의 배출량과 같습니다. 저탄소 친환경 축산으로의 전환이 시급한 이유입니다.

우리시는 정부와 함께 지속 가능한 축산환경 조성을 위해 깨끗한 축산농장 지정, 적정사육두수 관리, 메탄 발생 저감사료 개발 보급, 가축분뇨 퇴·액비화 등 다양한 정책을 마련해 시행하고 있습니다.

앞으로 더 나은 대안과 방안을 마련해 가는데 이번 학술발표회가 큰 도움이 될 것으로 생각합니다.

풍성한 논의를 기대합니다. 광주에 계시는 동안 광주가 가진 맛과 멋도 마음껏 즐기시기 바랍니다.

감사합니다.

2023년 7월

광주광역시 시장

강 기 정

축 사

여러분 반갑습니다.

2023년 한국축산학회의 학술발표회 개최를 진심으로 축하드립니다.

한국축산학회는 1956년 10월 창립 하여 67년의 역사를 가진 우리나라 축산분야의 대표 학회입니다. 학회 설립 이후 지금까지 우리나라 축산업의 성장과 발전을 함께해 왔습니다.

한국농촌경제연구원의 농업전망에 따르면 축산업 생산액은 2021년 기준 약 24조 6천억 원으로 농업 생산액의 약 41.5%를 차지하고 있습니다. 또한 국내 육류 소비 증가와 가격 상승으로 2032년에는 28조 7,410억 원에 이르고, 농업 생산액 중 축산업의 비중은 45%까지 확대될 것으로 전망하고 있습니다.

하지만 이러한 성장 전망에도 현재 축산업의 상황은 안도할 수 없습니다. 우리 앞에는 기후변화 가속화, 고령화, 악성 가축질병의 상시 발생, 시장 개방 확대 등 많은 어려움이 놓여 있습니다. 또한 소비자들은 더 이상 생존을 위해서 식품을 섭취하기보다 탄소중립, 친환경, 동물복지 등을 고려하고 윤리와 가치를 담아 소비하는 경향이 늘어나고 있기 때문입니다.

이렇게 중요한 시점에'저탄소 친환경 축산'을 주제로 심도 있는 논의를 할 수 있게 자리를 마련하신 한국축산학회 오세종 회장님을 비롯한 임직원 및 관계자 여러분께 감사드립니다.

최근 미 FDA 및 농무성은 유전자편집기술로 생산된 돼지고기와 연어고기 그리고, 세포 배양으로 생산된 닭고기 시판을 승인했습니다. 축산업에 주어진 난제 해결에 이러한 다양한 과학기술의 접목이 필요합니다. 한국축산학회 회원 여러분들의 역할이 간절히 요구되는 시기입니다.

국립축산과학원에서도 축산분야 온실가스 배출량 산정에 필요한 축종별 국가고유 배출계수 개발과, 반추가축 메탄 저감 사료 개발, 저탄소 사양관리 등 연구를 지속해오고 있습니다. 또한 축산 냄새 저감 기술과 가축분뇨의 비농업계 이용 확대를 위한 기술 개발에도 연구 역량을 집중하고 있습니다.

'저탄소 친환경 축산'의 실현은 학계와 산업계, 정책기관이 모두 힘을 모으고 축산농가와의 공감대 형성이 되어야 가능할 것입니다.

오늘 종합학술대회 자리에서 최근 부각되고 있는 저탄소 축산물 생산, 환경 친화적인 축산물 생산과 관련된 최신기술들을 공유하고, 우리나라 축산업 발전방향을 모색하는 장이 되기를 기원합니다.

끝으로 축산업 발전을 위해 밤낮으로 애쓰시는 회원님들의 노고에 다시 한 번 감사드리며, 여러분 가정에 늘 행복이 충만하시길 기원합니다. 감사합니다.

2023년 7월

국립축산과학원 원장

박 범 영

행사장 안내도

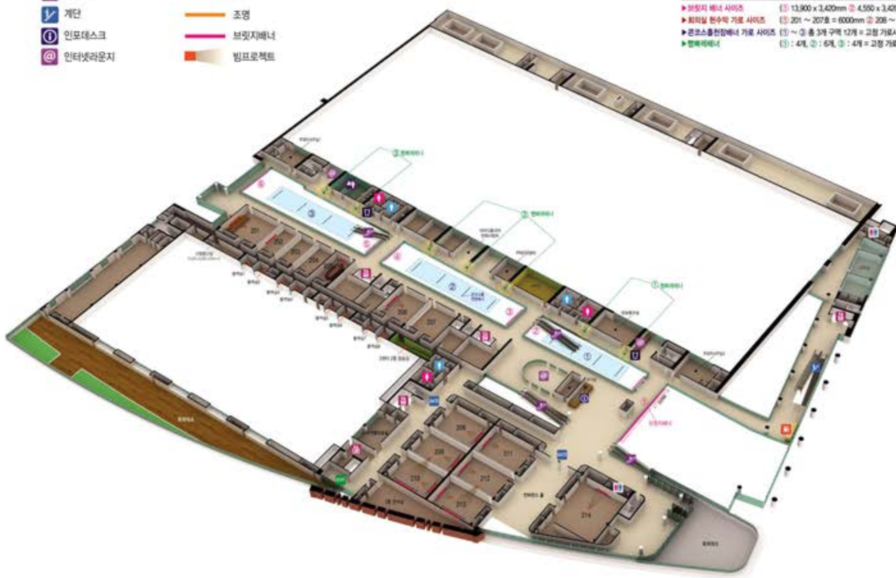
김대중컨벤션센터 **1층**

김대중컨벤션센터 2층

- GATE 출입구
- 화장실
- 남자화장실
- 여자화장실
- 엘리베이터
- 화물용 엘리베이터
- 에스컬레이터
- 계단
- 인포데스크
- 인터넷라운지
- 비즈니스 센터
- 물건보관소
- (고정)정수기 위치
- EXIT 비상구
- 홀 나눔 칸막이
- 스크린
- 현수막봉
- 조명
- 브릿지배너
- 빔프로젝트

구분	Room No.	회의실 규격 (가로 x 세로 x 높이)	설치 빔프로젝터 (ANSI)	전동스크린	Room No.	회의실 규격 (가로 x 세로 x 높이)	설치 빔프로젝터 (ANSI)	전동스크린
중소회의실	201	12,130 x 9,630 x 4,200	4500ANSI	150"	208	11,300 x 8,120 x 4,200	6000ANSI	180"
	202	5,840 x 9,630 x 4,200	–	120"	209	11,300 x 8,120 x 4,200	6000, 8600ANSI	180"
	203	5,840 x 9,630 x 4,200	–	–	210	11,300 x 8,120 x 4,200	6000ANSI	180", 200"
	204	5,990 x 9,630 x 4,200	–	–	211	11,300 x 8,120 x 4,200	6000ANSI	180"
	205	5,730 x 9,630 x 4,200	4500ANSI	150"	212	11,300 x 8,120 x 4,200	6000, 6600ANSI	180"
	206	8,790 x 9,630 x 4,200	4500ANSI	150"	213	11,300 x 8,120 x 4,200	6000ANSI	180", 200"
	207	8,790 x 9,630 x 4,200	–	–	214	11,620 x 13,550 x 4,200	6000ANSI	200"

▶브릿지 배너 사이즈 (① 13,900 x 3,420mm ② 4,550 x 3,420mm ③ 7,000 x 3,420mm ④ 7,000 x 3,420mm ⑤ 6,250 x 3,420mm ⑥ 9,900 x 3,420mm)
▶회의실 현수막 가로 사이즈 (① 201 ~ 207호 = 6000mm ② 208 ~ 214호 = 5000mm)
▶컨코스홀천장배너 가로 사이즈 (① ~ ③ 총 3개 구역 12개 = 고정 가로사이즈 900mm)
▶행복께배너 (① : 4개, ② : 6개, ③ : 4개 = 고정 가로사이즈 500mm)



김대중컨벤션센터 4층

- GATE 출입구
- 화장실
- 남자화장실
- 여자화장실
- 엘리베이터
- 화물용 엘리베이터
- 에스컬레이터
- 계단
- (고정)정수기 위치
- 인터넷라운지
- 구내전화
- 물품보관소
- 홀 나눔 칸막이
- 스크린
- 현수막봉
- 조명
- 빔프로젝트

구분	규격	구분	규격
빔프로젝터(ANSI)	10,000ANSI(2층 방송실) 7,000ANSI(이동식)	현수막 사이즈	15,000 x 900mm
전동식스크린	400"	통천 사이즈(스크린 뒤쪽으로)	12,000 x 7,000mm
무대 사이즈	15,000 x 6,000 x 900mm	※컨벤션 홀 분할 사용시 이동식 빔프로젝터 및 스크린 별도문의	

목　차

학술대회 전체일정표

◆ **광주 김대중컨벤션센터 컨벤션홀 (4층)**

2023년 7월 5일 (수)

시간 \ 장소	김대중컨벤션센터 컨벤션홀 (4층)	
14:00 ~	등록 및 접수 (2층)	
15:00~15:20	개회사 : 오 세 종 (한국축산학회장) 환영사 : 강 기 정 (광주광역시장) 축　사 : 박 범 영 (국립축산과학원장)	
15:20~16:20	Plenary Lecture 1	
	김유용 교수 (서울대학교)	저단백질 양돈사료의 이용과 탄소중립
16:20~17:20	학회 시상 및 수상자 특강	
16:20~17:20	축산 관련 학과 학과장 간담회(주관: 국립축산과학원, 3층 307호)	
18:00~	축산 기업과의 소연(小宴) (홀리데이인호텔 3층 컨벤션1)	

2023년 7월 6일 (목)

시간 \ 장소	김대중컨벤션센터 컨벤션홀 (4층)			
	208호 (2층)	214호 (2층)	209호 (2층)	212호 (2층)
08:00~	등록접수			
08:30~09:00	포스터 부착(08:30까지) *주의: 포스터 게시시간 엄수 (08:30~16:50)			
	Plenary Lecture 2 (컨벤션홀, 4층)　　좌장: 길동용 교수 (중앙대학교)			
09:00~09:50	Dr. Mingan Choct (Univ. of New England, 호주)		Sustainable feed formulation for poultry	
10:00~12:30	마연구회 세션	영양사료 연구회세션	동물마이크로바이옴 연구회세션	JAST 학술윤리세션
12:30~13:20	정기총회 (컨벤션홀, 4층)			
12:30~13:30	점심식사 (점심 미제공, *상품권 대체)			
	Plenary Lecture 3 (컨벤션홀, 4층)　좌장: 김민석 교수 (전남대학교)			
13:30~14:20	Dr. Frances Cowley (Univ. of New England, 호주)		Triumphs and troubles in trying to reduce enteric methane from ruminants	
14:20~15:00	휴　식 (Coffee Break) 포스터발표회(Ⅰ): 우수포스터 심사 (장소: 4층 로비)			
15:00~17:00	카길 애그리퓨리나 세션 (컨벤션홀, 4층)　　좌장: 윤진현 교수(전남대학교)			
	김정훈 박사 (카길애그리퓨리나 지속가능경영본부장) 김동혁 박사 (카길애그리퓨리나 양돈연구기술부장) 오준표 박사 (카길애그리퓨리나 축우연구기술부장)		친환경 지속가능 경영 소개 지속가능축산을 위한 양돈연구 저메탄사료 개발과 산업에의 적용	

시간	구두발표 I						
	208호(2층)	209호(2층)	210호(2층)	211호(2층)	212호(2층)	213호(2층)	214호(2층)
15:00~15:50	단위영양 (i) 좌장 송민호 교수	단위영양 (ii) 좌장 조진호 교수	단위영양 (iii) 좌장 공창수 교수	동물생명 공학 좌장 홍석만 박사	조지 및 환경 좌장 안희권 교수	축산물 이용 및 가공 좌장 정사무엘 교수	반추영양 좌장 서자겸 교수
16:00~16:50							번식 및 생리 좌장 이영주 교수

2023년 7월 7일 (금)

장소 / 시간	김대중컨벤션센터 컨벤션홀 (4층)						
08:00~	등록접수						
08:00~09:30	*주의: 포스터 게시시간 엄수 (08:30~15:00)						
09:30~12:00	신진과학자 세션 좌장: 김현범 교수 (단국대학교)						
	용해인 교수 (충남대학교)	식육 및 식육가공품 내 대기압플라즈마의 적용					
	장재철 교수 (경상국립대학교)	정밀 사료 공급과 지속 가능한 양돈 생산					
	김종혁 교수 (충북대학교)	고온 및 밀집 사육 스트레스에 노출된 육계의 스트레스 저감 및 장벽 기능 강화를 위한 기능성 사료 물질 개발					
12:00~13:00	점심식사 (점심 미제공, *상품권 대체)						
13:00~13:50	구두발표 II						
	208호(2층)	209호(2층)	210호(2층)	211호(2층)	212호(2층)	213호(2층)	214호(2층)
	단위영양(ⅰ) 좌장 김종혁 교수	단위영양(ⅱ) 좌장 장재철 교수	단위영양(ⅲ) 좌장 최정석 교수	동물생명 공학 좌장 오상현 교수	초지 및 환경 좌장 김진수 교수	축산물 이용 및 가공 좌장 용해인 교수	반추영양 좌장 김명후 교수
13:50~15:00	휴 식 (Coffee Break) 포스터발표회(II): 우수포스터 심사 (장소: 4층 로비)						
15:30~16:00	시상 및 폐회식 (컨벤션홀 4층)						

[2023 Annual International Conference of KSAST]

Date: July 5 (Wed) - 7 (Fri), 2023
Place: Kimdaejung Convention Center, Gwangju
Theme: "Low carbon to become environment-friendly animal industry"

Wednesday, July 5 2023

Place / Time	Kimdaejung Convention Center, Convention hall (4F)	
14:00 ~	Registration/reception (2F)	
15:00~15:20	Opening Speech : Sejong Oh (President of KSAST) Welcoming Speech : Kang Ki-jung (Mayor of Gwangju) Congratulatory Address : Beomyoung Park (President of NIAS)	
15:20~16:20	Plenary Lecture 1	
	Prof. Yoo Yong Kim (Seoul National University)	Utilization of Low-Protein Swine Feed and Carbon Neutral
16:20~17:20	The grand prize winner's presentation	
16:20~17:20	Discussion session with heads of animal science departments Hosted by NIAS Rm. 307 (3F)	
18:00~	Welcome Reception with livestock companies (Convention hall 1, 3F, Hotel Holiday Inn)	

Thursday, July 6 2023

Time \ Place	Kimdaejung Convention Center, Convention hall (4F)			
	Rm. 208	Rm. 214	Rm. 209	Rm. 212
08:00~	Registration/reception (2F)			
08:30~09:00	Poster Setup (until 08:30) *Posters must be set between 08:30 AM ~ 16:50 AM			
	Plenary Lecture 2 Convention hall (4F)			
09:00~09:50	Dr. Mingan Choct (Univ. of New England, Australia)		Sustainable feed formulation for poultry	
10:00~12:30	Horse Research Association	Nutritional Feed Research Association	Microbiome Research Association	JAST Editorial Meeting
12:30~13:20	Regular General meeting Convention hall (4F)			
12:30~13:30	Break Time (Lunch not provided, *Receipt of gift certificates)			
	Plenary Lecture 3 Convention hall (4F)			
13:30~14:20	Dr. Fran Cowley (Univ. of New England, Australia)		Triumphs and troubles in trying to reduce enteric methane from ruminants	
14:20~15:00	Break Time Poster Presentation Ⅰ : Poster review (Lobby, 4F)			

Time	Cargill Agri Purina session Convention hall (4F)	
15:00~17:00	Dr. Kim, Jeong-Hoon (Cargill Agri Purina Director of Sustainable Management)	Introducing eco-friendly sustainable management
	Dr. Dong Hyuk Kim (Cargill Agri Purina Director of Swine Research and Technology)	Swine Research for Sustainable Livestock Farming
	Dr. Joonpyo Oh (Cargill Agri Purina Director of Cattle Research and Technology)	Development and Application of Low-Methane Feed in the Industry

Time	Oral Presentation Ⅰ						
	Rm. 208 (2F)	Rm. 209 (2F)	Rm. 210 (2F)	Rm. 211 (2F)	Rm. 212 (2F)	Rm. 213 (2F)	Rm. 214 (2F)
15:00~15:50	Monogastric Nutrition (i)	Monogastric Nutrition (ii)	Monogastric Nutrition (iii)	Animal Biotechnology	Forage Science and Environment	Utilization and Processing of Livestock Products	Ruminant Nutrition
16:00~16:50							Reproduction and Physiology

Friday, July 7 2023

<table>
<tr><th>Place / Time</th><th colspan="7">Kimdaejung Convention Center, Convention hall (4F)</th></tr>
<tr><td>08:00~</td><td colspan="7">Registration/reception (2F)</td></tr>
<tr><td>08:00~09:30</td><td colspan="7">Poster Setup (until 08:30)
*Posters must be set between 08:30 AM ~ 16:50 AM</td></tr>
<tr><td rowspan="4">09:30~12:00</td><td colspan="7">Young scientist session</td></tr>
<tr><td colspan="3">Prof. Hae In Yong
(Chungnam National University)</td><td colspan="4">Application of Atmospheric Pressure Plasma in Meat and Meat Processed Products</td></tr>
<tr><td colspan="3">Prof. Jaecheol Jang
(Gyeongsang National University)</td><td colspan="4">Precision Feeding and Sustainable Swine Production</td></tr>
<tr><td colspan="3">Prof. Jonghyuk Kim
(Chungbuk National University)</td><td colspan="4">Development of Functional Feed Ingredients for Stress Reduction and Barrier Function Enhancement in Broilers Exposed to High Temperature and Crowded Conditions</td></tr>
<tr><td>12:00~13:00</td><td colspan="7">Break Time
(Lunch not provided, *Receipt of gift certificates)</td></tr>
<tr><td rowspan="3">13:00~13:50</td><td colspan="7">Oral Presentation Ⅱ</td></tr>
<tr><td>Rm. 208
(2F)</td><td>Rm. 209
(2F)</td><td>Rm. 210
(2F)</td><td>Rm. 211
(2F)</td><td>Rm. 212
(2F)</td><td>Rm. 213
(2F)</td><td>Rm. 214
(2F)</td></tr>
<tr><td>Monogastric Nutrition (ⅰ)</td><td>Monogastric Nutrition (ⅱ)</td><td>Monogastric Nutrition (ⅲ)</td><td>Animal Biotechnology</td><td>Forage Science and Environment</td><td>Utilization and Processing of Livestock Products</td><td>Ruminant Nutrition</td></tr>
<tr><td>13:50~15:00</td><td colspan="7">Break Time
Poster PresentationⅡ : Poster review (Lobby, 4F)</td></tr>
<tr><td>15:30~16:00</td><td colspan="7">The Grand Prize winner's Presentation & Closing Ceremony
Convention hall (4F)</td></tr>
</table>

Poster Presentation Ⅰ

Thursday, July 6 2023 14:20~15:00(Convention hall : Lobby, 4F)

Date	Section	Number	Poster No.
6 (Thur)	Monogastric Nutrition	24	PA23001 ~ PA23024
	Animal Biotechnology	16	PB23001 ~ PB23016
	Ruminant Nutrition	23	PC23001 ~ PC23023
	Reproduction and Physiology	9	PD23001 ~ PD23009
	Breeding and Genetics	7	PE23001 ~ PE23007
	Forage Science and Environment	22	PF23001 ~ PF23022
	Utilization and Processing of Livestock Products	5	PG23001 ~ PG23005
	Total	106	

Poster Presentation Ⅱ

Friday, July 7 2023 13:50~15:00(Convention hall : Lobby, 4F)

Date	Section	Number	Poster No.
7 (Fri)	Monogastric Nutrition	23	PA23025 ~ PA23048
	Animal Biotechnology	16	PB23017 ~ PB23032
	Ruminant Nutrition	24	PC23024 ~ PC23047
	Reproduction and Physiology	10	PD23010 ~ PD23019
	Breeding and Genetics	7	PE23008 ~ PE23014
	Forage Science and Environment	22	PF23023 ~ PF23044
	Utilization and Processing of Livestock Products	5	PG23006 ~ PG23010
	Total	107	

Oral Presentation Ⅰ

Thursday, July 6 2023 15:00~16:50 (Kimdaejung Convention Center : 2F)

※ 10min per each presenter / Q&A (5min)

Date	Section	Number	Oral presentation No.
6 (Thur)	Monogastric Nutrition	19	OA23001 ~ OA23019
	Animal Biotechnology	7	OB23001 ~ OB23007
	Ruminant Nutrition	4	OC23001 ~ OC23004
	Reproduction and Physiology	4	OD23001 ~ OD23004
	Forage Science and Environment	6	OF23001 ~ OF23004, OF23007, OF23008
	Utilization and Processing of Livestock Products	6	OG23001 ~ OG23006
	Total	46	

Oral Presentation Ⅱ

Friday, July 7 2023 13:00~13:50 (Kimdaejung Convention Center : 2F)

※ 10min per each presenter / Q&A (5min)

Date	Section	Number	Oral presentation No.
7 (Fri)	Monogastric Nutrition	10	OA23020 ~ OA23029
	Animal Biotechnology	4	OB23008 ~ OB23011
	Ruminant Nutrition	3	OC23005 ~ OC23007
	Reproduction and Physiology	4	OF23005, OF23006, OF23009, OF23010
	Forage Science and Environment	3	OG23007 ~ OG23009
	Total	24	

The grand prize winner's presentation & Closing

- Date : Friday, July 7 2023 15:30
- Place : Convention hall, 4F
- Award : Sejong Oh (President of KSAST)
- Participants : all members and winner (prize draw event)

※ The oral presentation and poster presenters will have an award ceremony in the order of the closing ceremony, so please attend (No proxy award is available, and if the winner is absent, the next winner will be awarded).

세부 일정 (7월 5일)

종 합 심 포 지 엄

2023년 7월 5일(수) 14:00~18:00

주 제: 저탄소 친환경 축산
Low Carbon to become environment-friendly Animal Industry

시 간	개회식 및 시상식	
14:00 ~	등록 및 접수	
15:00~15:20	개회사 : 오 세 종 (한국축산학회장) 환영사 : 강 기 정 (광주광역시장) 축 사 : 박 범 영 (국립축산과학원장)	
15:20~16:20	Plenary Lecture 1	
	김유용 교수 (서울대학교)	저단백질 양돈사료의 이용과 탄소중립
16:20~17:20	학회 시상 및 수상자 특강	
16:20~17:20	축산 관련 학과 학과장 간담회(주관: 국립축산과학원, 3층 307호)	
18:00~	축산 기업과의 소연(小宴) (홀리데이인호텔 3층 컨벤션1)	

세부 일정 (7월 6일)

한국축산학회 산하 연구회 행사

2023년 7월 6일(목) 10:00~12:30

1. 마연구회

- **주 제 : 국내 말(馬) 과학 분야별 연구 성과**

사회 : 박정웅 박사 (경북대학교, 마연구회 학술위원장)

09:00~10:00	등 록	
10:00~10:10	개 회 / 회장인사 (회장: 윤민중 교수)	
연 사 및 제 목		
10:10~10:40 (20분 발표/ 10분 질의 응답)	최연주 (경북대학교)	Effects of training program and human-horse interaction on behavioral changes in young horses
10:40~11:10 (20분 발표/ 10분 질의 응답)	박정웅 (경북대학교)	Molecular biological analysis to investigate muscle injury recover related gene in horse derived cell
11:10~11:40 (20분 발표/ 10분 질의 응답)	유지현 (농촌진흥청)	말 방목 효과 및 초지 이용기간 증진 방법
11:40~12:10 (20분 발표/ 10분 질의 응답)	정용욱 (경북대학교)	Gentle rubbing induces hormone level-related pair bonding and stress relief in receiving horses and giving women
12:10~12:30	종 합 토 론 및 폐 회	

2. 영양사료연구회

● **주 제 : 영양사료 기술과 산업**

사회 : 김법균 교수 (건국대학교)

09:00~09:50	등 록	
10:10~10:20	개 회 / 회장인사 (회장: 김유용 교수)	
	연 사 및 제 목	
10:20~11:00	백명기 (서울대학교)	한우 산업의 현황과 전망 및 근내지방 축적 조절 방안
11:00~11:40	김상호 (케이애니웰)	산란계 사육시스템과 영양
11:40~12:20	김동혁 (카길애그리퓨리나)	분만전후 모돈의 전환기 관리
12:20~12:40	종합토론 및 폐 회	

3. 동물마이크로바이옴연구회

● **주 제 : 동물마이크로바이옴을 활용한 축산의 새로운 도약**

사회 : 김영훈 교수 (서울대학교)

09:00~10:00	등 록	
10:00~10:10	개 회 / 회장인사 (회장: 이상석 교수)	
	연 사 및 제 목	
	좌장: 김종남 교수 (동서대학교)	
10:10-10:45	최양호 교수 (국립경상대학교)	Effects of nutritional and environmental conditions on broiler growth and cecal metagenome
10:45-11:20	김기현 박사 (국립축산과학원)	Pet nutrition and microbiome
11:20-11:55	김현범 교수 (단국대학교)	Understanding the pig microbiome: Principles & Applications
11:55~12:30	종 합 토 론 및 발전방안 토의	

포스터발표회 I

2023년 7월 6일(목) 14:20~15:00 (컨벤션홀: 4층 로비)

발표일	분 야	편 수	포 스 터 NO.
6일 (목)	단위영양	24	PA23001 ~ PA23024
	동물생명공학	16	PB23001 ~ PB23016
	반추영양	23	PC23001 ~ PC23023
	번식 및 생리	9	PD23001 ~ PD23009
	유전 및 육종	7	PE23001 ~ PE23007
	초지 및 환경	22	PF23001 ~ PF23022
	축산물이용 및 가공	5	PG23001 ~ PG23005
	소계	**106**	

구두발표회 I

2023년 7월 6일(목) 15:00~16:50 (김대중컨벤션센터: 2층)

※ 발표자 1인당 10분 발표 / 5분 질의 및 응답

발표일	분 야	편 수	구두발표 NO.
6일 (목)	단위영양	19	OA23001 ~ OA23019
	동물생명공학	7	OB23001 ~ OB23007
	반추영양	4	OC23001 ~ OC23004
	번식 및 생리	4	OD23001 ~ OD23004
	초지 및 환경	6	OF23001 ~ OF23004, OF23007, OF23008
	축산물이용 및 가공	6	OG23001 ~ OG23006
	소계	**46**	

세부 일정 (7월 7일)

신진 과학자 특강

2023년 7월 7일(금) 09:30~12:00

좌장: 김현범 교수 (단국대학교)		
시 간	연 사	제 목
09:30~10:10	용해인 교수 (충남대학교)	식육 및 식육가공품 내 대기압플라즈마의 적용
10:10~11:00	장재철 교수 (경상국립대학교)	정밀 사료 공급과 지속 가능한 양돈 생산
11:00~12:00	김종혁 교수 (충북대학교)	고온 및 밀집 사육 스트레스에 노출된 육계의 스트레스 저감 및 장벽 기능 강화를 위한 기능성 사료 물질 개발

구두발표회 II

2023년 7월 7일(금) 13:00~13:50 (김대중컨벤션센터: 2층)

※ 발표자 1인당 10분 발표 / 5분 질의 및 응답

발표일	분 야	편 수	구두발표 NO.
7일 (금)	단위영양	10	OA23020 ~ OA23029
	동물생명공학	4	OB23008 ~ OB23011
	반추영양	3	OC23005 ~ OC23007
	초지 및 환경	4	OF23005, OF23006 OF23009, OF23010
	축산물이용 및 가공	3	OG23007 ~ OG23009
	소계	**24**	

포스터발표회 II

2023년 7월 7일(금) 13:50~15:00 (컨벤션홀: 4층 로비)

발표일	분 야	편 수	포 스 터 NO.
7일 (금)	단위영양	23	PA23025 ~ PA23048
	동물생명공학	16	PB23017 ~ PB23032
	반추영양	24	PC23024 ~ PC23047
	번식 및 생리	10	PD23010 ~ PD23019
	유전 및 육종	7	PE23008 ~ PE23014
	초지 및 환경	22	PF23023 ~ PF23044
	축산물이용 및 가공	5	PG23006 ~ PG23010
	소계	**107**	

발표논문시상식 및 폐회식

- 일 시 : 2023년 7월 7일(금) 15:30
- 장 소: 컨벤션홀 4층
- 시 상 : 오세종 한국축산학회장
- 대 상: 전 회원 및 수상자(경품추첨행사)

※ 구두발표 및 포스터 발표자는 폐회식순에 시상식이 있으니 전원 참석하여 주시길 부탁드립니다.
(대리수상은 불가하며 수상자가 불참 시, 차 순위자에게 시상합니다)

2023년도 Plenary Lecture

저단백질 양돈사료의 이용과 탄소중립
Utilization of Low Protein Swine Feed and Carbon Neutrality

김 유 용
Kim, Yoo Yong
(서울대학교)
(Seoul National University)

Curriculum Vitae

- 2001~현재 서울대학교 식품동물생명공학부 교수
- 2022~현재 ㈜사조동아원 사외이사
- 2014~현재 양돈수급조절협의회 위원장
- 2012~현재 부경양돈농협 기술자문관
- 2022~2022 (사)한국축산학회 회장
- 2020~2022 아세아태평양 축산학회 회장
- 2015~2019 농협중앙회 경제사업 평가위원
- 2006~2012 ㈜팜스코 및 도드람양돈농협 사외이사
- 1994~1999 오하이오주립대학교 박사
- 1983~1990 서울대학교 축산학과 학사, 석사

The Low Protein Policies and Measures in Domestic Pig Feed

2023. 07. 05.

Yoo Yong Kim

Seoul National University

Contents

Low Protein in Pig Feed

- **In Korea, the need for economic feed for pigs has been claimed since 2006**
  - → CP is 4-6% higher than in the EU, a leading pig farming countries
- **The government has proposed a carbon neutral-policy direction to reduce greenhouse gas emissions**
  - → 24.4% reduction in 2030 compared to 2017, carbon neutrality by 2050
  - → GHG emissions from agriculture account for 3% of the total and livestock 1.35%
- **Report to the Blue House on low-carbon, low-methane feed from the Ministry of Agriculture, Food and Rural Affairs in early**
  - → Start of low protein feed development project by livestock species (2021, IPET)
  - → Low-protein feed process standards starting with pig feed (2022.7)
  - → Incentives are also being considered for the use of low-methane and low-protein feeds in the future
- **The government is investing in various research funds for the development of low-methane feed**
  - → Over the past 30 years, 3-NOP was the only achievement

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The Total Greenhouse Gas Emissions and Reduction Targets by Country

Class	Target Year	NDC ratio	2030 target emission	2010~2030 reduction goal		2018~2030 reduction goal	
				2010 total emission	Reduction rate	2018 total emission	Reduction rate
U.S.	2005 2030	50~ 52%	3,548~ 3,696	6,991	47.1~ 49.2%	6,671	44.6~ 46.8%
U.K.	1990 2030	68%	255	609	58.1%	467	45.3%
EU	1990 2030	55%	2,542	4,780	46.8%	4,223	39.8%
Canada	2005 2030	40~ 45%	401~ 438	703	37.7~ 42.9%	728	39.9~ 44.9%
Japan	2013 2030	46%	760	1,300	41.5%	1,245	38.9%
Korea	2018 2030	35%	473	656	27.9%	728	35%

(Ministry of Environment, 2020)

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Low Protein and Methane Diet

- **Excretion of excess protein that cannot be used by the body is a problem**
  - ➔ Reduction of protein in pig and chicken feed
  - ➔ Reducing excess protein in feed alleviates feed costs as well as odor
- **Nitrogen (N) discharged in manure is the cause of nitrous oxide (N_2O)**
  - ➔ Causes global warming through various pathways
  - ➔ Approximately 310 times more potent than carbon dioxide (CO_2)
- **Development of feed for methane reduction in ruminants**
  - ➔ Attempt to reverse ruminant physiology
  - ➔ It has been studied for a long time, but there are no tangible results
- **An attempt has been made to develop a feed additive for methane reduction with brown algae**

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Variation Table for Global Warming Potential

CV between greenhouse gases (conversion factor)	Index of global warming	Lifetime in the atmosphere (year)	Greenhouse effect contribution(%)	Emission source
Carbon dioxide (CO_2)	1	5~ 200	65	About 80% of greenhouse gas emissions, greenhouse gas unit When fossil fuels burn/ and plants photosynthesize
Methane (CH_4)	21	12.4	15	Main component of LNG, found in food and livestock manure
Nitrous oxide (N_2O)	310	121	6	Sources of nitrogen from agricultural land and animal manure, (nitrogenous manure and protein excreted in animal manure)
Chlorofluoro Carbons (CFC)	4,600~ 10,200	45~ 100	24	Widely recognized as Freon gas, steadily decreasing since Montreal Protocol (1989)
Hydrofluoro carbon (HFCs)	11,700	65~ 130		Used as a refrigerant in refrigerators and air conditioners, as a substitute for Freon gas U.S. and EU to reduce 85% by '35, developing countries to reduce 80% by '45
Perfluoro carbons (PFCs)	131,000	65~ 130		Used for cleaning in the electronics and plating industries especially used for cleaning semiconductors Japan's global market share is about 70%
Sulfur hexafluoride (SF6)	23,900	3,200		Used in insulators for high-voltage power equipment, transformers, etc.

(nationalecocredit.com)

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Characteristics of Nitrous Oxide (N_2O)

- **CO_2, CH_4, along with Nitrogen, are responsible for global warming**
  - → **Most dangerous with CO_2 : CH_4 : N_2O = 1 : 30 : 310 times**
  - → Global warming contribution CO_2: CH_4 : N_2O = 65 : 15 : 6
- **Uses of N_2O**
  - → Absorbs heat from the atmosphere and is used as an inhalation anesthetic in surgery.
  - → Recently used as a fuel for rocket engines (low cost)
- **N_2O is a major contributor to global warming by destroying the ozone layer**
  - → Destroys the ozone layer, which blocks ultraviolet radiation at altitudes of 25 to 30 km (stratosphere).
- **Major source of N_2O emissions**
  - → **Nitrogen fertilizers (43%), crop cultivation, animal manure**
  - → Regulation of chemical fertilizers in Europe has reduced emissions by 21% in the last 20 years
- **N_2O** persists in the atmosphere for more than 120 years, with about 17 million tons produced annually and about 13.5 million tons destroyed, a net increase of about 3.5 million tons per year
  - → Atmospheric concentration 270ppb in 1750 year, 331ppb in 2018

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Greenhouse Gas Emissions from in Korea

Gut fermentation emissions in livestock

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Cattle	3,907	3,939	4,046	4,002	4,140	3,980	3,946	3,998	4,054	4,164
Dairy cattle	1,078	995	1,023	1,044	1,090	1,072	1,043	1,022	1,008	1,004
Beef cattle	2,829	2,943	3,023	2,959	3,051	2,908	2,903	2,975	3,046	3,160
Sheep	0.5	0.5	0.5	0.3	0.3	0.3	0.2	0.3	0.2	0.3
Goat	27	26	26	26	26	27	31	36	45	53
Horse	11	11	11	11	11	9	9	9	10	11
Pig	**309**	**239**	**300**	**318**	**311**	**319**	**328**	**354**	**358**	**358**
Deer	8	7	6	5	4	4	4	3	3	3
Total	**4,263**	**4,222**	**4,390**	**4,363**	**4,493**	**4,339**	**4,318**	**4,400**	**4,471**	**4,589**

Emissions from livestock manure

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Cattle	**2,533**	**2,522**	**2,615**	**2,638**	**2,700**	**2,510**	**2,404**	**2,431**	**2,516**	**2,579**
Dairy cattle	711	656	674	684	701	671	635	639	640	640
Beef cattle	1,822	1,896	1,942	1,954	1,999	1,838	1,768	1,792	1,876	1,939
Sheep	0.5	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Goat	99	97	98	98	98	102	115	134	168	197
Horse	12	12	12	12	12	10	10	10	11	11
Pig	**1,314**	**1,014**	**1,176**	**1,201**	**1,146**	**1,166**	**1,188**	**1,375**	**1,400**	**1,277**
Poultry	816	821	752	772	734	790	773	700	829	822
Deer	29	25	22	19	17	15	14	12	11	11
Total	**4,803**	**4,522**	**4,676**	**4,739**	**4,707**	**4,592**	**4,504**	**4,662**	**4,936**	**4,897**

(National Greenhouse Gas Inventory Report, 2021)

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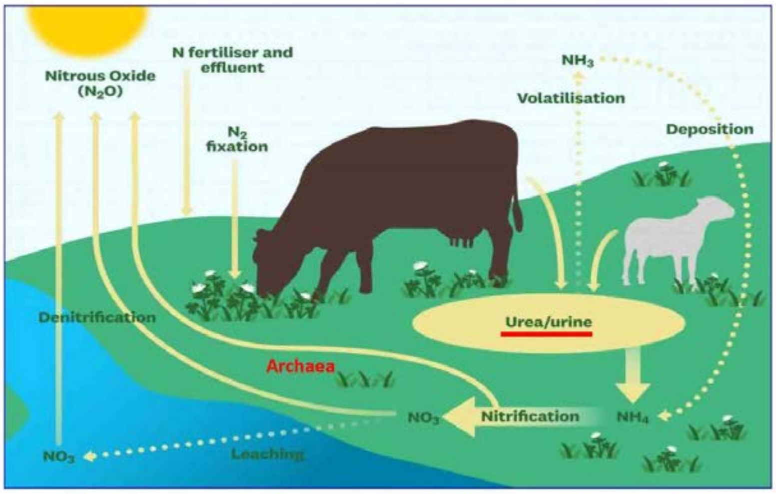
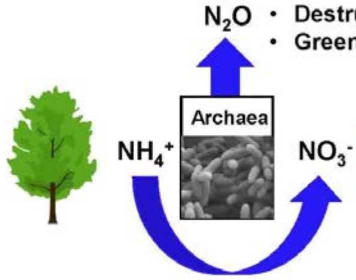
Sources of Nitrous Oxide (N_2O)



➔ **The source of nitrous oxide is the unutilized protein in the feed consumed by livestock**

Production of Nitrous Oxide in Soil

N_2O
- **Destruction of the ozone layer**
- **Green-house gases**



- **Decrease the efficiency of N fertilizer**
- **Surface water eutrophication**
- **Ground water pollution**

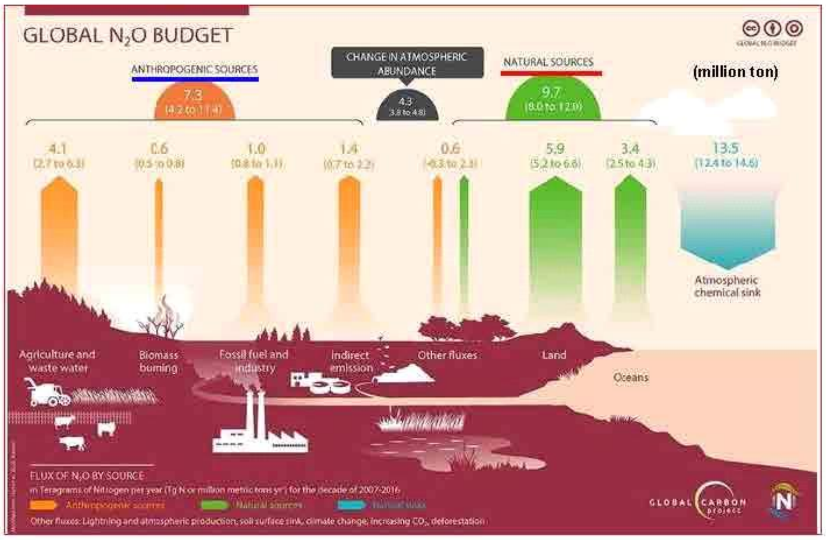
Nitrification in soil

➢ **Microorganisms that can survive under extreme conditions**
- Survive in environments with high salinity, hot springs, anaerobic condition, and acidity

➢ **It accounts 20% of Earth's total biomass**
- Ancient microorganisms

(Lee et al., 2013)

Sources of Supply and Sink of Nitrous Oxide



[Tian et al, Nature (2020)]

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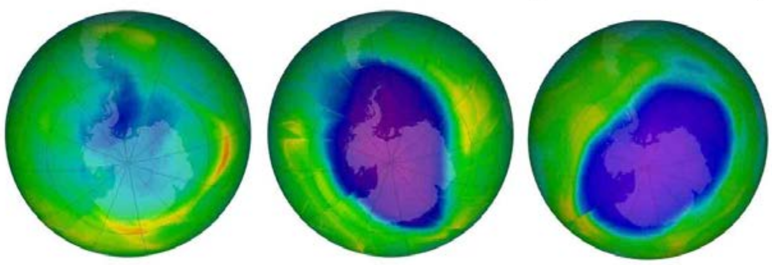
Changes in the Antarctic Ozone Layer

(Ozone Hole 2022, NASA)



1979 year | 2009 year | 2022 year

A major contributor to ozone depletion

➔ **Freon gas in air conditioning refrigerants, sprays, etc.**

➔ The Montreal Protocol of 1989 banned the use of Freon gas (CFC)

➔ Today, the international community has reduced CFC use by 99%

➔ **Antarctica's ozone layer is not expected to return to 1980 levels until 2066**

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The Need for Low-Protein Feed for Pigs

✓ **If pigs are fed an excess of crude protein in their diet**

➔ **Excess protein is excreted through urine and feces**

➔ **It leads to odor complaints and eutrophication of river**

➔ **Excessive CP in feed results in an increase in feed costs**

- **Increase in production cost of about 20~30 won/kg when increasing CP by 2%**

➔ **Excessive N_2O accumulation in the soil and atmosphere contributes to the destruction of the ozone layer**

Excess nitrous oxide (N_2O) accumulates in the soil and atmosphere, leading to the destruction of the ozone layer

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NRC Pig Specification Standard (2012)

Nutrient requirements (energy, feed intake, amino acids) for piglets and grower/finisher pigs

Item	Body Weight Range (kg)						
	5-7	7-11	11-25	25-50	50-75	75-100	100-135
NE content of the diet (kcal/kg)[a]	2,448	2,448	2,412	2,475	2,475	2,475	2,475
Effective DE content of diet (kcal/kg)[b]	3,542	3,542	3,490	3,402	3,402	3,402	3,402
Effective ME content of diet (kcal/kg)[b]	3,400	3,400	3,350	3,300	3,300	3,300	3,300
Estimated effective ME intake (kcal/day)	904	1,592	3,033	4,959	6,989	8,265	9,196
Estimated feed intake + wastage (g/day)[c]	280	493	953	1,582	2,229	2,636	2,933
Body weight gain (g/day)	210	335	585	758	900	917	867
Body protein deposition (g/day)	—	—	—	128	147	141	122
	Calcium and phosphorus (%)						
Total calcium	0.85	0.80	0.70	0.66	0.59	0.52	0.46
STTD phosphorus[d]	0.45	0.40	0.33	0.31	0.27	0.24	0.21
ATTD phosphorus[e,f]	0.41	0.36	0.29	0.26	0.23	0.21	0.18
Total phosphorus[f]	0.70	0.65	0.60	0.56	0.52	0.47	0.43
	Amino acids[g,h] *Standardized ileal digestible basis (%)*						
Arginine	0.68	0.61	0.56	0.45	0.39	0.33	0.28
Histidine	0.52	0.46	0.42	0.34	0.29	0.25	0.21
Isoleucine	0.77	0.69	0.63	0.51	0.45	0.39	0.33
Leucine	1.50	1.35	1.23	0.99	0.85	0.74	0.62
Lysine	**1.50**	**1.35**	**1.23**	**0.98**	**0.85**	**0.73**	**0.61**
Methionine	0.43	0.39	0.36	0.28	0.24	0.21	0.18
Methionine + cysteine	0.82	0.74	0.68	0.55	0.48	0.42	0.36
Phenylalanine	0.88	0.79	0.72	0.59	0.51	0.44	0.37
Phenylalanine + tyrosine	1.38	1.25	1.14	0.92	0.80	0.69	0.58
Threonine	0.88	0.79	0.73	0.59	0.52	0.46	0.40
Tryptophan	0.25	0.22	0.20	0.17	0.15	0.13	0.11
Valine	0.95	0.86	0.78	0.64	0.55	0.48	0.41
Total nitrogen	3.10	2.80	2.56	2.11	1.84	1.61	1.37

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NRC Pig Specification Standard (2012)

Nutrient requirements of piglet, growing/finishing pigs (total AA, %)

Item	Body Weight Range (kg)						
	5-7	7-11	11-25	25-50	50-75	75-100	100-135
				Total basis (%)			
Arginine	0.75	0.68	0.62	0.50	0.44	0.38	0.32
Histidine	0.58	0.53	0.48	0.39	0.34	0.30	0.25
Isoleucine	0.88	0.79	0.73	0.59	0.52	0.45	0.39
Leucine	1.71	1.54	1.41	1.13	0.98	0.85	0.71
Lysine	**1.70**	**1.53**	**1.40**	**1.12**	**0.97**	**0.84**	**0.71**
Methionine	0.49	0.44	0.40	0.32	0.28	0.25	0.21
Methionine + cysteine	0.96	0.87	0.79	0.65	0.57	0.50	0.43
Phenylalanine	1.01	0.91	0.83	0.68	0.59	0.51	0.43
Phenylalanine + tyrosine	1.60	1.44	1.32	1.08	0.94	0.82	0.70
Threonine	1.05	0.95	0.87	0.72	0.64	0.56	0.49
Tryptophan	0.28	0.25	0.23	0.19	0.17	0.15	0.13
Valine	1.10	1.00	0.91	0.75	0.65	0.57	0.49
Total nitrogen	3.63	3.29	3.02	2.51	2.20	1.94	1.67

- The amino acid content in the feed is important, but **it is necessary to accurately determine the feed intake in order to calculate the amino acid intake**

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Korean Pig Specification Standard (2022)

Nutrient requirements (energy, feed intake, amino acids) for piglets and grower/finisher pigs

	Body Weight (kg)					
	7-11	11-25	25-45	45-65	65-85	85-120
DE content (kcal/kg)	3,542	3,490	3,402	3,402	3,402	3,402
ME content (kcal/kg)	3,400	3,350	3,300	3,300	3,300	3,300
NE content (kcal/kg)	2,488	2,412	2,475	2,475	2,475	2,475
Estimate feed intake (g/d)	475	906	1,442	1,952	2,278	2,673
AA requirement (%)						
Lys	1.56	1.39	1.22	1.01	0.91	0.76
Met	0.47	0.42	0.37	0.30	0.27	0.23
Met + Cys	0.94	0.83	0.73	0.61	0.55	0.46
Thr	1.01	0.90	0.79	0.66	0.59	0.50
Trp	0.28	0.25	0.22	0.18	0.16	0.14
Ile	0.94	0.83	0.73	0.61	0.55	0.46
Leu	1.56	1.39	1.22	1.01	0.91	0.76
Val	1.09	0.97	0.86	0.71	0.64	0.53

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Korean Pig Specification Standard (2022)

The total daily AA requirements for piglet, growing/finishing pigs (g/d)

	Body Weight (kg)					
	7-11	11-25	25-45	45-65	65-85	85-120
DE content (kcal/kg)	3,542	3,490	3,402	3,402	3,402	3,402
ME content (kcal/kg)	3,400	3,350	3,300	3,300	3,300	3,300
NE content (kcal/kg)	2,488	2,412	2,475	2,475	2,475	2,475
Estimate feed intake (g/d)	475	906	1,442	1,952	2,278	2,673
AA requirement (g/d)						
Lys	7.41	12.6	17.62	19.81	20.71	20.38
Met	2.22	3.78	5.29	5.94	6.21	6.11
Met + Cys	4.45	7.56	10.57	11.88	12.43	12.23
Thr	4.82	8.19	11.46	12.87	13.46	13.25
Trp	1.33	2.27	3.17	3.56	3.73	3.67
Ile	4.45	7.56	10.57	11.88	12.43	12.23
Leu	7.41	12.60	17.62	19.81	20.71	20.36
Val	5.19	8.82	12.34	13.86	14.50	14.26
Phe	3.70	6.30	8.81	9.90	10.36	10.19
Phe + Tyr	7.04	11.97	16.74	18.81	19.68	19.36
His	2.37	4.03	5.64	6.34	6.63	6.52
Arg	3.11	5.29	7.40	8.32	8.70	8.56

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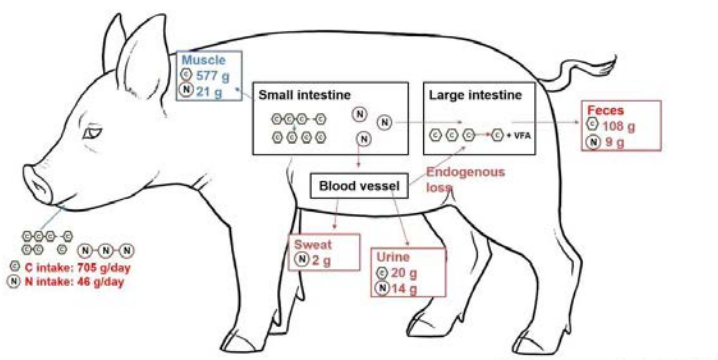
Carbon and Nitrogen Excretion in Pigs



(JØrgensen et al., 2013)

Carbon ➔ About 18% of the intake is excreted from the body (128/705g)

Nitrogen ➔ About 54% of the intake is excreted from the body (25/46g)

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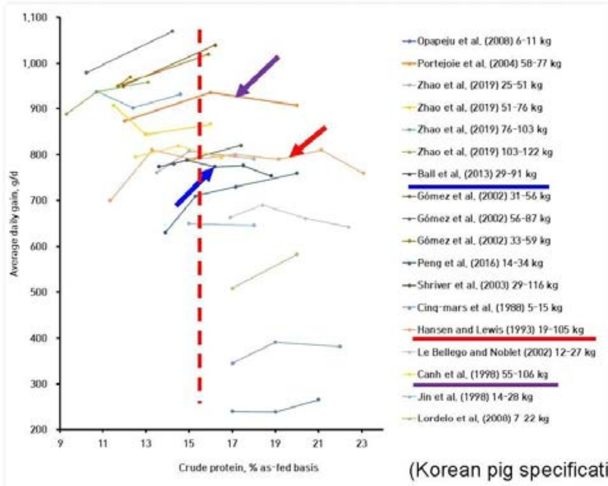
Growth Performance of Pigs based on Protein Content in the Feed



(Korean pig specification standard, 2022)

➔ **Higher protein in feed does not equal faster growth**

➔ **Growth performance of young animals increases with the level of protein in the diet**

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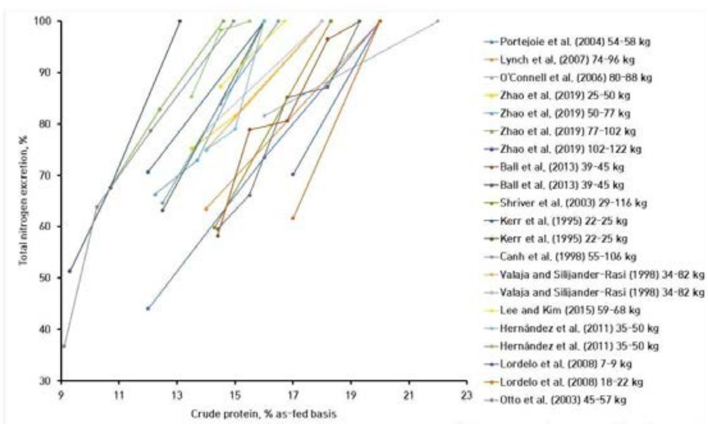
Nitrogen Emissions in Pigs based on Protein Content in the Diet



(Korean pig specification standard, 2022)

➔ **Nitrogen excretion in manure increases dramatically with higher protein content in feed**

➔ **For every 1% increase in protein in feed, ammonia emissions in manure increase by about 10%**

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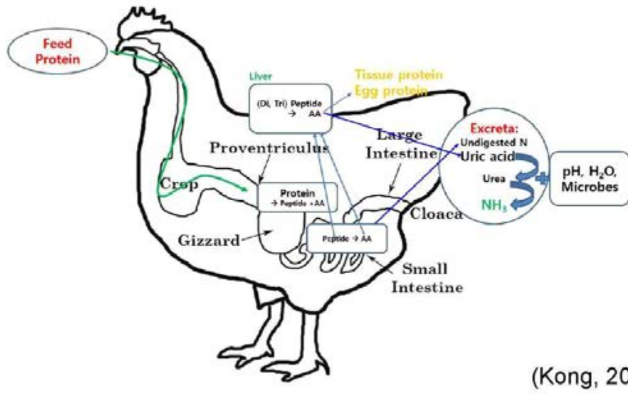
Carbon and Nitrogen Excretion in Chickens



(Kong, 2020)

➔ Undigested protein and uric acid are excreted out of the body

➔ Increased production of ammonia (NH_3), which is a source of nitrous oxide (N_2O)

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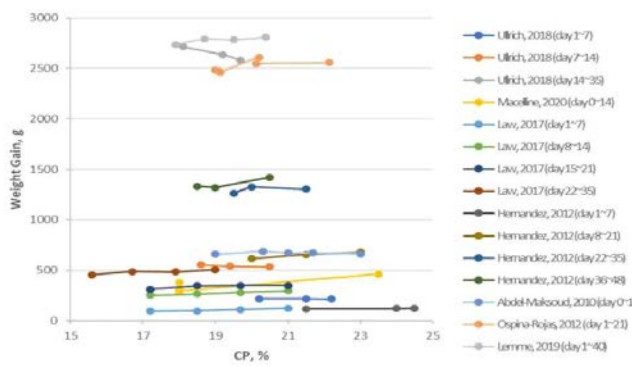
Growth Performance of Broiler according to Protein Content in Feed



(Broiler Raising Specification in Korea, 2022)

➔ Higher protein content in chicken feed does not increase broiler growth

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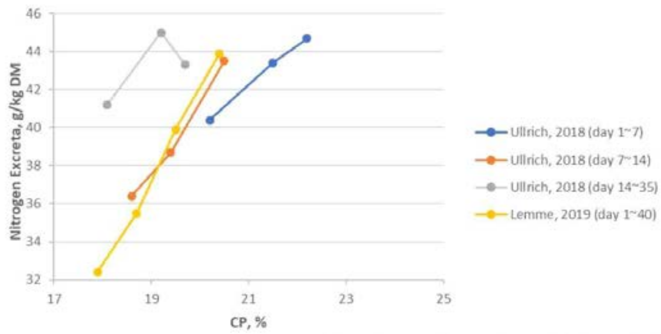
Nitrogen Emissions of Chickens based on Protein Content in feed



(Broiler Raising Specification in Korea, 2022)

➔ **Nitrogen excreted in urine increases dramatically with increasing protein content in the feed**

➔ **Ammonia emissions increase by about 10% for every 1% increase in protein in the feed**

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Crude Protein (CP) Content in Pig Feed

- No indication of CP in EU, US and Korean specification standards
- **In Korea, CP content was set as a minimum until November 2016**
  - ➔ Feed companies have been competitively raising dietary CP
  - ➔ Mandatory reduction of 1-3% from July 2022
- **CP in domestic pig feed is still about 2-4% higher than in the EU**
- **Recently, feeds have been formulated based on total amino acid content and SID amino acid requirement rather than CP**

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Changes in Allowable Protein Content in Domestic Pig Feeds

Nutrient range for registration of swine feed, Left: Before 2016, Right: After 2012.12.01.

No	Name	Usage	Registration Min (%)	Registration Max (%)
1	Creep (젖먹이돼지)	Before weaning	**CP**, Fat, Ca, Lys	Ash, Fiber, P
2	Starter (젖뗀돼지)	BW 5kg ~ or after weaning ~ 20kg		
3	Early growinig (육성돈전기)	BW 20kg ~ 50kg		
4	Late growing (육성돈후기)	BW 50kg ~ 80kg		
5	Early finishing (비육돈)	BW 50kg or 80kg ~ Before market 15 d		
6	Late finishining (비육돈출하)	Before market 15 d ~ Market		
7	Boar (번식용수퇘지)	BW 25kg ~ Boar		
8	Gilt (번식용암퇘지)	BW 25kg ~ before gestation		
9	Gestation (임신돼지)	Gestation		
10	Lactation (포유돼지)	Lactation		

No	Name	Usage	Registration Min (%)	Registration Max (%)	
1	Creep (포유자돈)	Before weaning	Fat, Ca, Lys	**CP, 23% Max**	+ Ash, Fiber, P
2	Weaner (이유돈 전기)	BW 7kg ~ 11kg		**CP, 21% Max**	
3	Starter (이유돈 후기)	BW 11kg ~ 25kg		**CP, 20% Max**	
4	Early growing (육성돈 전기)	BW 25kg ~ 45kg		**CP, 19% Max**	
5	Late growing (육성돈 후기)	BW 45kg ~ 65kg		**CP, 18% Max**	
6	Early finishing (비육돈 전기)	BW 65kg ~ 85kg		**CP, 17% Max**	
7	Later finishing (비육돈 후기)	BW 85kg ~ Market		**CP, 16% Max**	
8	Boar (번식용 웅돈)	BW 25kg ~ Boar		**CP, 14% Max**	
9	Gilt (번식용 모돈)	BW 25kg ~ before gestation		**CP, 16% Max**	
10	Gestation (임신 모돈)	Gestation		**CP, 16% Max**	
11	Lactation (포유 모돈)	Lactation		**CP, 20% Max**	

(Korea feed act, MAFRA, 2016)

Changes in Allowable Protein Content in Domestic Pig Feeds

(control of livestock feed act, 2022. 7.1)

현 행			개 정(안)			
명 칭	**사용범위 및 용도**	**등록성분**	**명 칭**	**사용범위 및 용도**	**등록성분**	**비 고**
포유자돈	이유 이전	조단백질 23%이하	포유자돈	~이유 초기	조단백질 20%이하	△3%
이유돈전기	7~11kg	21%이하				
이유돈후기	11~25kg	20%이하	이유돈	이유 초기 ~25kg	18%이하	△2%
육성돈전기	25~45kg	19%이하	육성돈	25~65kg	16%이하	△2~3%
육성돈후기	45~65kg	18%이하				
비육돈전기	65~85kg	17%이하	비육돈	65kg~출하,	14%이하	△2~3%
비육돈후기	85kg~출하	16%이하				
번식용웅돈	25kg이상	14%이하	삭제(사용없음)		-	
번식용모돈	25kg이상	16%이하	번식용모돈	25kg이상	15%이하	△1%
임신모돈	임신중	16%이하	임신돈	임신중	13%이하	△3%
포유모돈	포유중	20%이하	포유돈	포유중	19%이하	△1%

(MAFRA, 2022)

Purpose of revising feed act

➔ **Reduction of pig feed costs, reduction of odor due to reduction of NH_3, reduction of greenhouse gas (N_2O)**

➔ **However, Incorporation of growth stage classification is highly inappropriate**

Comparison of the Protein Content in Pig Feed in Denmark and Finland

Korea			Denmark	Finland	Compare to Korea
Stage	Body Weight	Protein Contents	CP in Feed	CP in Feed	CP in Feed
Creep	Before weaning	**23%, Max**	Wheat bran	14.41%	**-8.6%**
Weaner	7~11kg	**21%, Max**	15.8%	13.06%	**-5~8%**
Starter	11~25kg	**20%, Max**	16.23%		**-3.7%**
Early growing	25~45kg	**19%, Max**	15.34%	15.5%	**-3.5%**
Late growing	45~65kg	**18%, Max**	-		
Early finishing	65~85kg	**17%, Max**	14.61%	12.33%	**-2.4~4.7%**
Late finishing	85kg~market	**16%, Max**	-		
Boar	>25kg	**14%, Max**	-		
Gilt	>25kg	**16%, Max**	13.01%		**-3%**
Gestation	Gestation	**16%, Max**	-	11.20%	**-4.8%**
Lactation	Lactation	**20%, Max**	-	13.48%	**-6.5%**

(Kim, 2022)

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AA Content in Pig Feed in Denmark and Finland

Pig Feed in EU			AA contents (%)			
Stage	Body Weight	CP (%)	Lys	Met	Thr	Val
Creep	Before weaning	14.41	1.2097	0.5260	0.9732	1.0220
Weaner	**7~11kg**	**15.80**	**1.1354**	**0.3861**	**0.7954**	**0.9849**
Starter	11~25kg	16.23	1.2515	0.3834	0.8698	0.9078
Early growing	25~45kg	15.34	0.9093	0.3426	0.4835	0.7020
Late growing	45~65kg	15.03	0.7078	0.2230	0.5638	0.6117
Growing	25~65kg	14.67	0.8278	0.2661	0.6662	0.7057
Finishing	65~120kg	13.47	0.8085	0.2357	0.6676	0.6866
Gilt	>25kg	13.01	0.6685	0.2521	0.6003	0.6998
Gestation	**Gestation**	**11.20**	**0.5074**	**0.2015**	**0.4836**	**0.5822**
Lactation	**Lactation**	**13.48**	**0.8492**	**0.2793**	**0.7121**	**0.7247**

(Kim, 2022)

→The low protein level of gestating sow feed is due to the fact that because the amount of feed is higher than in Korea

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Examples of CP and AA Content in Domestic Pig Feed

Feed for Different Growth Stages of Pigs			AA contents (%)			
Stage	Body Weight	CP (%)	Lys	Met	Thr	Val
Milk replacer	<7 kg	20.45	**1.434**	1.021	1.369	1.578
Weaner	7~11kg	18.67	**1.079**	0.470	0.933	0.907
Pre-starter	1~16kg	18.44	**1.031**	0.503	0.969	0.946
Starter	6~25kg	16.91	**0.949**	0.302	0.777	0.827
Early growing	25~45kg	14.42	**0.851**	0.354	0.820	0.785
Late growing	45~65kg	14.01	**0.733**	0.337	0.820	0.739
Early finishing	65~85kg	13.51	**0.650**	0.297	0.639	0.638
Late finishing	85~120kg	13.97	**0.660**	0.312	0.678	0.638
Gestation	Gestation	12.12	**0.630**	0.170	0.501	0.530
Lactation	Lactation	15.49	**0.721**	0.120	0.565	0.655

(Kim, 2023)

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Does Nutrient Content in Pig Feed Matter ?

- **How much difference does feed intake per head make?**
- What is the quality of the raw feed? New vs. old songs?
- **How much to feed gestating sows?**
  - ➔ European sows are much heavier and culled earlier
- Farmers would be wise to calculate the total intake of each nutrient based on the pig's feed intake
- **If the lysine content in the feed is 0.75% and the daily feed intake is 2.7 kg per day**
  - ➔ Total lysine intake is 20.25g/d (7.5 g x 2.7 = 20.25 g/d)

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Feed Analysis Results of the Korea Pork Producers Association (23.1.16)

- Announcing the start of feed quality inspection by producer organizations
- It is expected to be an opportunity for complex feed names to be changed to scientific names in Korea
  - ➔ nursery, weanling, bridge, transition feed...
- We need to use scientific and legal feed terms
  - ➔ Creep, early weaning, late weaning, early growing, late growing, early finishing and late finishing
- What is the controversial nursery feed?
  - ➔ Domestic pig farms often raise fattening pigs with nursery feed
  - ➔ The actual analyzed specification of nursery pig feed is close to the specification of fattening pig feed
  - ➔ Farmers mostly request feed companies to supply nursery pig feed
- Early and late finishing feed account for about 6% of total feed sales in Korea

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Conclusion

- Reducing 2% of protein in pig feed can save
  - ➔ Feed cost by 20~30 won/kg
  - ➔ Difference of feed price for early growing and early finishing is about 30~40 won/kg when feeding by phase feeding
- Excessive protein content in feed is not related to livestock growth
  - ➔ Content of amino acids in feed, relative ratio among amino acids is important
- The excess protein content in domestic pig feed, should be systematically reduced
- Reducing excess protein in livestock feeds
  - ➔ Reducing NH_3 emissions from manure
  - ➔ **1% reduction in CP in feed reduces NH_3 by 110%,** preventing odor complaints
  - ➔ Reducing nitrous oxide (N_2O) as a global warming factor

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THANK YOU

Sustainable Feed Formulation for Poultry

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Sustainable feed formulation for poultry

Overview

Sustainable poultry production requires the industry to remain economically viable while implementing environmentally friendly and socially responsible practices throughout the entire poultry production system, which includes breeding, rearing, feed management, waste management, and animal welfare. The definition of sustainable systems are ones which “meet the needs of the current generation without compromising the ability of future generations to meet their own needs”.

There is now an overarching imperative for sustainability, given by the global net-zero emissions target. The momentum to curb temperature rises and cut harmful greenhouse gas (GHG) emissions is strong, with more than 70 countries - representing more than ¾ of global emissions - committing to net zero by 2050. Agriculture accounts for 18.4% of GHG emissions, of which poultry production contributes a small proportion, estimated to be around 9% of total sector emissions (1.66% of global emissions in 2018, according to the United Nations). This includes: livestock emissions from crop production for feed, land use, manure management, water usage, meat or egg processing, and energy use along the chain. Of course, emissions are not uniform across countries, regions and locations as there are numerous influencing factors such as production systems, management practices, dominant animal protein sources and overall economic development.

Kleyn and Ciacciariello (2023) aptly summarised the four key elements of sustainability for the poultry industry termed the “4E’s of sustainability”. Environmental, Ethical, Economic and Enactment. All four elements have a strong relationship with feed. This is because feed accounts for 60 – 80% of production costs for poultry. Thus, the sustainability of poultry production can never be achieved if the role of nutrition is not properly considered.

Some key aspects for these four “E’s” are unpacked below to briefly illustrate the role of feed and nutrition in sustainability for the poultry industry. Some principles should be applicable to other animal industries as well.

The 4 E’s of sustainability

Environmental Impact

Poultry production has a low carbon footprint (Our World in Data, 2023). However, carbon footprint is only one of many elements that determine sustainability. Sustainable practices for poultry production include reducing water and energy consumption, mitigating greenhouse gas emissions, managing and recycling waste effectively, and reducing pollution and nutrient runoff. So how feed formulation and nutrition play a role in the environmental impact of poultry production?

Proper feed formulation relies on an accurate nutrient database and a good knowledge of the animal for which the feed is intended. A well-balanced diet will provide all the necessary nutrients to the bird to convert feed efficiently. Today, a broiler chicken fed a balanced diet under a reasonable husbandry condition is expected to exceed a body weight of 2,650g with a total feed intake of 4,055g or less, i.e., a feed conversion ratio (FCR) at around 1.53. If this is improved by 3-conversion points, i.e., reducing the FCR from 1.53 to 1.50 (or approximately a 2% improvement), it will save 80g of feed per bird. Which for a poultry company producing a million birds per week means 80 tonnes of feed saved per week or 4,160 tonnes of feed saved per year. Because it produces the same amount of meat but uses less feed, it represents less land used to grow the feed crops, less energy required to transport the feed, less electricity consumed to produce the feed. More importantly, it means 4,160 tonnes less excreta dry matter end up in the environment.

Kim et al. (2021) quantified and characterised the undigested components in the excreta of broiler chickens fed a commercial standard diet. The chickens were healthy and performed above the breed standard in their study. It revealed that at day 12, 34.3% of a wheat-based diet and 35.2% of corn-soy diet were undigested and at day 35, 32.0% of the wheat-based diet and 31.5% of the corn-soy diet were undigested, only around 3 percentage point improvement in digestion between day 12 and day 35. Approximately 50% of the organic matter in the undigested components consisted of non-starch polysaccharides and lignin (the two constituents of fibre in feed). This suggests that nutrition science has much to offer in increasing the utilisation of fibre in feed via a myriad of possible routes such as the use of enzymes, processing technologies and physicochemical treatments.

Ethical production of food

Ethical production of animal proteins requires that the animals are raised without damaging the environment, given feed that has no harm to human health or the ecosystem, and are managed in a welfare friendly manner. Feed formulation must incorporate an increasing level of novel raw materials such as algae, single cell proteins and insects; certain by-products not used as human food, and waste streams from food services, milling industries, primary industries and manufacturing. In Australia, food wastes account for 5% of greenhouse gas emissions (Arcadis, 2019). Uwizeye et al. (2019) estimated that feeding food wastes to commercial pigs grown worldwide would increase nitrogen use efficiency, reduce nitrogen losses, and achieve savings of 31 million tonnes of soybean and 20 million tonnes of grain, which represents an equivalent of 16 million hectares of land use.

All nutrients are required for one purpose or another in the animal, be it carbohydrates for energy; proteins for provision of amino acids for growth and body functions; or minerals for skeletal development and components of metal-containing proteins and hormones. In theory, any deficiency - however small that is - can affect health and hence welfare of the animal (McDonald et al., 2011). Thus, the role of feed formulation in animal welfare is immense because adequate nutrition is essential for the health of animals, and hence their welfare. There are numerous examples that show the inseparable link between nutrition, health and welfare in animals. One of the obvious examples is, an imbalance of minerals can lead to wet droppings in poultry, leading to major welfare issues, like increased incidence of breast blisters, hock burn and outbreaks of disease.

Economic considerations

Sustainability in an economic sense is a complex question as it concerns the whole agricultural sector or even a whole nation. Thus, only one example is given here to illustrate how economics, feed formulation and animal welfare are interwoven in the poultry industry. Necrotic enteritis is the most economically devastating disease for the broiler chicken industry and it is estimated to cost the global industry around $6B per annum (Moore, 2016). Indeed, there is a clear link between the use of viscous grains (rye, barley and wheat) and the outbreak of necrotic enteritis in broiler chickens (Kaldhusdal, 2000). Feed formulation that judicially uses feed additives, such as the use of enzymes to degrade the soluble non-starch polysaccharides present in viscous grains, can ameliorate the economic impact of the disease.

In addition, the interaction between genetics and nutrition is the key driver for productivity gain in the poultry industry. Indeed, selecting and breeding poultry for improved productivity, disease resistance, and resource efficiency contributes has been phenomenal over the past 60 years. In 1995, it would take 52 days for a broiler chicken to reach 2.3kg body weight with an FCR of 2.00. Today, it only takes 29 days to reach 2.3kg body weight with an FCR of 1.35. While genetic selection accounts for the main proportion of this improvement, without feed formulations taking into account over twenty different nutrients and energy, even the best genetics can not perform. Thus, sustainable poultry production will need both genetic advancements and nutrition technologies.

Enactment of sustainable practices

Although the role of feed formulation in sustainability is one distinct practice that can be implemented, it should not be considered in isolation. Advanced feed formulation will rely on precision nutrition, which, in turn, will rely on accurate knowledge of the ingredients in terms of their chemical composition, physical properties, physiological impacts and nutritional attributes. Furthermore, precision nutrition considers the precise nutrient requirements of the animals and their responses under various husbandry environments. Precision nutrition can enable a formulator to produce feed that minimises waste and maximises feed efficiency, which, in turn, will reduce the environmental impact of poultry production. Formulations can also be used to counter the impact of necrotic enteritis, leading to better welfare outcomes and economic returns to the farmer.

Sustainable poultry production seeks to balance economic viability with environmental stewardship and social responsibility. It aims to meet the growing global demand for poultry products while minimising negative impacts on the environment, promoting animal welfare, and supporting the long-term sustainability of the industry. However, enactment of sustainable practices is often hindered by conflicting demands by society. For instance, the public is becoming discerning in choosing food that they consume. This has translated into four major moves over the past twenty years. First is the removal of antimicrobials from feed. Although it addresses the public demand on one hand, it has made poultry production more susceptible to disease, leading to increased morbidity in animals. Second is transitioning to a free range system. But the free range system uses more land, is less efficient and the animals are more prone to diseases. Third is the use of all vegetable diets in some countries, leading to the exclusion of some high value by-products from feed formulation, which often end up as waste. Fourth is a demand for organic products and the ban of GMO ingredients from animal feed. Organic production is much more emissions intensive whereas GMO crops are high-yielding, water efficient and less reliant on chemicals.

Therefore, enactment of sustainability practices is a societal responsibility and it requires visionary leadership, global collaboration and a long term effort by everyone. Feed formulation is one of the low-hanging fruits that can be deployed to ensure that poultry production meets specific sustainability criteria and consumer expectations.

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Triumphs and Troubles in Trying to Reduce Enteric Methane from Ruminants

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Triumphs and troubles in trying to reduce enteric methane from ruminants

Introduction

Methane (CH_4) emissions are a focus of global action to reduce greenhouse gas (GHG) induced climate change, with attention heightened since the signing of the Global Methane Pledge in 20@@. Enteric CH4 from domestic ruminants is a small contributor overall to GHG emissions, and it has been argued that as a biogenic (as opposed to anthropogenic) GHG source, this should be considered part of 'background' pre-existing emissions. Nevertheless, the short lifespan of CH_4 in the atmosphere means that if enteric CH_4 emissions can be reduced, this could achieve a fast impact on climate change by removing CH_4 from the atmosphere, and offset historical anthropogenic emissions of longer life-span GHGs.

Research to measure livestock CH_4 emissions (and their inhibition) is not a new field, and we have many tools at our disposal now to measure CH_4 from ruminants, but all these tools have strengths and weaknesses in their application. Significant research effort is currently being expended globally to develop strategies to inhibit the production of enteric CH_4, but even though in many cases the fundamental science is not completely novel, very few strategies have yet been widely commercialised. This paper discusses the state of these research, development and adoption pathways to reduce enteric CH_4 in ruminant livestock industries.

Measuring methane

To provide high confidence data on the efficacy of methane inhibiting strategies, replicated research trials are required. The gold standard method for measurement of methane is the fully-enclosed respiration chamber, where total emissions from the measurement period are captured and analysed. Such facilities are few on a global level (20 or fewer chambers for each species on each continent, and the largest facility with 10 chambers), which limits the statistical power of research experiments, and therefore the scale of inhibition which can be detected. Respiration chambers by design poorly replicate production environments, in particular, grazing systems. Greater replication, measured in-field, can be achieved with equipment such as Greenfeed Emissions Monitors™ (C-Lock, South Dakota) and sulphur-hexafluoride (SF6) but these measurement systems also pose challenges in terms of scale, accuracy, deployability, and replicability in many production settings. All *in vivo* methodologies are expensive and challenging to implement at scale. Preliminary screening of potential CH_4 inhibitors thus often relies on *in vitro* incubations of rumen fluid, but overall, there has been notable inconsistency between *in vivo* and *in vitro* results, such that not only are promising *in vitro* results often not replicated *in vivo*, but results showing little effect *in vitro*, in some cases demonstrate greater efficacy *in vivo*.

Inhibiting enteric methane emissions

Research on strategies to inhibit enteric CH_4 production fall into several mechanistic categories: blockers of the enzymes catalysing reactions involved in methanogenesis (such as 3-nitrooxypropanol (3-NOP) and bromoform ($CHBr_3$)); alternative electron acceptors to compete with carbon for hydrogen (also called alternative hydrogen sinks, such as oxygen); strategies targeting the ecology of the microbiome and therefore its fermentation products (such as antimicrobials and probiotics, as well as vaccination); and systems-based changes (such as changing dietary starch and lipid content; and genetic selection) which may target a range of mechanistic traits.

In a review of 10 leading chemical groupings of methane-inhibiting feed additives, (Hegarty et al., 2021) found that only two (3-NOP and *Asparagopsis* (red algae) have routinely been able to suppress ruminant enteric CH_4 production by more than 20 %. Certainly, these two are outstandingly effective, with research at the University of New England demonstrating 98% abatement of CH_4 in cattle fed a feedlot total mixed ration (TMR), supplemented with either product. Most other classes of these feed-based inhibitors are unable to suppress CH_4 by more than 10 %.

Almost all research into feed additives has been conducted by animals fed TMRs, where each mouthful of CH_4-generating feed also contains the bioactive inhibitor. To suppress CH_4 emissions from grazing ruminants, feed additives must be able to be effective when provided intermittently, and yet not only has almost no research been conducted to support such systems, but not a single feed additive manufacturer currently considers grazing livestock an extremely high priority market (Hegarty et al., 2021). In the absence of near-term solutions from feed additives, genetics and improvements to the feedbase may play a role in reducing emissions from grazing livestock, yet both have significant impediments to adoption and achievement of CH_4 inhibition.

Achieving reduced livestock carbon footprints

All feed additive strategies will come at a cost, and so, in the absence of emissions penalties (such as a carbon tax or tariff) a productivity co-benefit will need to be established to support the business case for widespread adoption. There is insufficient evidence as yet that any CH_4-suppressing feed additive is able to consistently increase livestock productivity. Where there are indications of co-benefits, this is mostly no more than 5 % of current productivity. To statistically detect this level of improvement, very large *in vivo* trials are required, with 15 or more replications per treatment. However, without a strong body of evidence, adoption of producers may be very limited.

Genetic selection of low CH_4-emitting animals is the only strategy which is applicable across all production systems (Hegarty et al., 2022). The rate of genetic change in CH_4 emissions is slow, likely < 1 % per annum, but is permanent if selection pressure is maintained. As for feed additives, the value of selection for low CH_4-livestock, and the correlation with other productive traits, will need to be defined before adoption will be widespread.

Diets containing more water-soluble carbohydrates and starch are known strategies to reduce yield of CH_4 per kg of feed intake. Improvements to the feedbase to improve productivity are thus attractive strategies that potentially offer a win-win outcome of reduced CH_4 yield and improved production efficiency. This puts pressure from two axes on CH_4 intensity (g of CH_4/kg of animal product). Yet because daily intake tends to rise as diets become more digestible, this can cause CH_4 production (kg/animal.day) to rise. A system of policy incentives needs to be put in place if farmers to encourage farmers to not respond to increased production efficiency by raising more stock, and thereby increasing total CH_4 emissions.

Conclusion

Despite intense research focus in recent years, the R&D pathway to widespread adoption of strategies to inhibit enteric CH_4 is still in its infancy. Significant further research is required to find new CH_4 inhibiting feed additive products, to develop selection indices for low CH_4 livestock and to demonstrate the business case for adoption of these strategies. However, if farmers can adopt a combination of improved production efficiency, lower genetic CH_4 production, and inhibited CH_4 production by feed additives; and, especially in grazing systems, promote landscape carbon sequestration; then livestock systems have the potential to not only reach carbon neutrality, but become carbon negative.

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식육 및 식육가공품 내 대기압플라즈마의 적용
Application of Atmospheric Pressure Packaging

용 해 인
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Curriculum Vitae

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- 2018~2019 서울대학교 농업생명과학연구원 선임연구원
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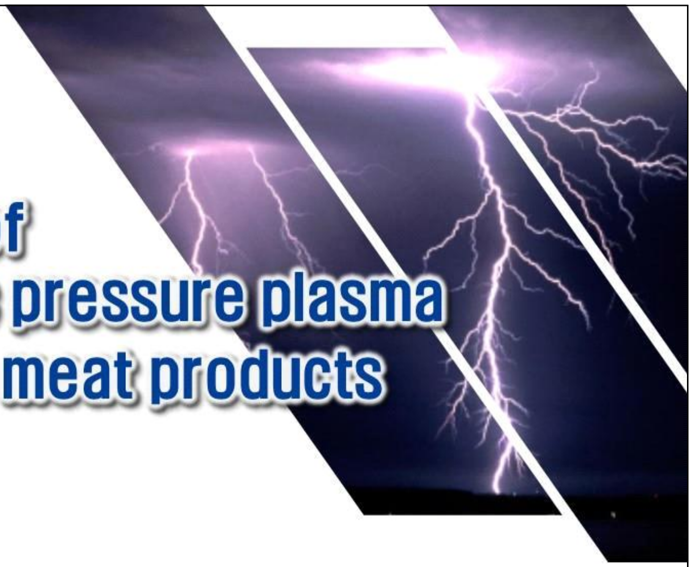
- 2012~2014 충남대학교 축산학과 농학석사
- 2008~2012 충남대학교 동물자원과학과 농학사



Application of atmospheric pressure plasma to meat and meat products

2023. 7. 7.

Yong Hae In

Chungnam National University

KSAST (사)한국축산학회

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❖ Research background

Climate change is the most critical issue in the worlds

- Global coalition for net-zero emissions is growing.
- To avoid the worst outcome of climate change, the world needs to limit global temperature rise to 1.5°C and achieve net zero emissions by 2050.

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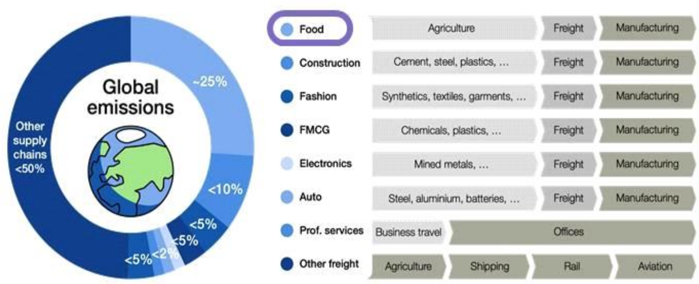
General introduction	Research I	Research II	Research III	Overall conclusion

❖ Research background

Cause of global greenhouse gas emissions



- One of the biggest factors for climate change is the food industry.
- Food industry contributes around a quarter of the gas emissions.

Note: Only selected value chain steps are shown here; value chain steps not shown at scale; FMCG = fast-moving consumer goods

Source: BCG

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Research background
Wasting food comprise a large proportion in the food industry's greenhouse gas emissions.
1.3 billion tons of food per year
1/3
20% MEAT
FOOD LOSSES
1/3 of all food is wasted before it is consumed by people.
Wasting food also have negative affect on food security.
Food security is a basic human right that allows access to at least an adequate amount of nutritious food.
To avoid climate changes & insure food security, world food waste must be reduced.
World Food Programme
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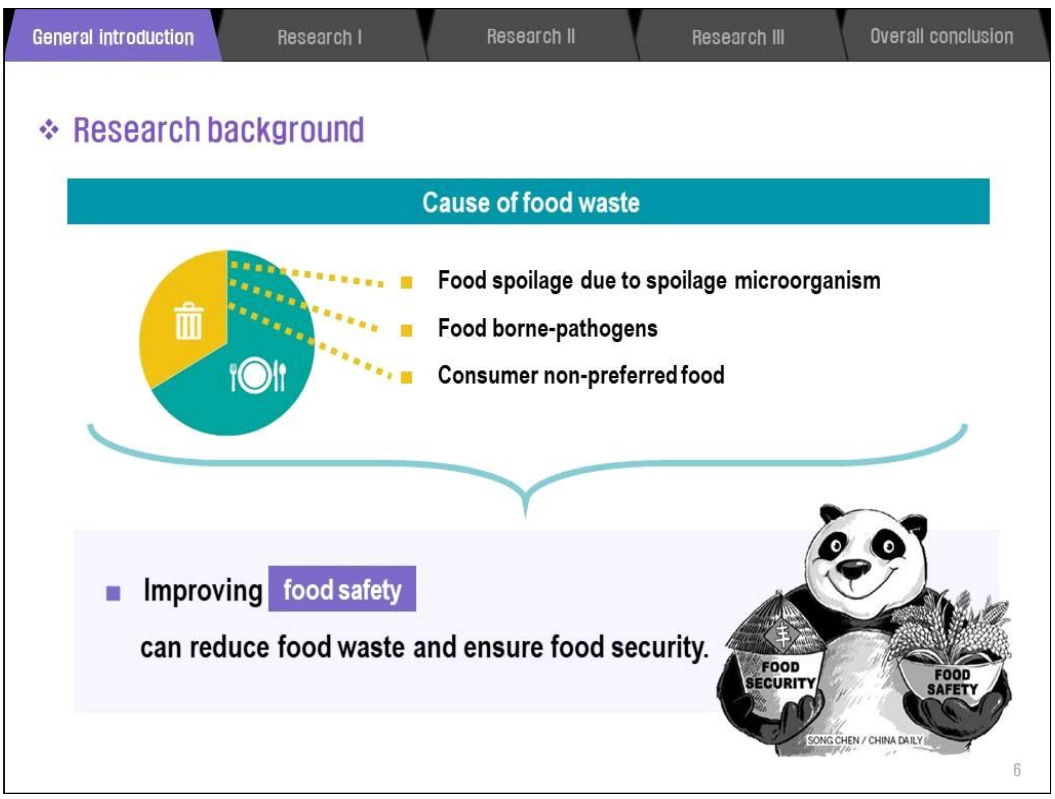
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Cause of food waste
Food spoilage due to spoilage microorganism
Food borne-pathogens
Consumer non-preferred food
Improving food safety can reduce food waste and ensure food security.
FOOD SECURITY
FOOD SAFETY
SONG CHEN / CHINA DAILY
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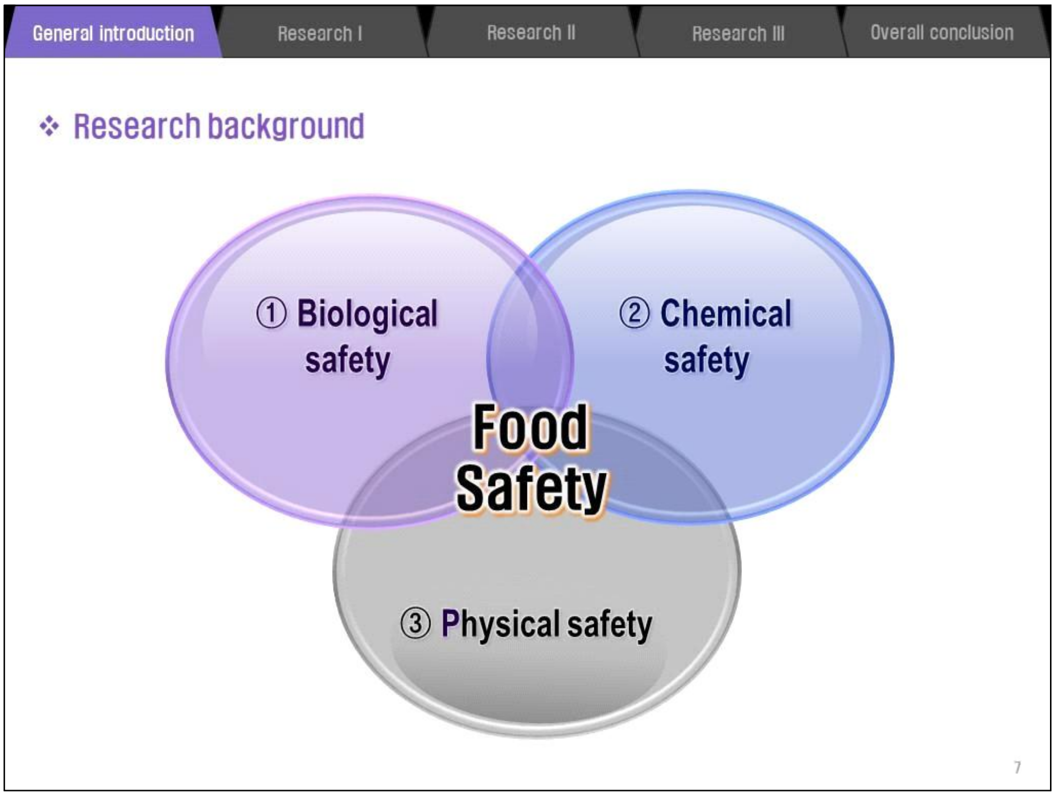
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① Biological safety
② Chemical safety
Food Safety
③ Physical safety
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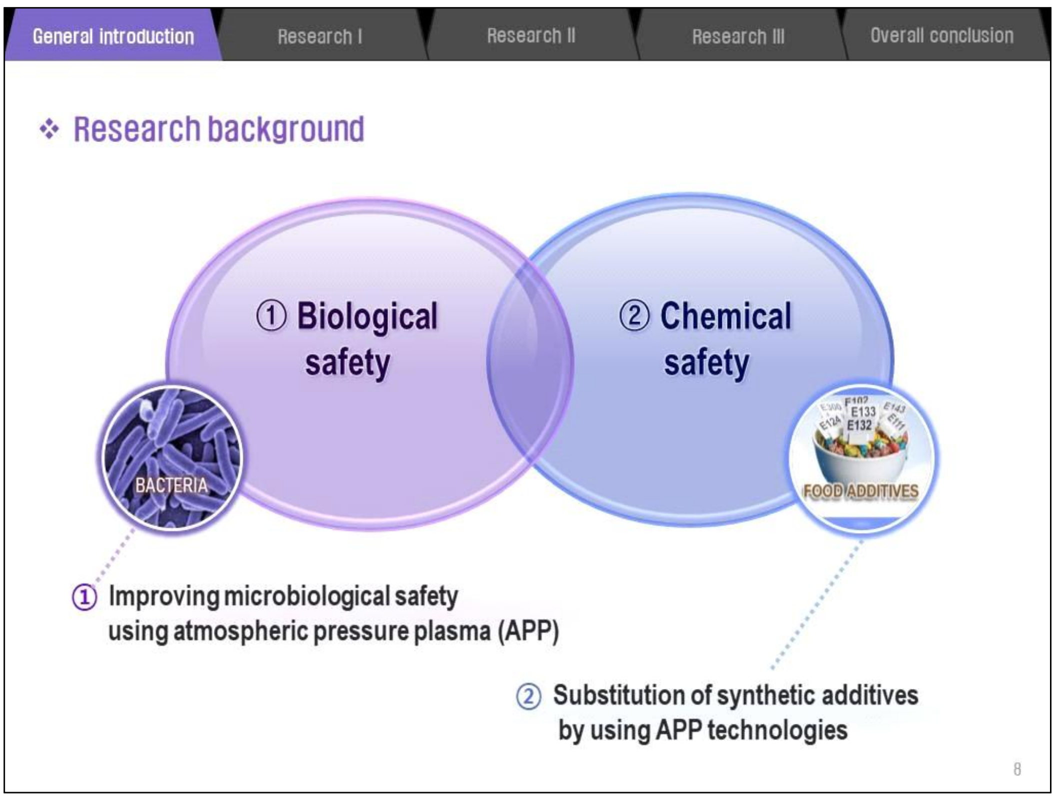
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① Biological safety
② Chemical safety
BACTERIA
FOOD ADDITIVES
① Improving microbiological safety using atmospheric pressure plasma (APP)
② Substitution of synthetic additives by using APP technologies
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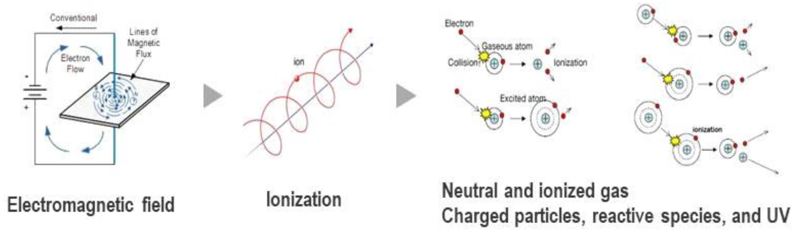
Evaluation of the microbiological safety, quality changes, and genotoxic safety of meat and dairy products using APP

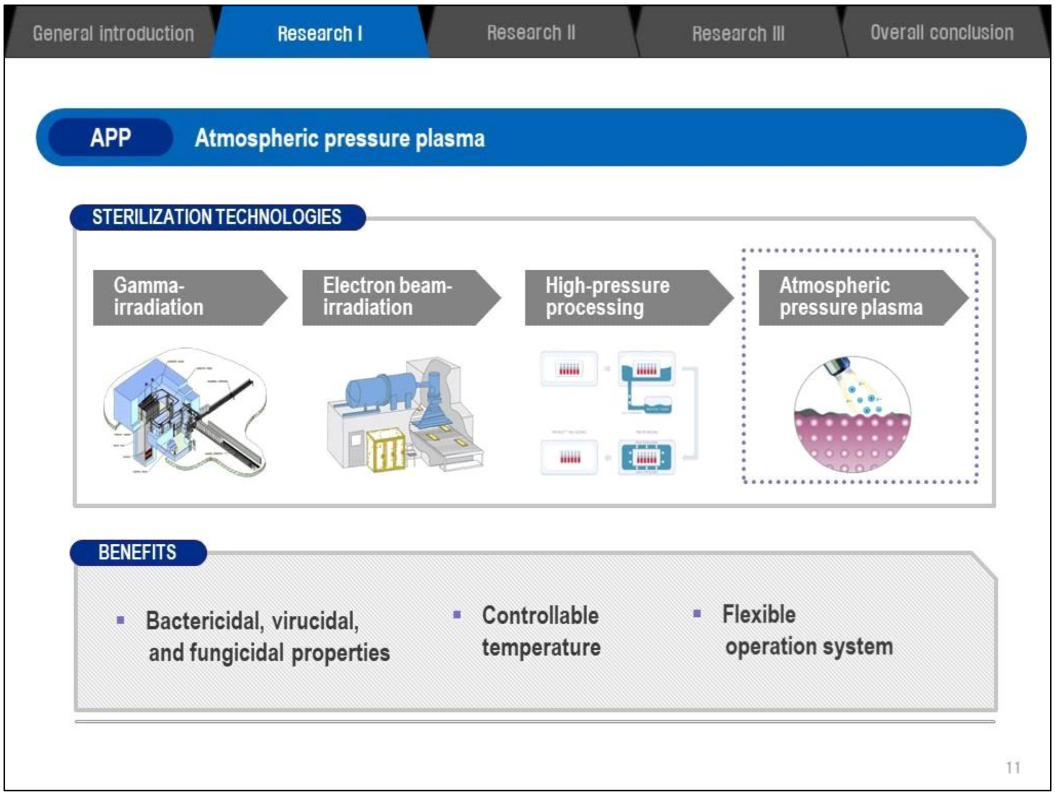
APP Atmospheric pressure plasma

DEFINITION

- The fourth state of matter
- Ionized gases

PRODUCTION

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APP
Atmospheric pressure plasma
STERILIZATION TECHNOLOGIES
Gamma-irradiation
Electron beam-irradiation
High-pressure processing
Atmospheric pressure plasma
BENEFITS
Bactericidal, virucidal, and fungicidal properties
Controllable temperature
Flexible operation system
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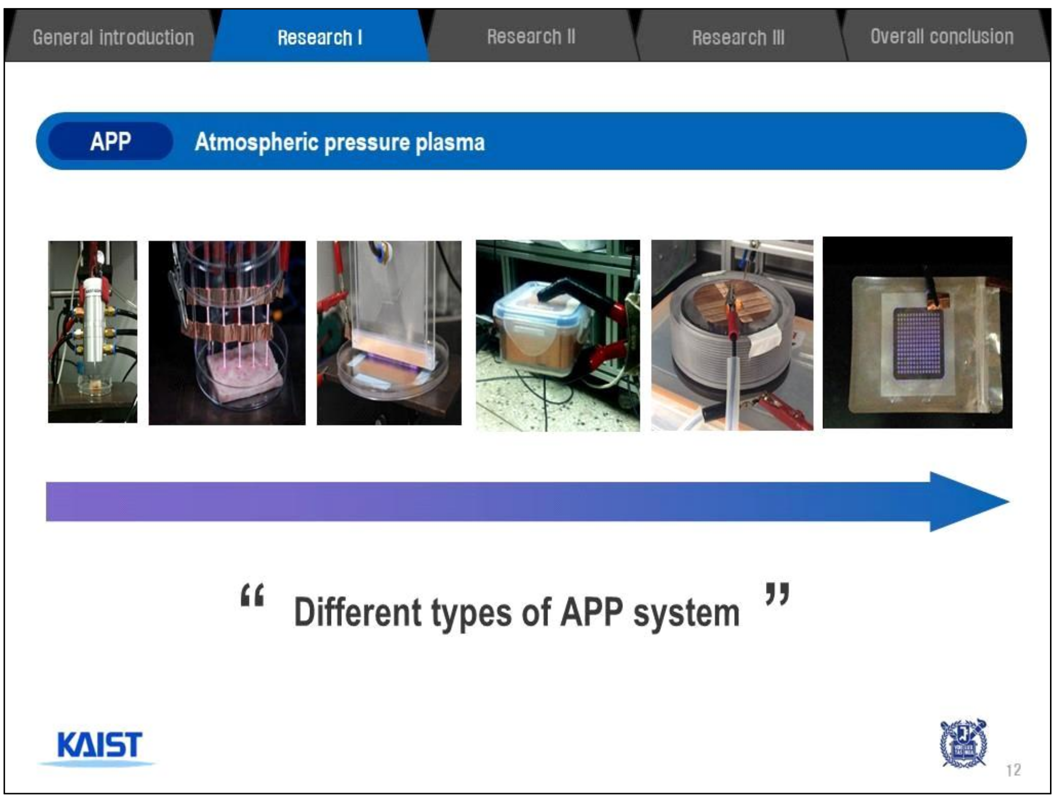
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APP
Atmospheric pressure plasma
" Different types of APP system "
KAIST
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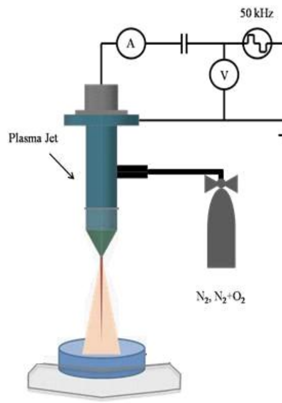
1. JET-TYPE PLASMA



❖ Limitation –(1)

→ **Poor antimicrobial effect**

① **Gas composition**

KAIST

Yong et al. (2014). Foodborne pathogens and disease

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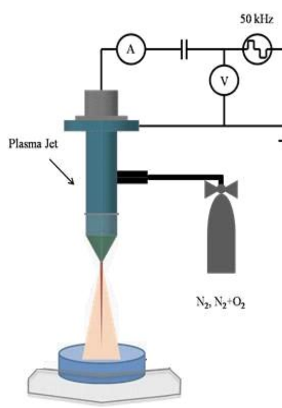
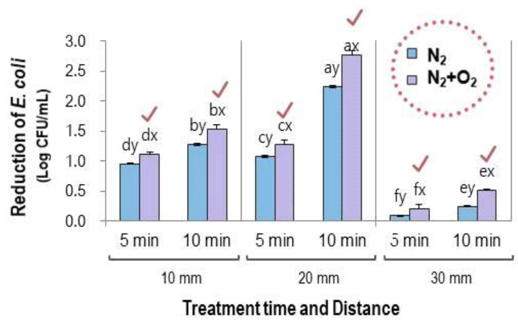
1. JET-TYPE PLASMA



❖ Limitation –(1)

→ **Poor antimicrobial effect**

① **Gas composition**



KAIST

Yong et al. (2014). Foodborne pathogens and disease

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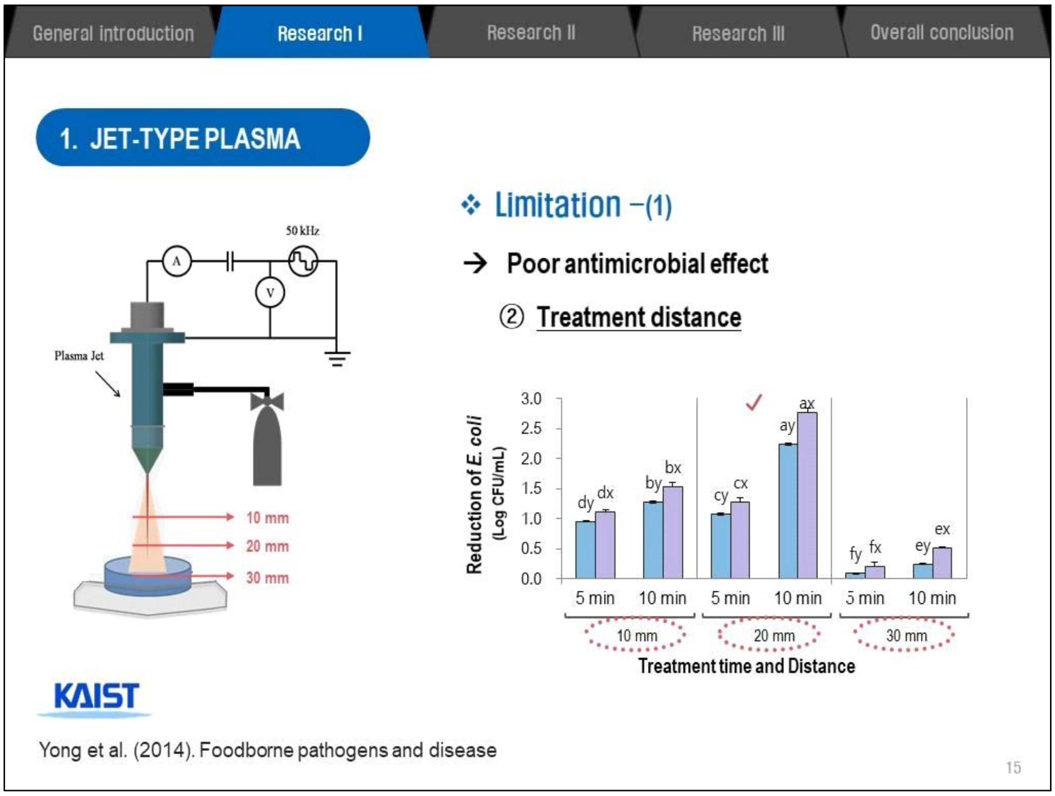
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1. JET-TYPE PLASMA
Limitation –(1)
→ Poor antimicrobial effect
② Treatment distance
50 kHz
Plasma Jet
10 mm
20 mm
30 mm
Reduction of E. coli (Log CFU/mL)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
dy dx by bx cy cx ay ax fy fx ey ex
5 min 10 min 5 min 10 min 5 min 10 min
10 mm 20 mm 30 mm
Treatment time and Distance
KAIST
Yong et al. (2014). Foodborne pathogens and disease
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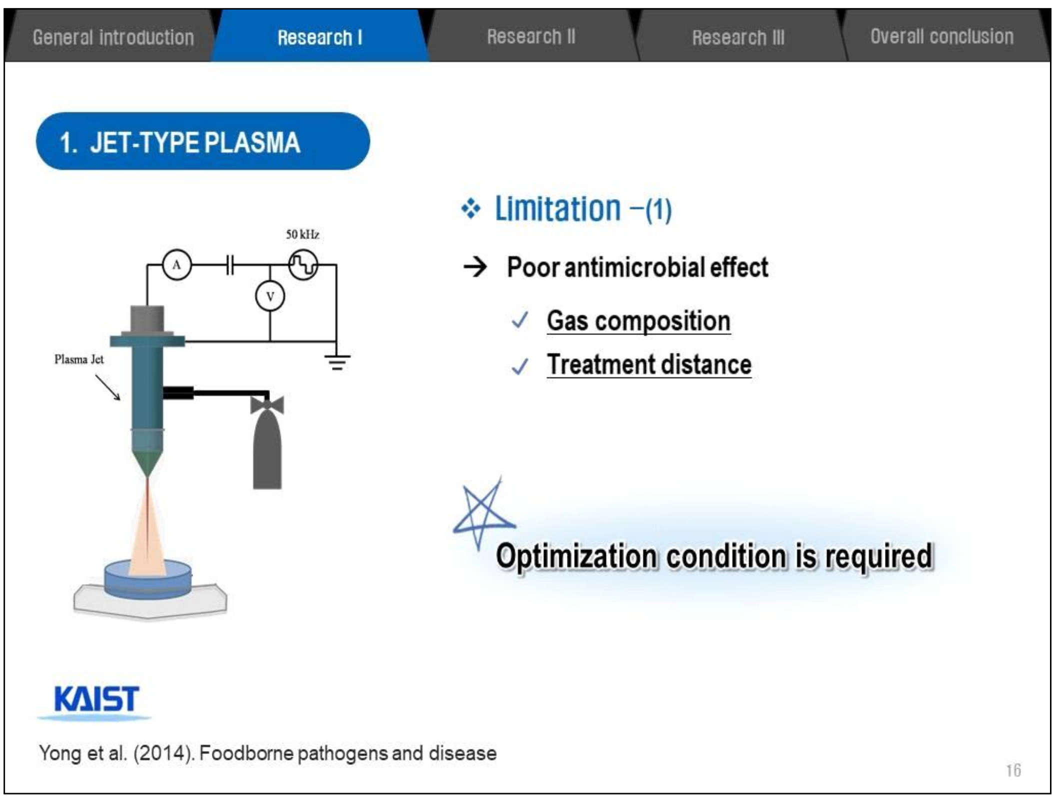
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1. JET-TYPE PLASMA
Limitation –(1)
→ Poor antimicrobial effect
✓ Gas composition
✓ Treatment distance
50 kHz
Plasma Jet
Optimization condition is required
KAIST
Yong et al. (2014). Foodborne pathogens and disease
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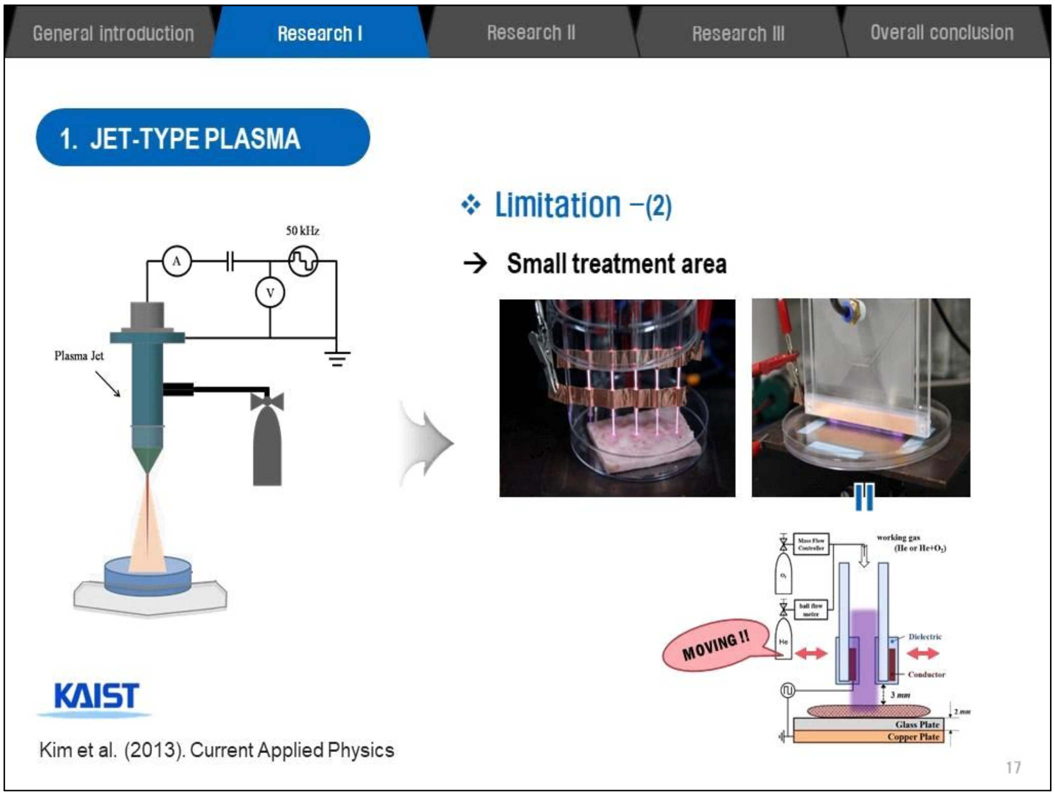
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1. JET-TYPE PLASMA
❖ Limitation –(2)
→ Small treatment area
50 kHz
Plasma Jet
MOVING !!
working gas
Dielectric
Conductor
3 mm
2 mm
Glass Plate
Copper Plate
KAIST
Kim et al. (2013). Current Applied Physics
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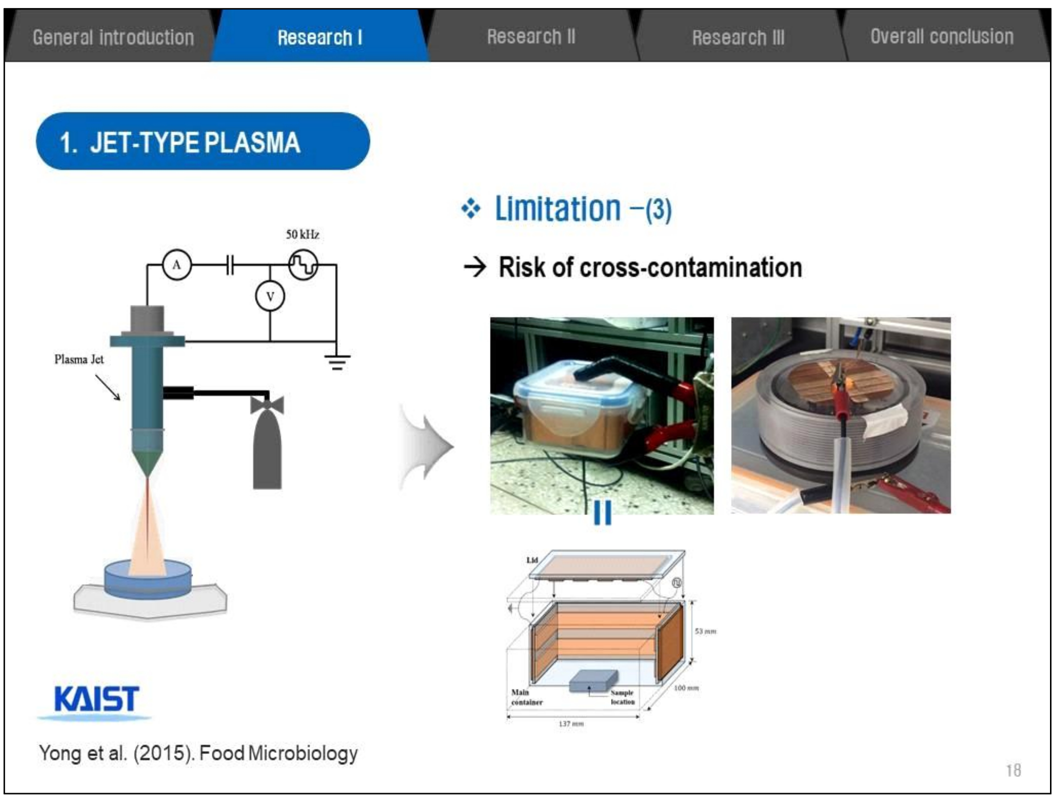
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1. JET-TYPE PLASMA
❖ Limitation –(3)
→ Risk of cross-contamination
50 kHz
Plasma Jet
Lid
Main container
Sample location
KAIST
Yong et al. (2015). Food Microbiology
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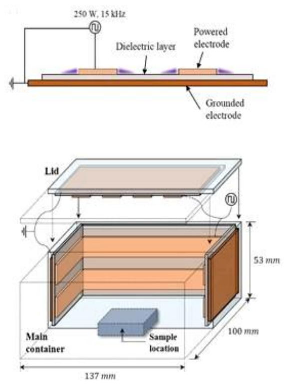
2. ENCAPSULATED TYPE PLASMA



❖ Optimization condition

→ **Duration time**

Plasma treatment → Turn off → Storage duration

↓

Evaluate the inactivation of pathogens

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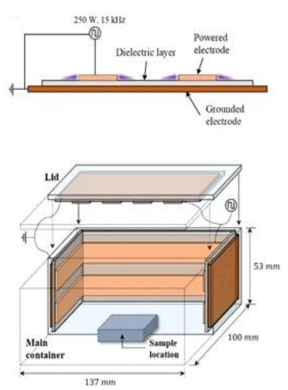
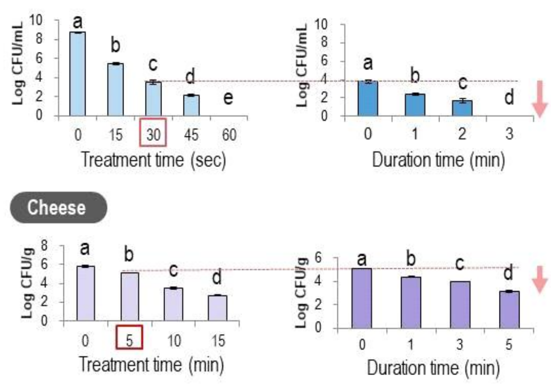
Yong et al. (2015). Food Microbiology

2. ENCAPSULATED TYPE PLASMA



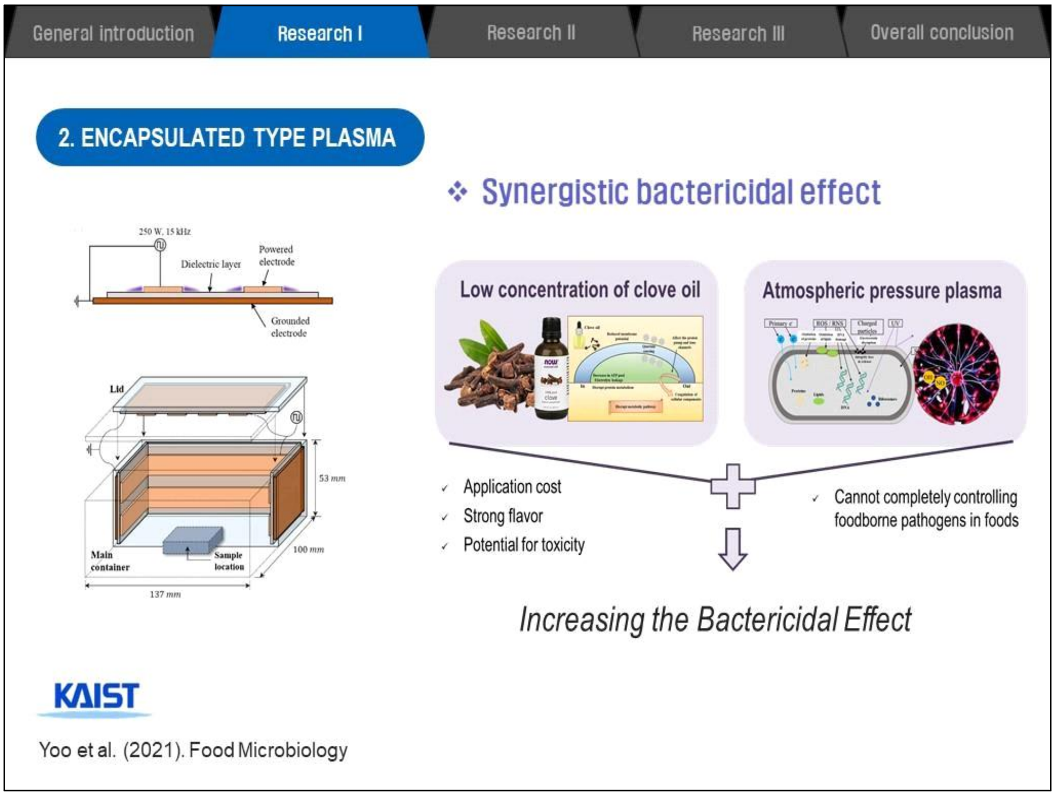
❖ Optimization condition

→ **Duration time**



KAIST

Yong et al. (2015). Food Microbiology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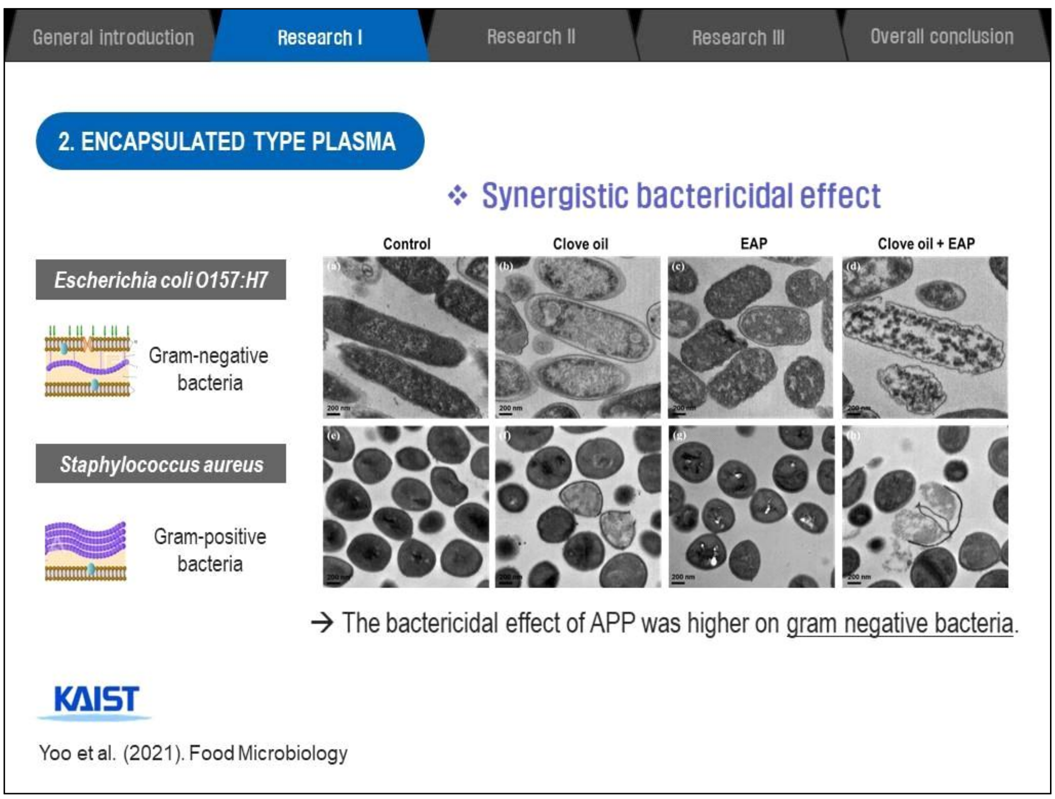
2. ENCAPSULATED TYPE PLASMA
Synergistic bactericidal effect
250 W, 15 kHz
Dielectric layer
Powered electrode
Grounded electrode
Lid
53 mm
100 mm
Main container
Sample location
137 mm
Low concentration of clove oil
Atmospheric pressure plasma
Application cost
Strong flavor
Potential for toxicity
Cannot completely controlling foodborne pathogens in foods
Increasing the Bactericidal Effect
KAIST
Yoo et al. (2021). Food Microbiology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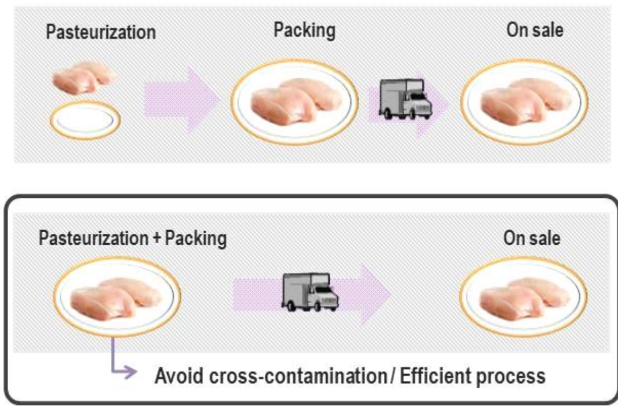
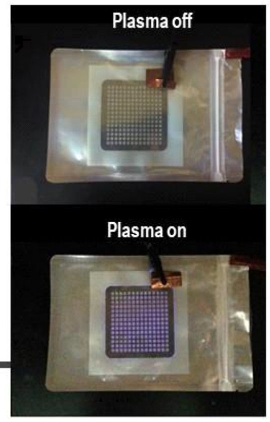
2. ENCAPSULATED TYPE PLASMA
Synergistic bactericidal effect
Escherichia coli O157:H7
Gram-negative bacteria
Staphylococcus aureus
Gram-positive bacteria
Control
Clove oil
EAP
Clove oil + EAP
→ The bactericidal effect of APP was higher on gram negative bacteria.
KAIST
Yoo et al. (2021). Food Microbiology

General introduction | Research I | Research II | Research III | Overall conclusion

3. PACKAGED TYPE PLASMA

= Flexible thin-layer dielectric barrier discharge plasma





KAIST

Lee et al. (2016). Food science and biotechnology
Yong et al. (2015). Food Research International

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3. PACKAGED TYPE PLASMA

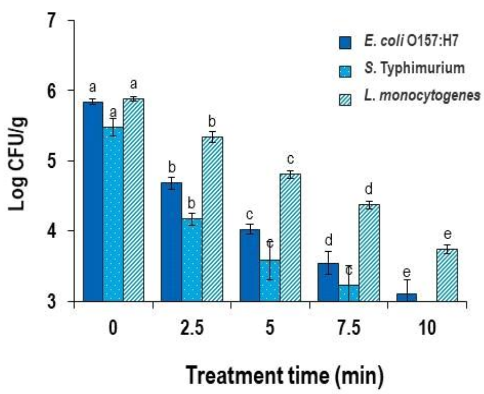

Fig. Pathogen counts (Log CFU/g)

Fig. *Salmonella* mutagenicity assay

Sample	Treatment[1]	Dose (μg/plate)	Number of revertant colonies (His+)[a] per plate			
			TA98 (-S9)	TA98 (+S9)	TA100 (-S9)	TA100 (+S9)
Chicken breasts	0	1,250	21±7	32±1	345±44	358±48
		2,500	28±8	33±8	385±18	404±6
		5,000	22±3	28±4	416±25	402±19
	10	1,250	22±5	34±3	317±30	350±34
		2,500	17±2	35±1	340±39	328±40
		5,000	21±5	34±8	322±40	358±31
Negative control	EtOH		20±3	24±5	304±15	356±25
Positive control	4-NQO	0.5	1063±14			
	2-A	2		2055±95		
	SA	0.5			861±88	
	2-AA[2)]	2				2343±112

[1)] EtOH, ethanol; 4-NQO, 4-Nitroquinoline-1-oxide; SA, Sodium azide; 2-AA, 2-Aminoanthracene dissolved in DDW
[a)] Values are the mean ± SD (P<0.05).

Lee et al. (2016). Food science and biotechnology

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3. PACKAGED TYPE PLASMA

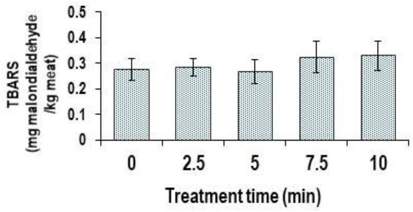

Fig.. Lipid oxidation values of chicken breast

Table. Texture profile of chicken breast

Treatment time (min)	Hardness (kg)	Adhesiveness (g/sec)	Springness (mm)	Chewiness (kg)
0	14.38	-31.02	0.71	1.18
5	13.58	-36.92	0.77	1.23
10	17.13	-39.26	0.73	1.76
SEM[1)]	2.508	10.351	0.035	0.281

Table. Surface color of chicken breast

Treatment time (min)	Color values		
	L^*	a^*	b^*
0	55.78^d	-0.21^a	8.42^b
2.5	59.62^d	-1.93^{ab}	6.83^b
5	64.61^c	-2.82^b	6.00^b
7.5	74.22^b	-3.05^b	9.43^b
10	82.18^a ↑	-1.31^{ab} ↓	14.79^a ↑
SEM[1)]	1.400	0.695	1.617

Lee et al. (2016). Food science and biotechnology

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3. PACKAGED TYPE PLASMA

Table. Surface color of pork and beef

Treatment time (min)	Pork butt		Beef loin	
	a^*	b^*	a^*	b^*
0	8.17^A	13.45	13.86^A	13.00^B
2.5	7.69^A	14.39	12.92^{AB}	13.80^{AB}
5	5.42^B	13.85	11.82^{AB}	13.47^{AB}
7.5	5.07^B	13.70	9.78^{BC}	14.63^{AB}
10	4.85^B	14.34	6.79^C	16.28^A
SEM[1)]	0.74	1.04	1.12	0.93

Frohling et al. (2012) also reported a green coloring effect in fresh pork due to plasma treatment.

- **Microbial safety of raw meat can be improved by APP system with minimal changes in color properties.**
- **Elucidation of the interaction of APP treatment with the meat color is highly required.**

Jayasena et al. (2015) Food Microbiology

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Elucidation of discoloration of myoglobin induced by atmospheric pressure plasma

Yong et el. (2018) Scientific Reports

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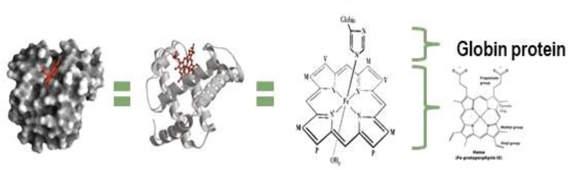
General introduction | Research I | Research II | Research III | Overall conclusion

Importance of meat color

- Primary factor for consumers' purchase decision.
- In the USA, 15% of retail beef is discounted or wasted due to discoloration.

Major contribution of meat color



= Myoglobin

= Globin protein
+ Protoporphyrin IX
+ Iron

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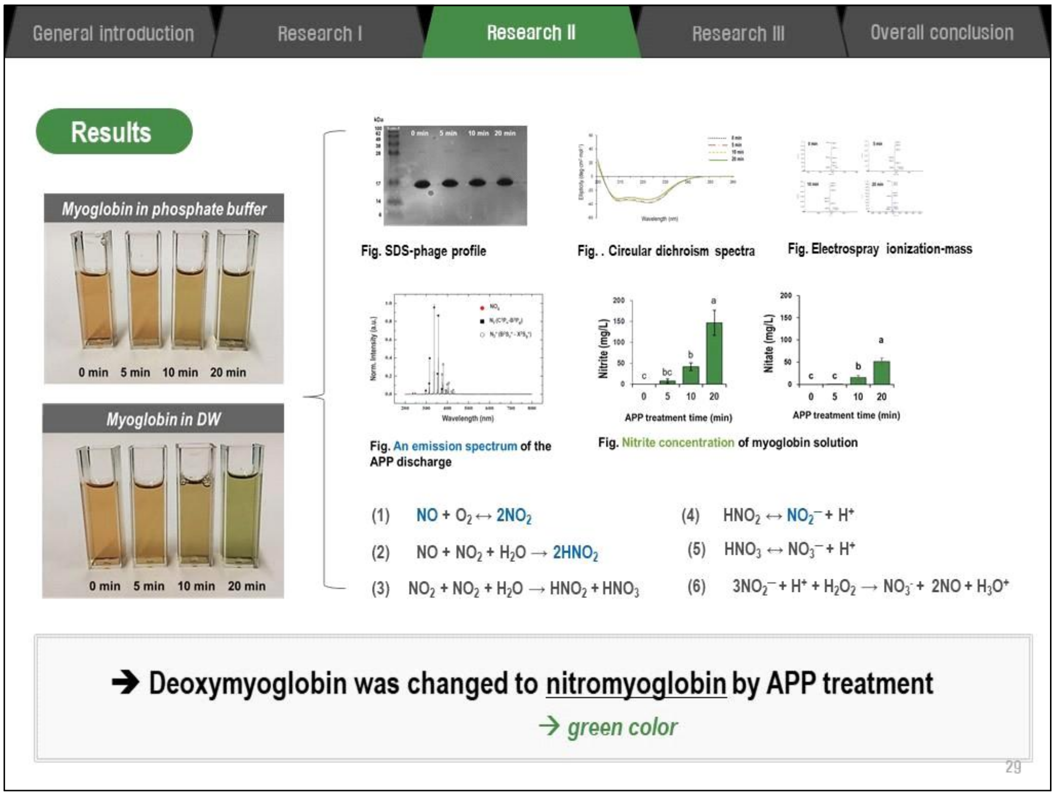
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Results
Myoglobin in phosphate buffer
0 min 5 min 10 min 20 min
Myoglobin in DW
0 min 5 min 10 min 20 min
Fig. SDS-phage profile
Fig. . Circular dichroism spectra
Fig. Electrospray ionization-mass
Fig. An emission spectrum of the APP discharge
Nitrite (mg/L)
APP treatment time (min)
Nitate (mg/L)
APP treatment time (min)
Fig. Nitrite concentration of myoglobin solution
(1) NO + O2 ↔ 2NO2
(2) NO + NO2 + H2O → 2HNO2
(3) NO2 + NO2 + H2O → HNO2 + HNO3
(4) HNO2 ↔ NO2− + H+
(5) HNO3 ↔ NO3− + H+
(6) 3NO2− + H+ + H2O2 → NO3- + 2NO + H3O+
➔ Deoxymyoglobin was changed to nitromyoglobin by APP treatment
→ green color
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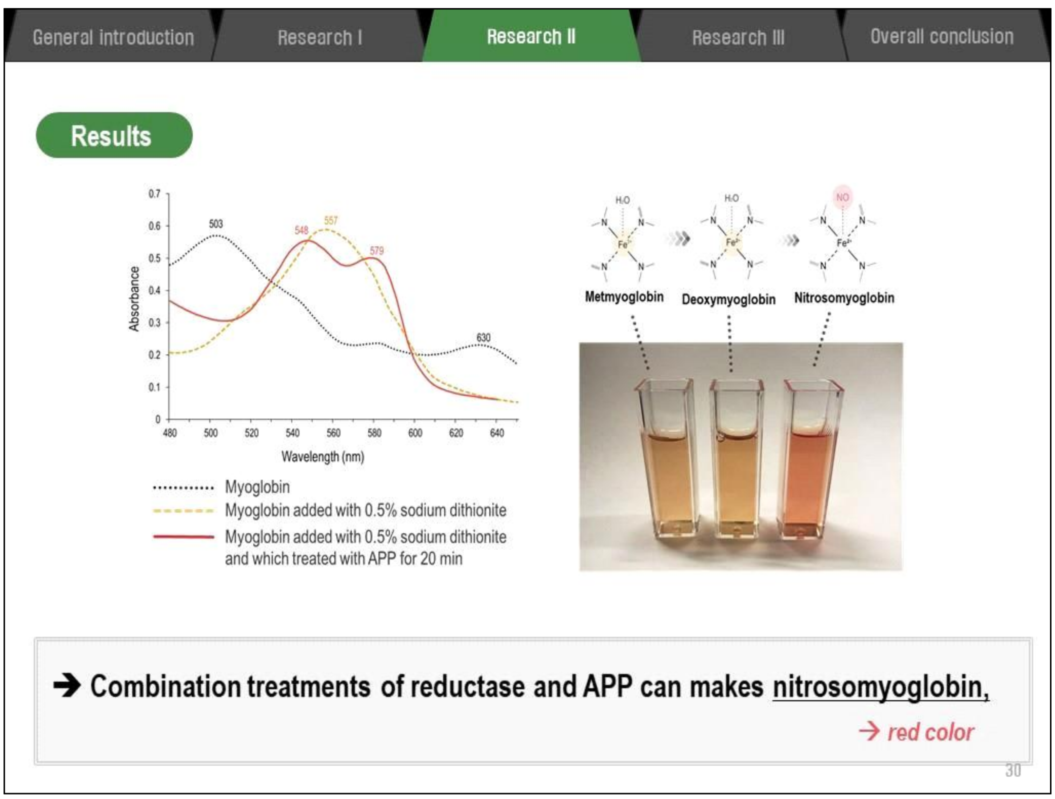
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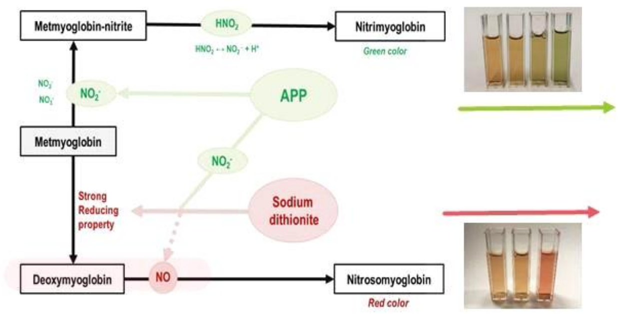
Results
Absorbance
Wavelength (nm)
503
548
557
579
630
Myoglobin
Myoglobin added with 0.5% sodium dithionite
Myoglobin added with 0.5% sodium dithionite and which treated with APP for 20 min
Metmyoglobin
Deoxymyoglobin
Nitrosomyoglobin
➔ Combination treatments of reductase and APP can makes nitrosomyoglobin,
→ red color
30

Conclusion

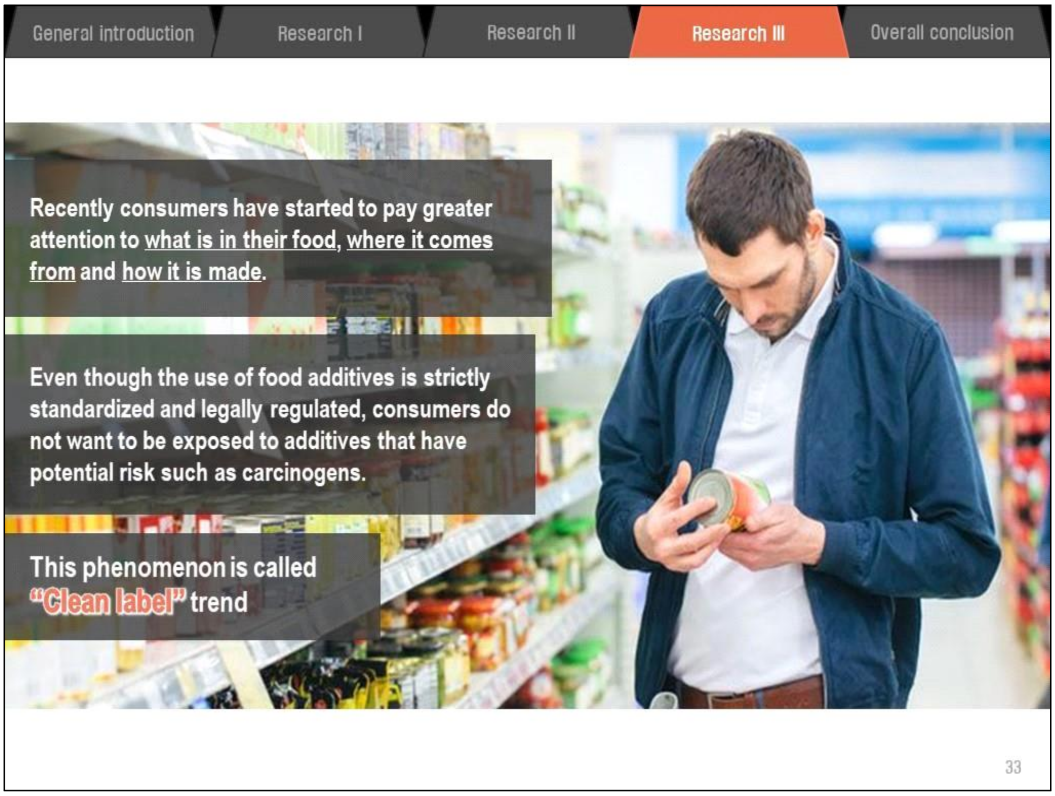


- ✓ These findings can be accelerate the application of APP in the industry by minimizing undesirable quality changes.
- ✓ Present study suggested the possibility that APP could be used as an nitrite source in meat product.

Color development & safety of meat products manufactured with atmospheric pressure plasma

KFE 한국핵융합에너지연구원 KOREA INSTITUTE OF FUSION ENERGY

KAIST 한국과학기술원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Recently consumers have started to pay greater attention to what is in their food, where it comes from and how it is made.
Even though the use of food additives is strictly standardized and legally regulated, consumers do not want to be exposed to additives that have potential risk such as carcinogens.
This phenomenon is called "Clean label" trend
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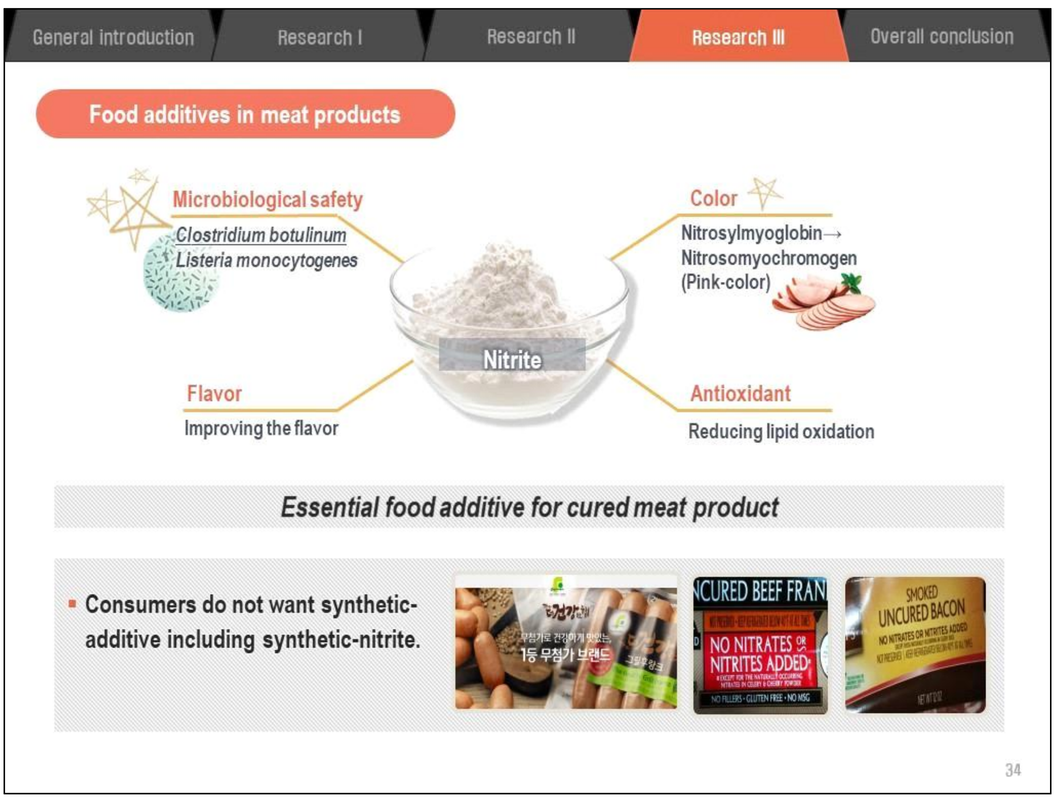
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Food additives in meat products
Microbiological safety
Clostridium botulinum
Listeria monocytogenes
Color
Nitrosylmyoglobin→
Nitrosomyochromogen
(Pink-color)
Nitrite
Flavor
Improving the flavor
Antioxidant
Reducing lipid oxidation
Essential food additive for cured meat product
▪ Consumers do not want synthetic-additive including synthetic-nitrite.
1등 무첨가 브랜드
NO NITRATES OR NITRITES ADDED
SMOKED
UNCURED BACON
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Experiments - 1

Fig. Effect of ascorbic acid addition and /or APP treatment on the pork color.

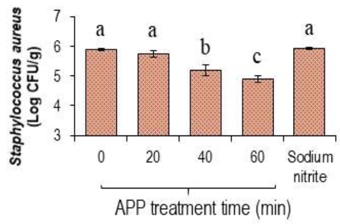
(a) Control
- Pork without any processing

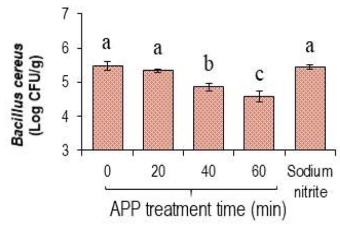
(b) APP
- Pork was treated with APP for 20 min

(c) Ascorbic acid
- Pork was immersed in 0.5% ascorbic acid solution for 10 min

(d) Ascorbic acid with APP
- Pork was immersed in 0.5% ascorbic acid solution for 10 min, then the solution was removed and treated with APP for 20 min

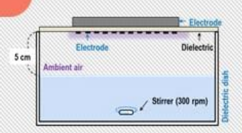
Jerky





Yong et al. (2019) Innovative Food Science and Emerging Technologies

Experiments - 2



Plasma-treated water (PTW)


ADVANCED SCIENCE NEWS

New Innovative Plasma Curing Process For Ham

A team of researchers found an innovative way of curing ham by using plasma-treated water as an alternative to chemical curing solutions.

The team compared two brine solutions made of sodium nitrite against PTW for curing of loin ham.

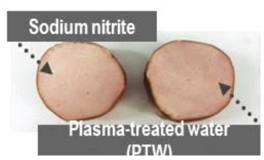
"Our previous work proposed that PTW is neither a chemical reagent nor a natural nitrite source but can be classified as purified water containing nitrite", according to team member Hae In Yong.

Table. *Salmonella* mutagenicity assay

Treatment	Dose (μg/plate)	Number of revertant colonies (His+) per plate[1) TA98 (-S9)	TA98 (+S9)	TA100 (-S9)	TA100 (+S9)
Sodium nitrite	188	30±7	39±5	329±47	323±41
	375	22±2	32±6	323±33	365±23
	750	34±3	30±6	385±44	468±4
	1,500	32±4	34±4	361±51	341±15
	3,000	33±6	29±3	341±65	456±50
PTW	188	16±5	23±9	293±85	282±19
	375	24±12	32±4	317±59	329±61
	750	22±4	33±1	338±72	338±40
	1,500	19±6	28±8	291±6	308±6
	3,000	20±3	27±7	332±29	346±13
Negative control[2)	EtOH	22±3	21±5	294±13	301±25
Positive control[2)	4-NQO	1108±22			
	2-AA		2214±48		
	SA			902±96	
	2-AA				2423±108

[1)Values are the mean ± SD ($P<0.05$).

[2)DW, Distilled water; 4-NQO, 4-nitroquinoline-1-oxide; SA, sodium azide; 2-AA, 2-aminoanthracene.



The loin ham manufactured using PTW showed no geno-toxicity by Ames test.

Yong et al. (2018) Plasma Processes and Polymers

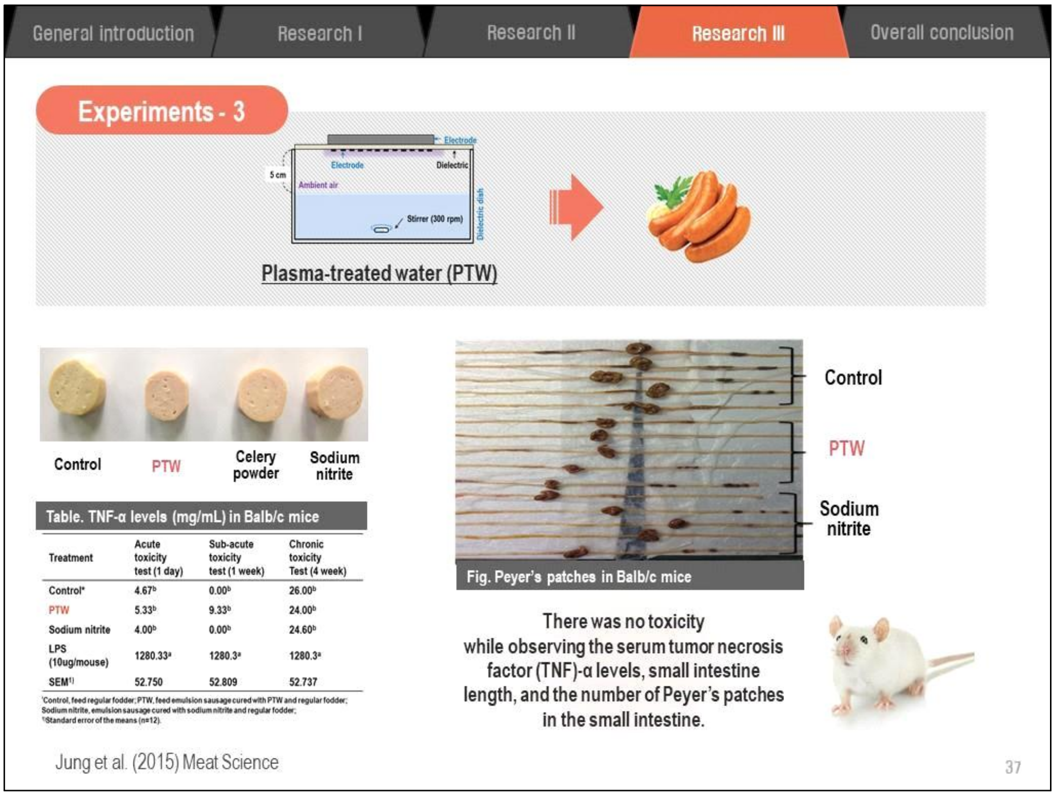
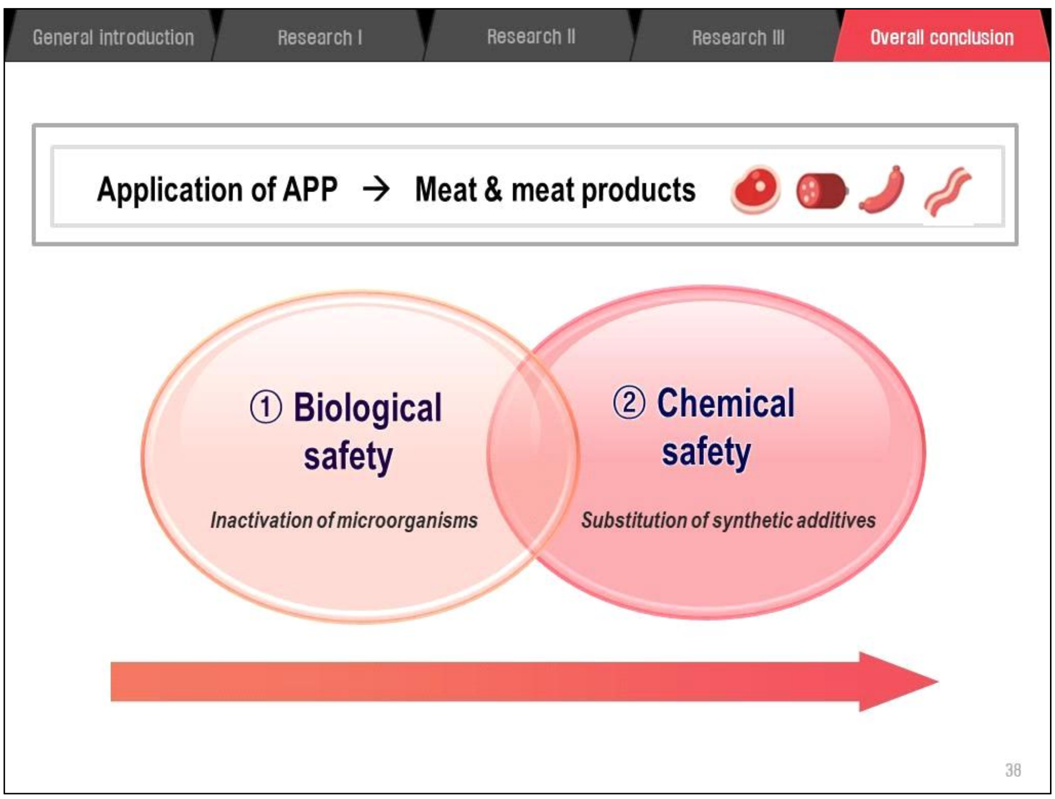


Table. TNF-α levels (mg/mL) in Balb/c mice

Treatment	Acute toxicity test (1 day)	Sub-acute toxicity test (1 week)	Chronic toxicity Test (4 week)
Control*	4.67^{b}	0.00^{b}	26.00^{b}
PTW	5.33^{b}	9.33^{b}	24.00^{b}
Sodium nitrite	4.00^{b}	0.00^{b}	24.60^{b}
LPS (10ug/mouse)	1280.33^{a}	1280.3^{a}	1280.3^{a}
SEM[1)]	52.750	52.809	52.737

*Control, feed regular fodder; PTW, feed emulsion sausage cured with PTW and regular fodder; Sodium nitrite, emulsion sausage cured with sodium nitrite and regular fodder;
[1)]Standard error of the means (n=12).



General introduction | Research I | Research II | Research III | **Overall conclusion**

APP is a promising technology for use in the meat and meat product industry as a non-thermal pasteurization and other technical advantages such as alternative curing method.

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THANK YOU

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KSAST
(사)한국축산학회

정밀 사료 공급과 지속 가능한 양돈 생산
Precision Feeding and Sustainable Swine Production

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Precision feeding and sustainable swine production

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The livestock industry faces several challenges, such as increasing production costs, managing livestock wastes, increasing demand for producing functional additives from producers, developing biosecurity, ensuring animal welfare, and preparing for the impacts of climate change. To cope with these risks, there is a wide scope to improve livestock sector practices so that they are more sustainable, and equitable. Sustainable swine production (SSP) is the effective and efficient rearing of livestock with neutral socio-economic and environmental outcomes. The objective of SSP is to 1) reduce greenhouse gas emissions, 2) maintain biodiversity, 3) provide ecosystem services, 4) improve nutrient cycling, and 5) increase soil carbon sequestration. Animal feed is a major component of the environmental sustainability of livestock production systems. Specifically, nitrogen (N) emissions from pork production systems have several detrimental environmental consequences, because of the low efficiency of converting dietary protein into carcass lean and the high environmental impact of various types of N losses. Major advancements in the development and use of accurate feed formulation approaches and precision feeding technologies can greatly enhance profitability, the efficiency of energy, and nutrient utilization to achieve sustainable production of high-quality and safe pork while minimizing negative environmental impacts. Life cycle assessment (LCA) of environmental impacts of food production systems has become a widely accepted reference method for guiding decisions and transitioning toward more globally sustainable food production and consumption patterns. Formulating diets multi-objectively (use of eco-friendly, and local feed ingredient) represents an efficient way to reduce the environmental impacts of pig production without compromising animal performance. Therefore, future swine feeding programs must be designed not only least-cost basis, but they must also minimize the environmental footprint of pork production by adopting multi-objective feed formulation in combination with precision nutrition practices.

Keywords: livestock industry, multi-objective feed formulation, nitrogen emission, precision swine nutrition, sustainable swine production

고온 및 밀집 사육 스트레스에 노출된 육계의 스트레스 저감 및 장벽 기능 강화를 위한 기능성 사료 물질 개발
Development of Functional Feed Materials to Improve Intestinal Barrier Functions and to Reduce Stress of Broiler Chickens raised under Heat Stress and High Stocking Density

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2023년 한국축산학회 신진과학자 특강

Development of functional feed materials to improve intestinal barrier functions and to reduce stress of broiler chickens raised under heat stress and high stocking density

Chungbuk National University

Jong Hyuk Kim

Outline of today's presentation

1. 서론: 고온 및 밀집사육 스트레스, 장벽기능 및 기능성 사료 물질
2. 실험 1: 닭장상피세포의 산화스트레스 저감 사료 물질 검증
3. 실험 2: 복합스트레스에 노출된 육계의 사료내 트레오닌, 트립토판 및 글라이신 첨가 효과 검증
4. 실험 3: 복합스트레스에 노출된 육계의 사료내 트레오닌 첨가 수준에 따른 효과 검증

Introduction

- 고온 및 밀집 사육스트레스
- 장벽 기능
- 기능성 사료 물질

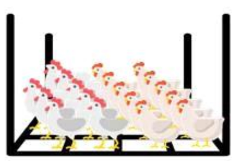
스트레스

- **가축에서의 스트레스**: 동물의 복지 및 생산성에 부정적인 영향을 끼치는 환경 조건

- 가금의 스트레스의 종류
  - 고온 스트레스
  - 밀집 사육 스트레스
  - 저온 스트레스
  - 수송 스트레스
  - 영양소 결핍

저온 스트레스

고온 스트레스



밀집 사육 스트레스

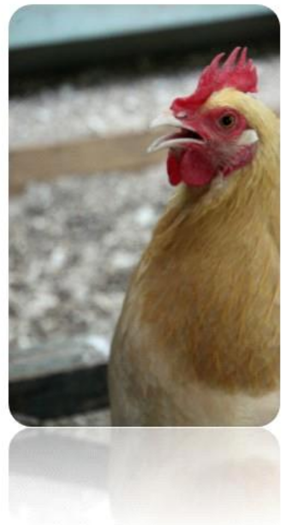
수송 스트레스

영양소 결핍 스트레스

고온 스트레스

가금류

- 닭의 체온은 41도로 높은 체온을 가진 온혈 동물
- 닭은 땀샘이 없고, 깃털로 덮여 있음
- 지방층이 두꺼워 체내 열 발산 능력 부족
- 고온 환경
  - 대부분 호흡을 통해 체열 발산
  - 일부 총배설강을 통해 체열 발산
  - 체표면적을 넓혀 체열 발산
- 극심한 고온 환경
  - 과호흡 (panting)을 통해 체열 발산



고온 스트레스

고온 스트레스로 인한 육계의 생체 변화

- 사료섭취량 감소: 사료 섭취 감소를 통한 체온 상승 방지
- 음수량 증가: 영양소 소화율 감소 및 연변 발생(깔짚 품질 저하)
- 과호흡으로 인한 호흡기성 알칼로시스 발생
- 행동 최소화: 사료섭취 행동의 감소
- 스트레스 관련 호르몬(코티코스테론)의 증가
  - 코티코스테론은 부신피질에서 생성되는 스테로이드성 호르몬
  - 발육을 위한 포도당생합성과정에 관여
    - 스트레스를 받는 동안 에너지 생산 가능
  - 지속적인 스트레스: 코티코스테론 고갈 및 불충분
    - 에너지 생산 중단: 생산성 감소 및 폐사 발생
- 체내 대사율 증가
- 체내 저장 영양소 요구량 증가

밀집 사육 스트레스

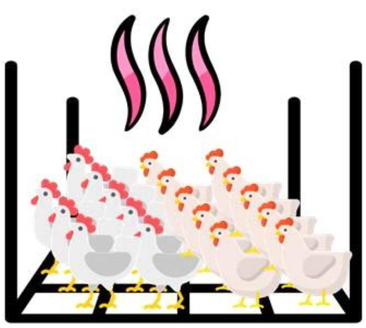
밀집 사육 스트레스

- 동물을 한정된 축사에서 대규모 밀집 사육하는 형태
- 높은 사육 밀도에서 발생하는 환경 스트레스
- **사육밀도**: 사육시설 면적을 사육두수로 나눈 값

밀집 사육 스트레스

밀집 사육 스트레스

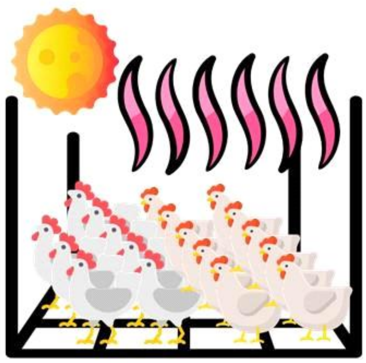
- 최소한의 좁은 공간: **체내 열 발산의 어려움**
  - 고온 스트레스와 유사한 환경
- 스트레스로 인한 **면역력 감소**: 질병 및 전염병 발생 증가
- **분뇨량 증가**: 계사내 암모니아 등 악취 및 민원 증가
- **동물 복지 문제 유발**: 소비자의 부정적인 인식 증가



고온 및 밀집 사육 스트레스

고온 및 밀집 사육 스트레스

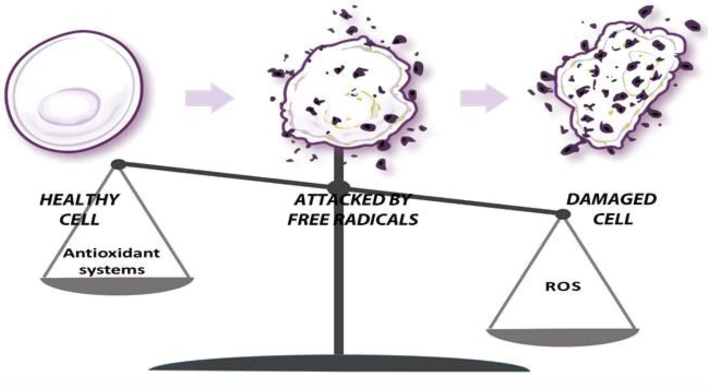
- 여름철 계사 환경과 유사함
- 2개의 스트레스를 동시에 받기 때문에 2배의 스트레스 가중
- 개인 공간 부족으로 이상행동 유발
- 과호흡으로 인한 계사내 습도 증가(깔짚 품질↓ 및 분뇨 수분함량↑)
- 급격한 생산성 저하 및 폐사율 증가



산화 스트레스

산화 스트레스

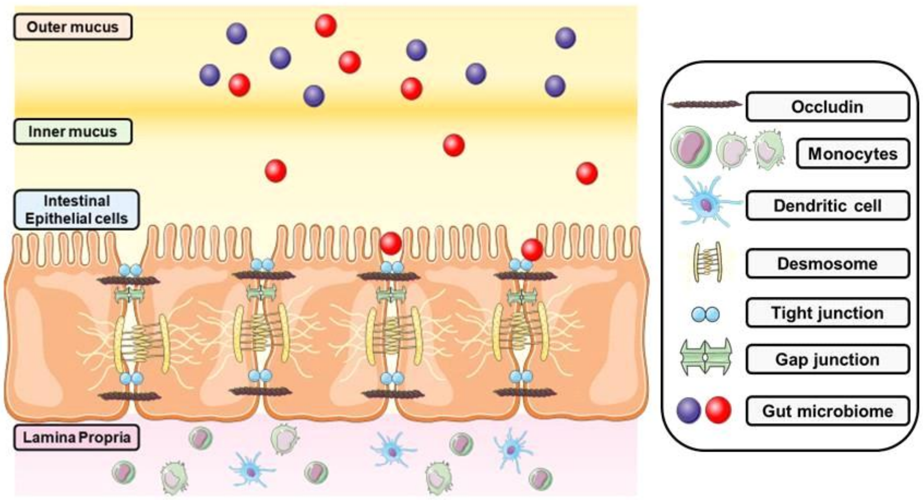
- 환경 스트레스로 인한 세포의 구조 및 생리적 영향
  - 산화 대사 능력 감소
  - 체내 산화 스트레스 유발
- 산화 스트레스: 항산화 시스템과 활성산소의 불균형
- 세포의 손상: 장 세포 손상으로 인한 생산성, 소화율 및 건강 감소



장벽 기능

장벽 기능

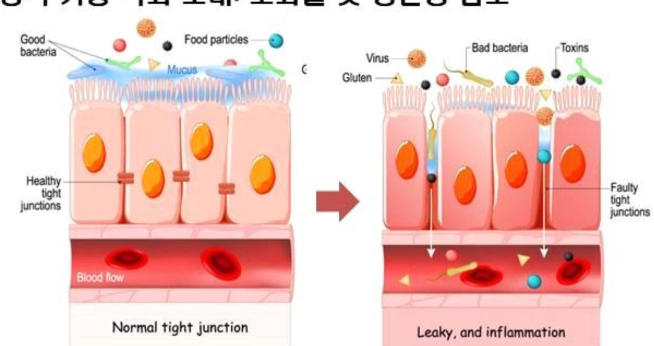
- 외부 미생물 및 유해물질의 체내 유입 차단



장벽 기능

스트레스로 인한 장벽 기능 약화

- 장내 밀착연접 약화
  - 외부 미생물 및 유해 물질 유입 증가
  - 과면역반응
  - 장벽 기능 약화 초래: 소화율 및 생산성 감소



스트레스 상황에서의 육계 장내 밀착연접 강화를 위한 다양한 기능성 사료 물질 연구가 필요

기능성 사료 물질

아미노산

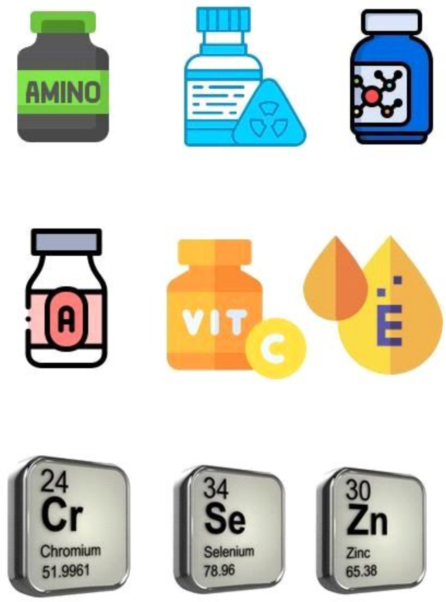
- 트레오닌: 뮤신 생성 장벽 강화
- 트립토판: 세로토닌 및 멜라토닌 전구체
- 글라이신: 크레아틴, 글루타치온

비타민

- 비타민 A: 면역 기능 향상
- 미타민 C: 항산화 효과
- 비타민 E: 항산화 효과

미네랄

- 크롬: 인슐린
- 셀레늄: 항산화 효과
- 아연: 면역 강화

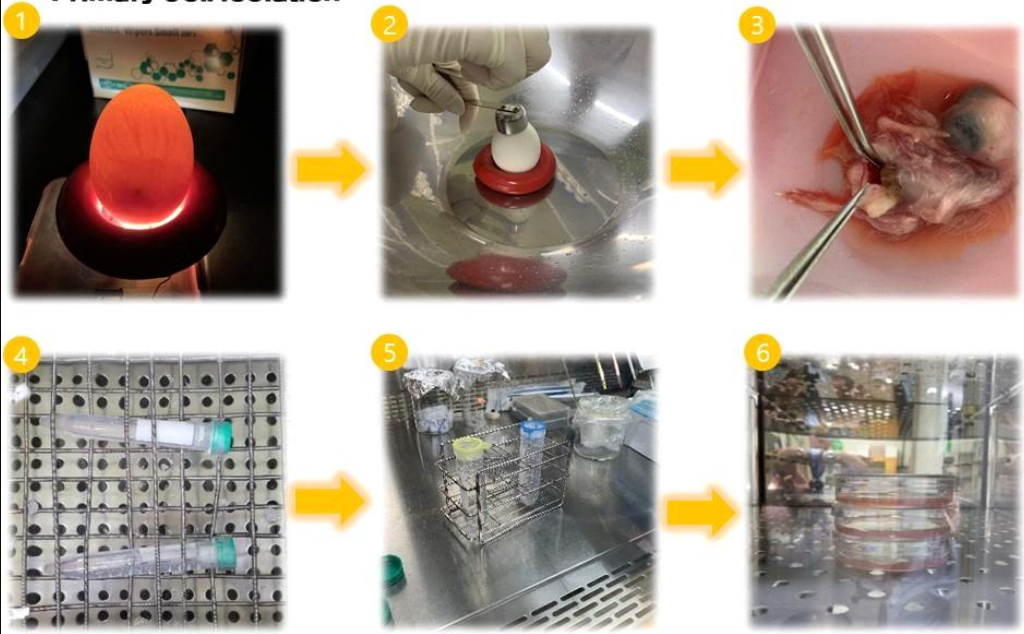


Experiment 1

Effects of functional nutrients on chicken intestinal epithelial cells induced with oxidative stress

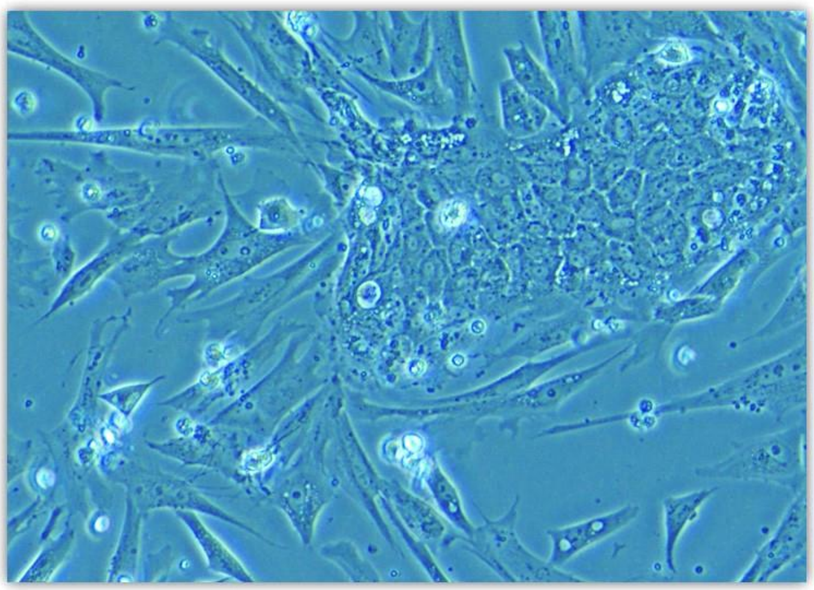
Materials and Methods

- **Primary cell isolation**



Materials and Methods

- **Primary cell morphology**



Materials and Methods

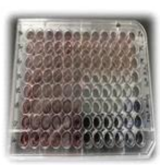
- **Experimental design**

	PC	NC	Thr	Trp	Gly	Vit C	Vit E	Vit A	Zn	Se	Cr
Basal	DMEM + 10% FBS + 1% Insulin + 1% Penicilin / Streptomicin										
H_2O_2	-	+	+	+	+	+	+	+	+	+	+
Supplement	-	-	Thr	Trp	Gly	Vit C	Vit E	Vit A	Zn	Se	Cr

Materials and Methods

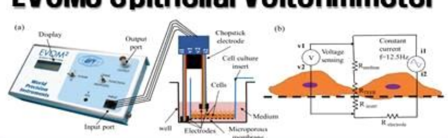
- **Measurements**

Cell viability
- Quanti-Max WST-8 assay

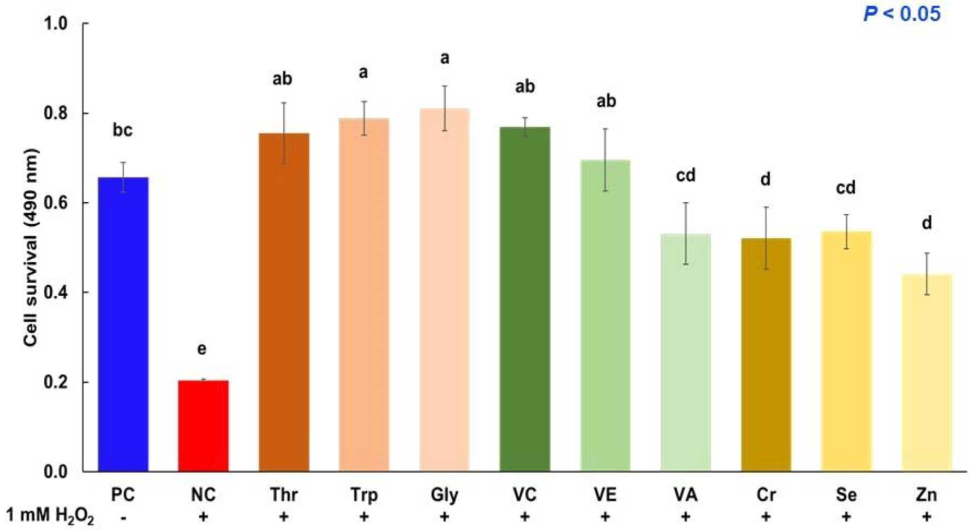



Permeability
- Fluorescein isothiocyanate (FITC)-dextran analysis

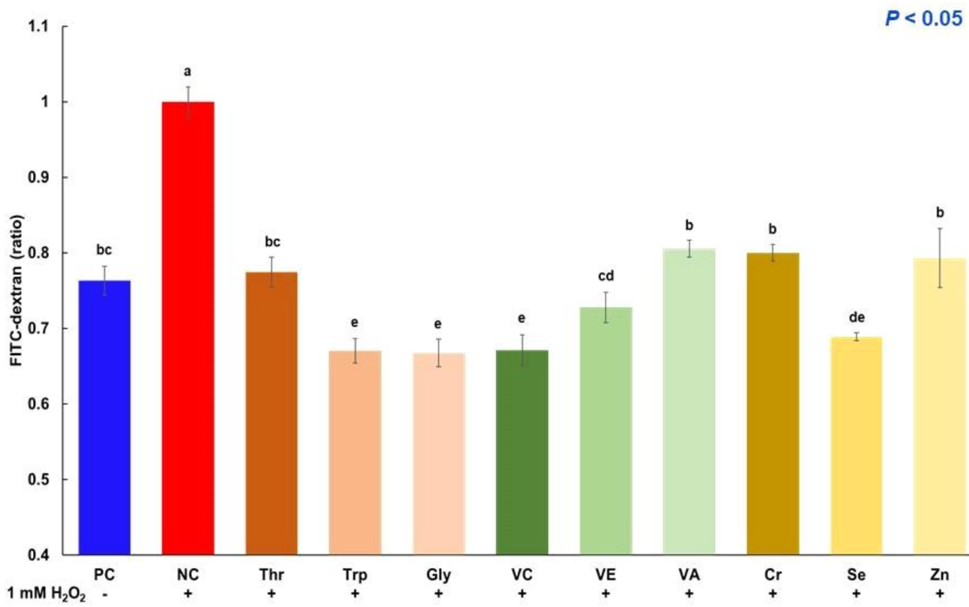
Tight junction
- Trans-epithelial electrical resistance
- EVOM3 epithelial voltohmmeter



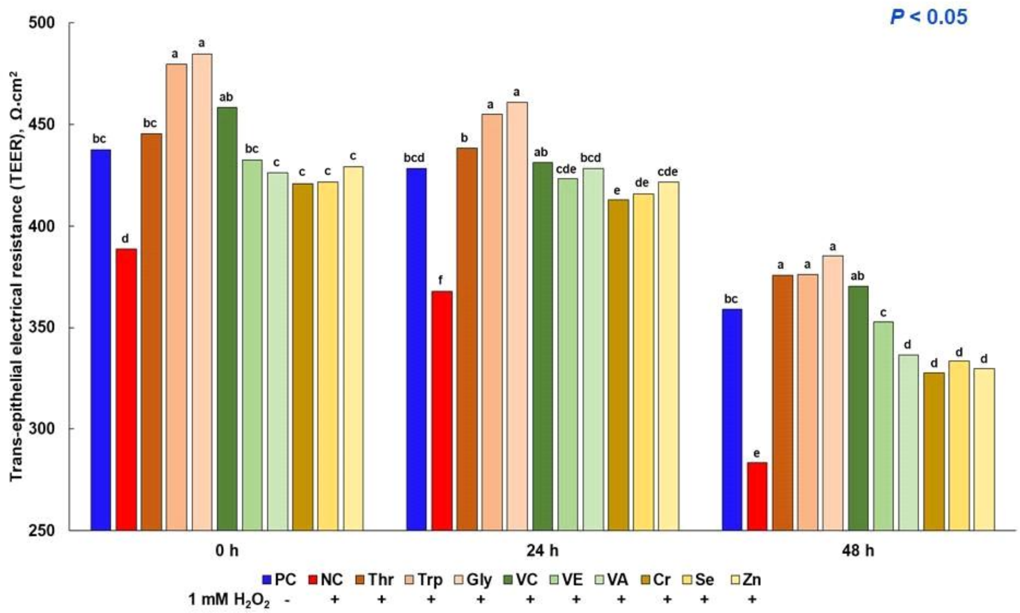
Results – Cell viability



Results – FITC-dextran (permeability)



Results – Trans-epithelial electrical resistance



Conclusion

All functional nutrients used in the current study improve cell viability and decrease intestinal permeability

Thr, Trp, Gly, and VC are more effective in improving cell viability and decreasing intestinal permeability in intestinal epithelial cells

The current experiment can provide the potential approach to screen various functional nutrients *in vitro* before conducting their *in vivo* studies

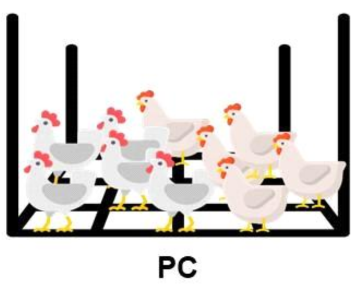
Experiment 2

Effect of dietary supplementation of threonine, tryptophan, and glycine on growth performance, relative organ weight, stress biomarker, and intestinal barrier function in broiler chickens raised under multiple stress conditions

Materials and Methods

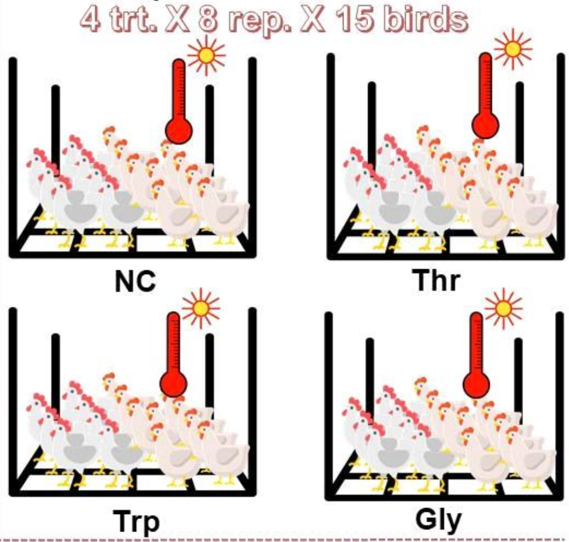
Normal conditions

1 trt. X 8 rep. X 10 birds



Multiple stress conditions

4 trt. X 8 rep. X 15 birds



Stocking density: 16.9 birds/m²
Temperature: 23 ± 0.7°C

Stocking density: 25.3 birds/m²
Temperature: 30 ± 0.3°C for 10 h/d and 23 ± 0.2°C for remaining time

Materials and Methods

- Treatments

Condition	Dietary treatment	
Normal condition	Positive control (PC)	Basal diet
Multiple stress conditions	Negative control (NC)	Basal diet
	Threonine (Thr)	Basal diet + 0.68% digestible Thr (100% greater than basal diet)
	Tryptophan (Trp)	Basal diet + 0.19% digestible Trp (100% greater than basal diet)
	Glycine (Gly)	Basal diet + 1.60% digestible Gly (100% greater than basal diet)

Materials and Methods

- Measurements

Growth performance
- Body weight gain
- Feed intake
- Feed efficiency

Relative organ weight
- Relative organ weight

Stress response
- Blood H:L ratio
- Feather corticosterone

Intestinal health
- Intestinal morphology in jejunum
- Goblet cell count
- Intestinal permeability

Materials and Methods

- Statistical analysis was performed using the PROC MIXED procedure of SAS (SAS Institute Inc., NC, USA)
- Each cage was considered as the experimental unit for all analyses
- Outlier data were checked using the UNIVARIATE procedure of SAS
- The LSMEANS procedure was used to calculate treatment means and the PDIFF option of SAS was used to separate the means if the difference was significant.
- Significance for statistical tests was set at $P < 0.05$

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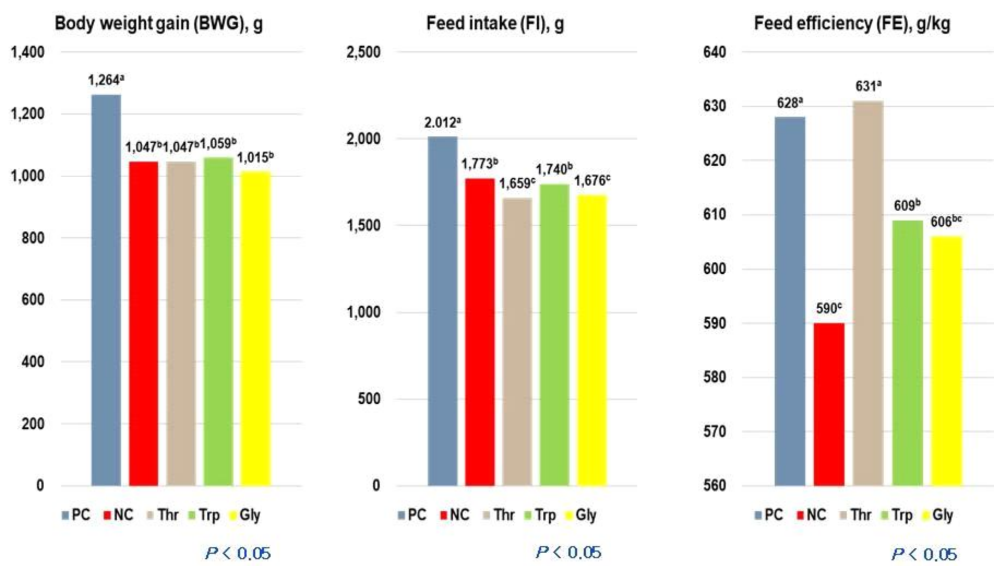
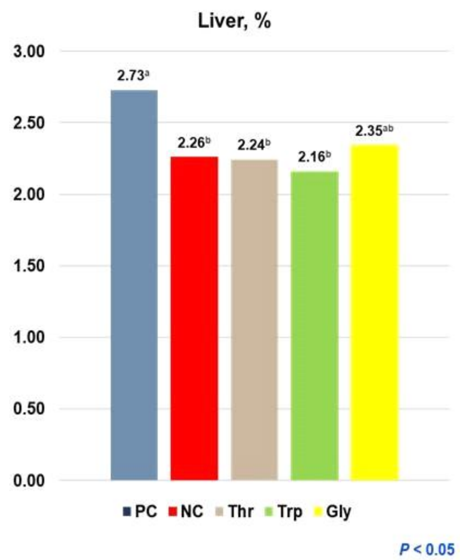
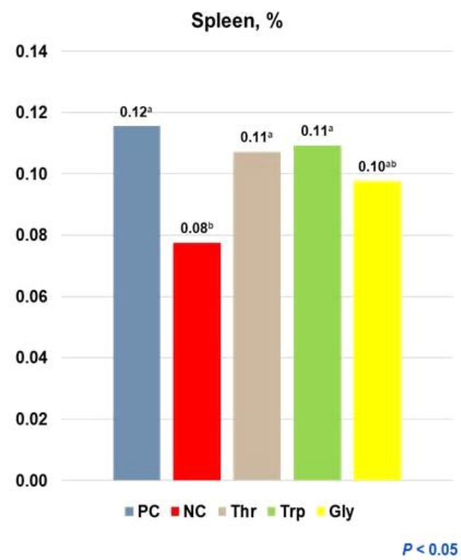
Results – growth performance

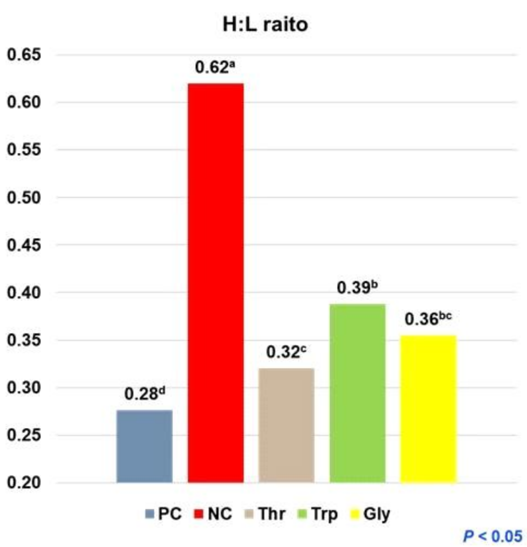


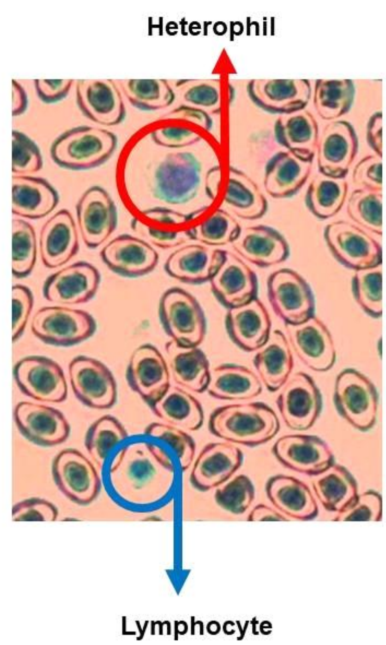
Results – relative organ weight



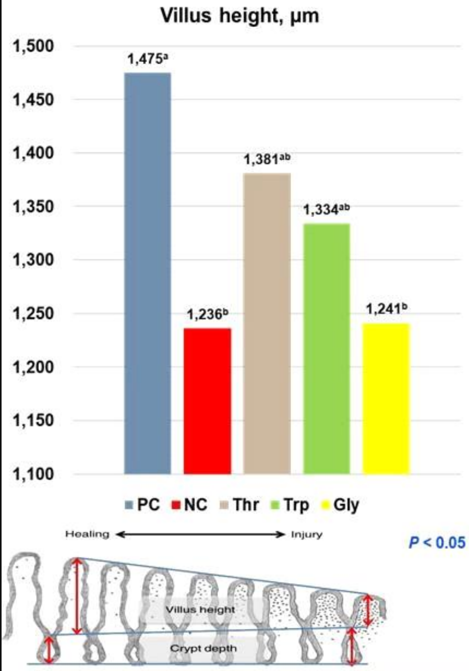


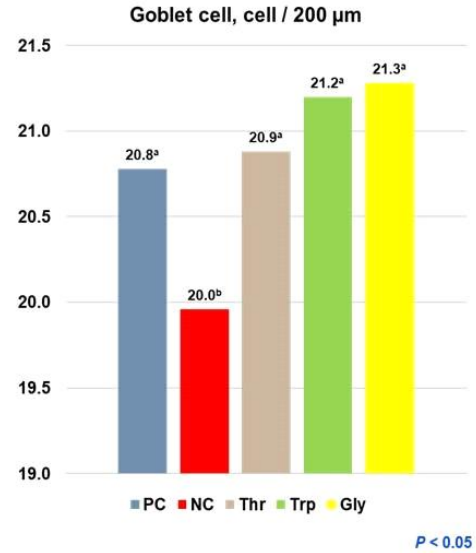
Results – stress biomarker



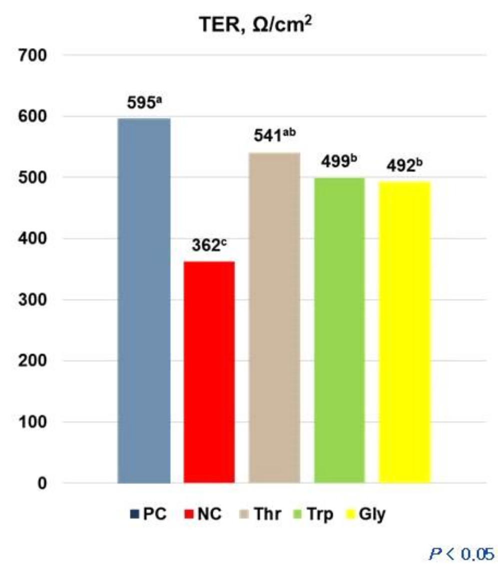


Results – jejunal morphology





Results – intestinal barrier permeability



Conclusion

The multiple conditions decrease growth performance and intestinal health of broiler chickens

Dietary supplementation of Thr, Trp, and Gly improves growth performance of broiler chickens raised under multiple conditions possibly due to decreased stress responses and improved intestinal health

Dietary supplementation of Thr can be a novel dietary treatment to improve growth performance and health in broiler chickens raised under multiple conditions

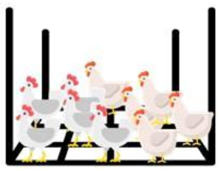
Experiment 3

Effect of dietary concentrations of threonine on growth performance, antioxidant capacity, stress biomarker, and intestinal barrier function in broiler chickens raised under multiple stress conditions

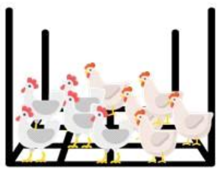
Materials and Methods

Normal conditions

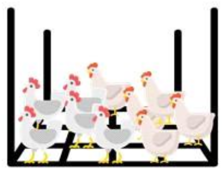
3 trt. X 6 rep. X 38 birds



PC (positive control)



50% Thr



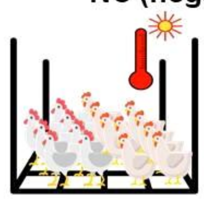
100% Thr

Stocking density: 9 birds/m²
Temperature: 24 ± 0.9°C

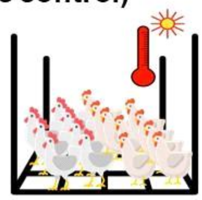
Multiple stress conditions

3 trt. X 6 rep. X 76 birds

NC (negative control)



50% Thr



100% Thr

Stocking density: 18 birds/m²
Temperature: 31 ± 0.3°C for 10 h/d and 24 ± 1.6°C for remaining time

Materials and Methods

- **Treatments**

Condition	Dietary treatments	
Normal condition	Positive control (PC)	Basal diet
	50% Thr	Basal diet + 0.34% digestible Thr (50% greater than basal diet)
	100% Thr	Basal diet + 0.68% digestible Thr (100% greater than basal diet)
Multiple stress conditions	Negative control (NC)	Basal diet
(Heat stress + High stocking density)	50% Thr	Basal diet + 0.34% digestible Thr (50% greater than basal diet)
	100% Thr	Basal diet + 0.68% digestible Thr (100% greater than basal diet)

Materials and Methods

- Measurements

Growth performance

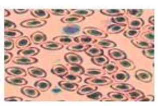
- Body weight gain
- Feed intake
- Feed efficiency

Antioxidant capacity

- TAC (total antioxidant capacity)
- ROS (reactive oxygen species)
- MDA (malondialdehyde)

Stress response

- Blood H:L ratio
- Feather corticosterone



Intestinal health

- Intestinal morphology in jejunum
- Goblet cell count
- Intestinal permeability

Materials and Methods

- Statistical analysis was performed using the PROC MIXED procedure of SAS (SAS Institute Inc., NC, USA)
- The statistical model included conditions, dietary supplements of Thr levels, and their interactions
- Orthogonal polynomial contrast tests were also performed to verify the linear and quadratic effect of increasing inclusion levels of Thr in diets
- Significance for statistical tests was set at $P < 0.05$

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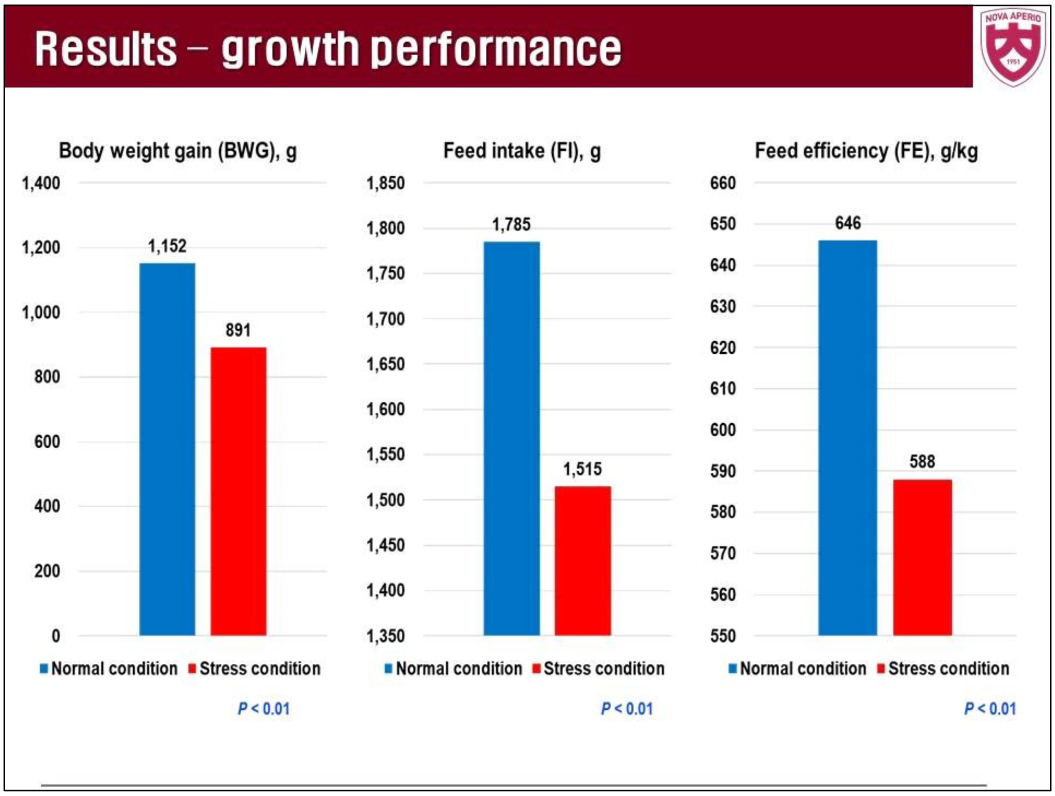
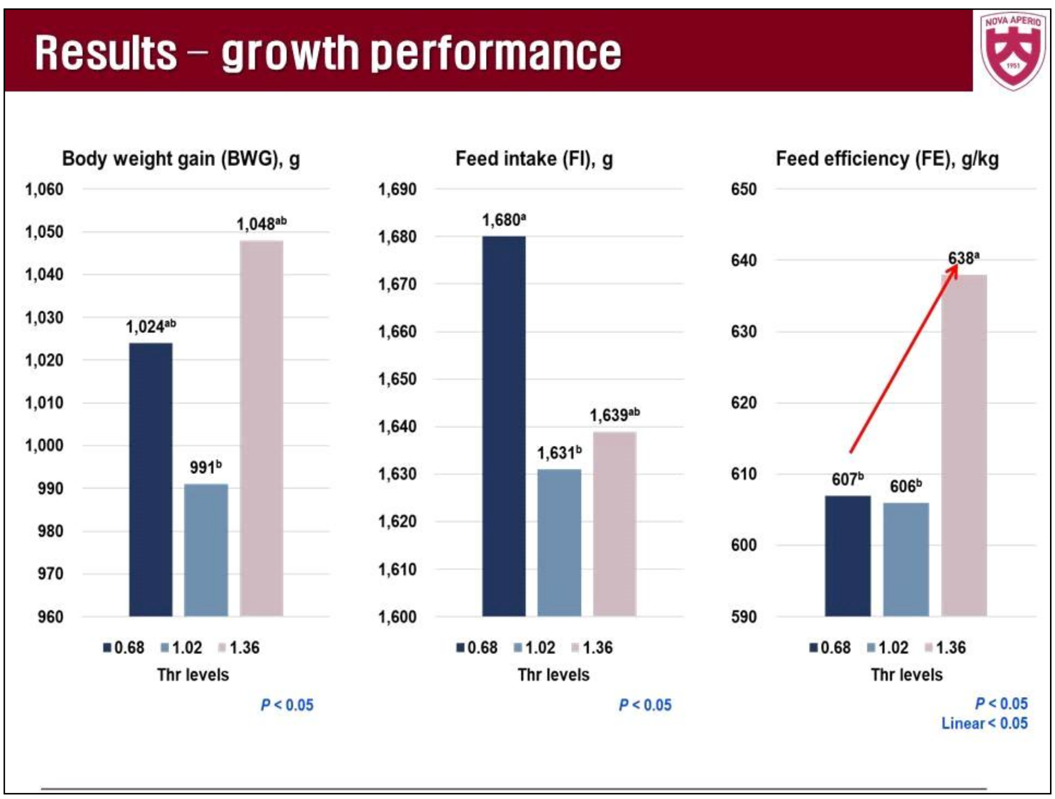
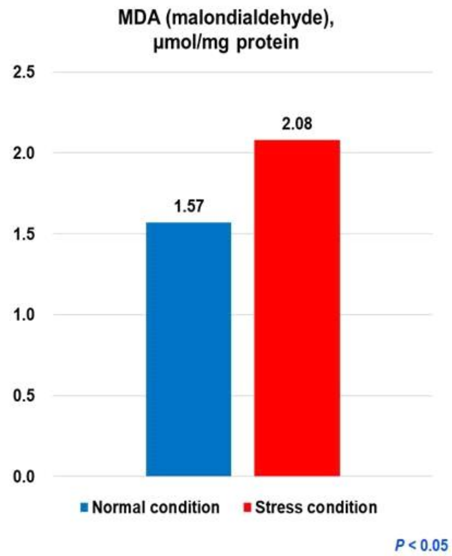
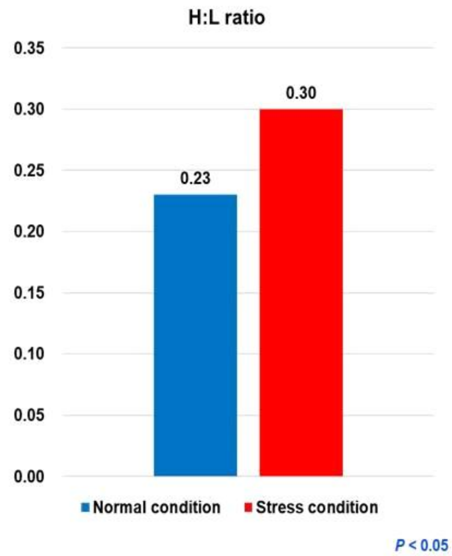

Results – growth performance
NOVA APERIO
Body weight gain (BWG), g
1,152
891
Feed intake (FI), g
1,785
1,515
Feed efficiency (FE), g/kg
646
588
Normal condition
Stress condition
P < 0.01

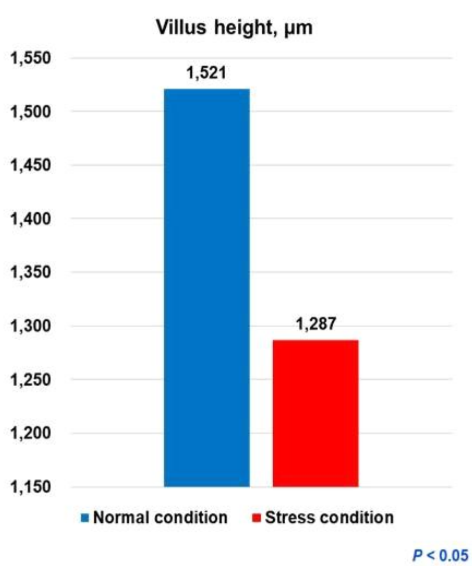

Results – growth performance
NOVA APERIO
Body weight gain (BWG), g
1,024ab
991b
1,048ab
Feed intake (FI), g
1,680a
1,631b
1,639ab
Feed efficiency (FE), g/kg
607b
606b
638a
0.68
1.02
1.36
Thr levels
P < 0.05
Linear < 0.05

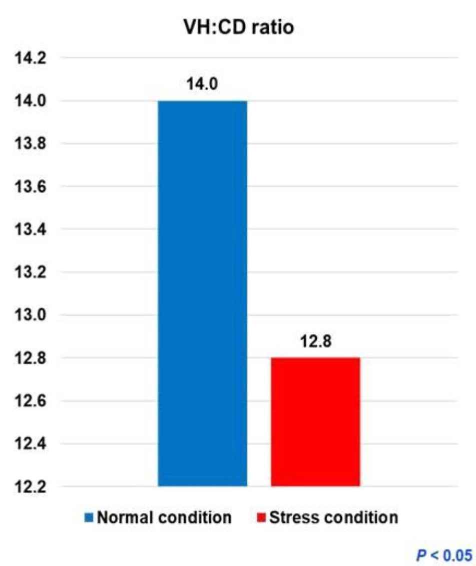
Results – antioxidant capacity, stress biomarker

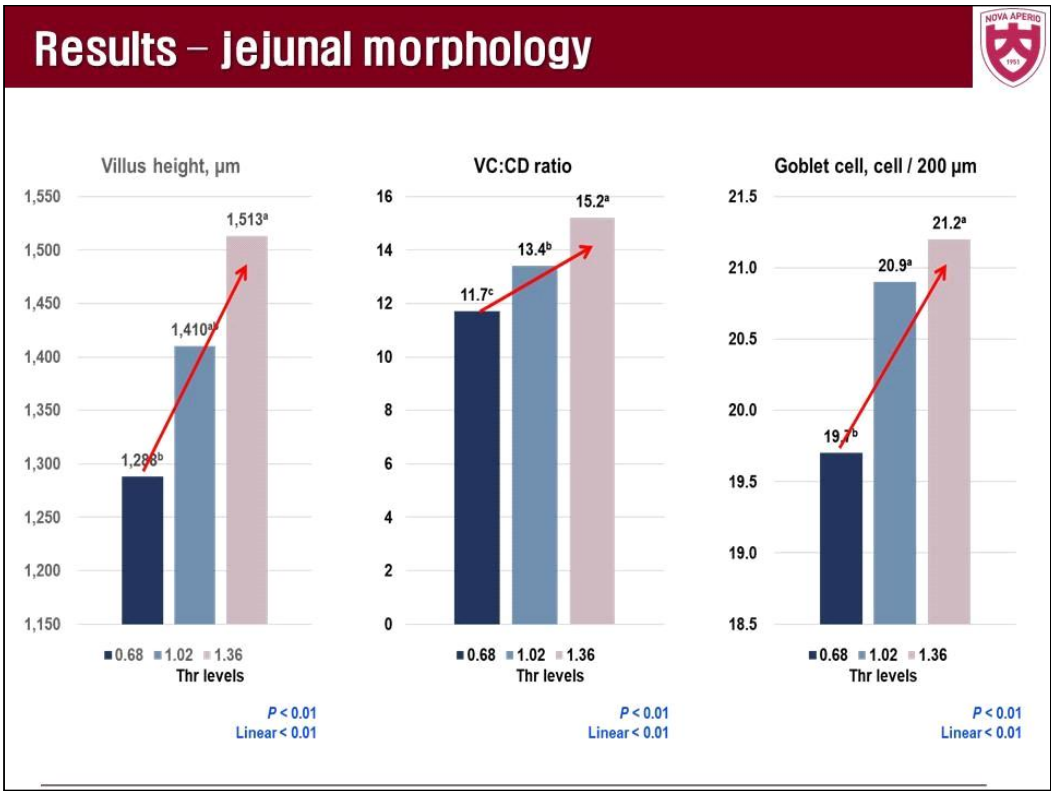


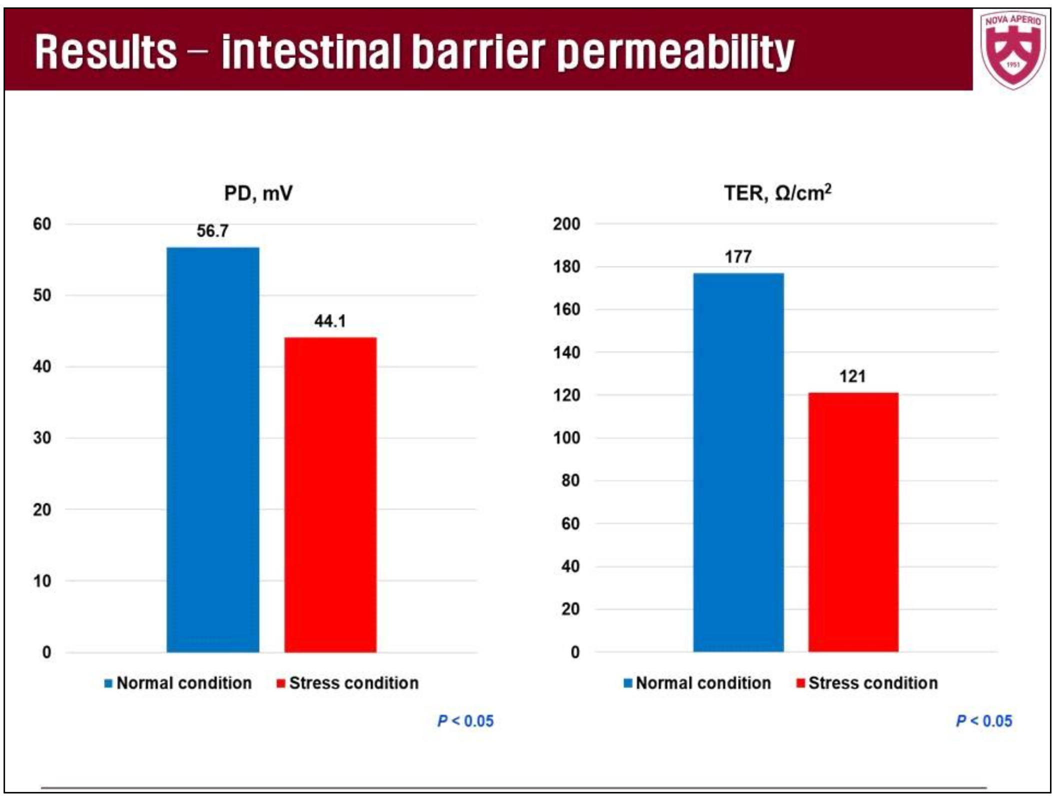


Results – jejunal morphology

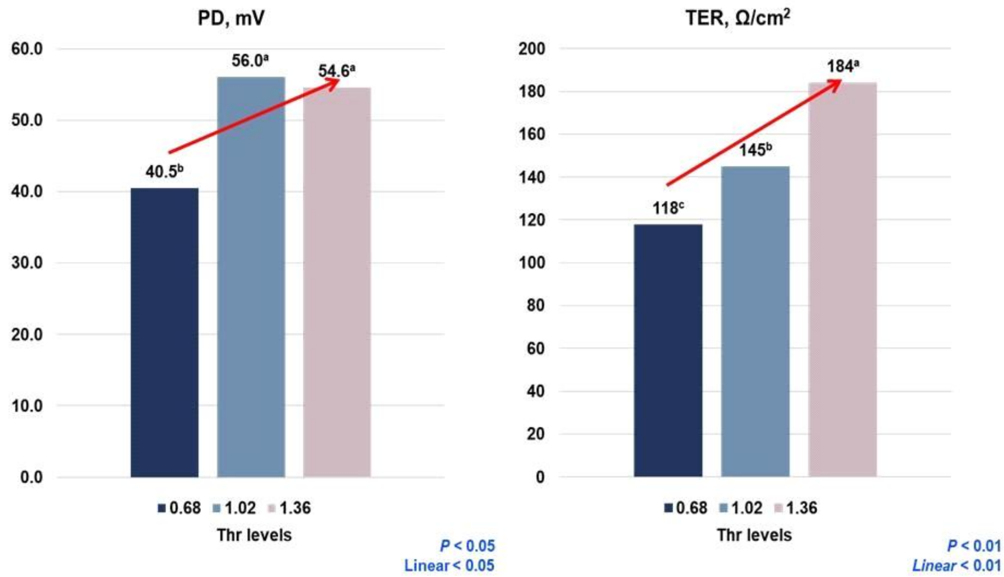





Results – jejunal morphology
Villus height, µm
1,513a
1,410ab
1,288b
VC:CD ratio
15.2a
13.4b
11.7c
Goblet cell, cell / 200 µm
21.2a
20.9a
19.7b
0.68 1.02 1.36
Thr levels
P < 0.01
Linear < 0.01


Results – intestinal barrier permeability
PD, mV
56.7
44.1
TER, Ω/cm2
177
121
Normal condition Stress condition
P < 0.05

Results – intestinal barrier permeability

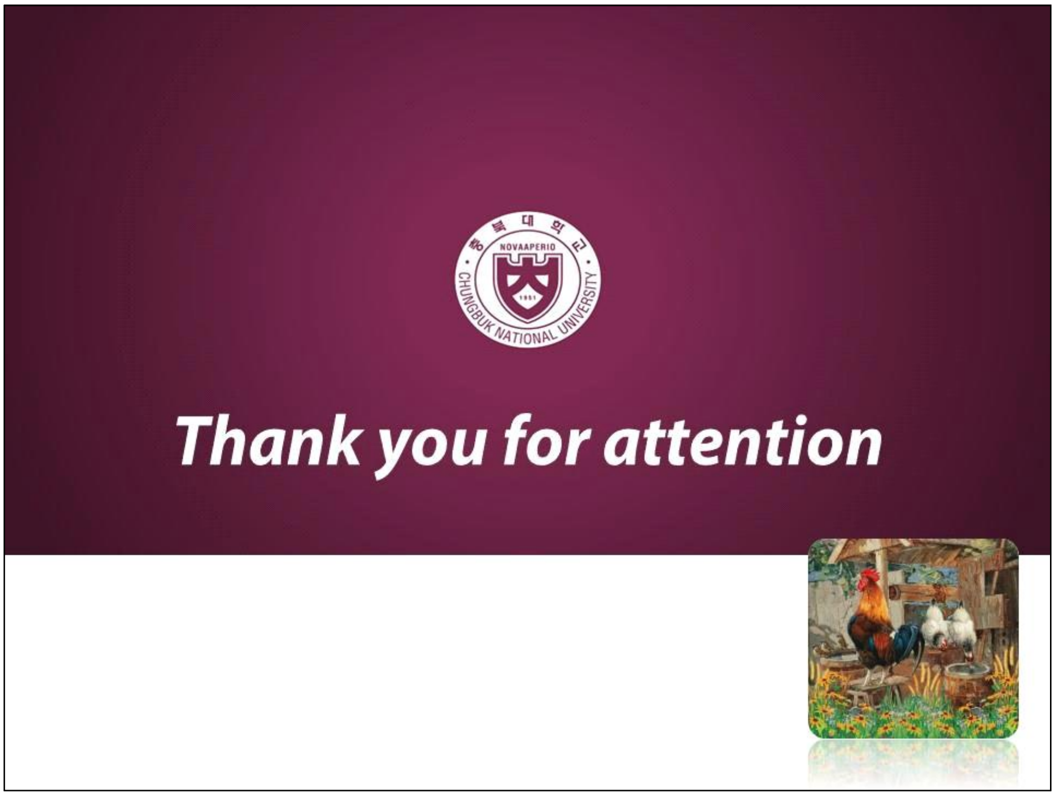


Conclusion

The multiple conditions decrease growth performance and intestinal health of broiler chickens

Increasing dietary concentrations of Thr from 0.68 to 1.36% improves growth performance, gut morphology, and intestinal permeability of broiler chickens

It is expected that broiler chickens fed diets supplemented with Thr improve growth performance and gut health in various stress conditions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Proceedings of 2023 Annual Congress of KSAST Vol. I

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오해

축산 VS 운송수단 온실가스 배출량

계산법 기준이 다릅니다

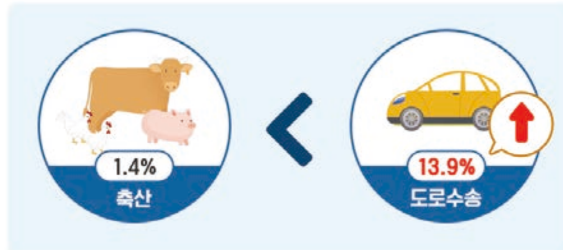
축 산 "생애주기 전 과정" 계산

운송수단 "제조를 제외한 연료의 양"만 계산

2

진실

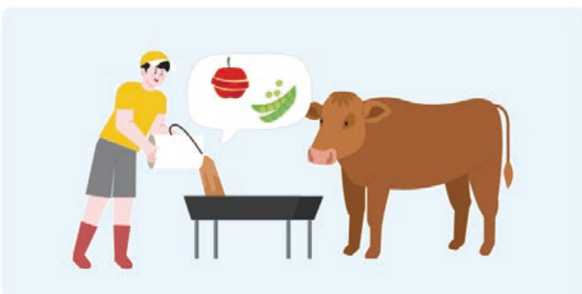
동일기준으로 온실가스 배출량을 비교한다면?



세계 공통보고 방법에 의해 계산하면!

자동차가 압도적으로 많아요

3



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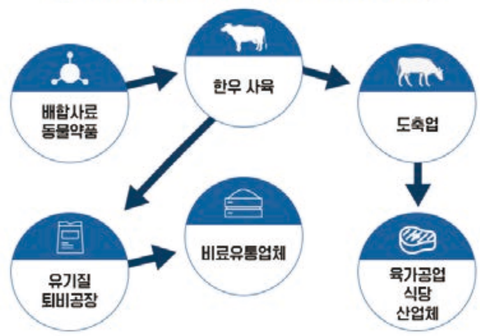

5

한우 부산물 어떻게 이용될까?

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뼈	**뿔, 발굽**	**가죽**	**내장**
정제설탕, 유리	접착제, 깁스, 사진인화기	젤라틴, 캔디, 조미료(향료), 의약품, 벽지, 접착제	악기줄, 테니스 라켓 줄, 의약품, 건강보조식품

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*출처: 강원대학교(연구책임자 박규현 교수), 2022년 「전과정 측면에서 한우의 환경적·산업적 특징 연구」

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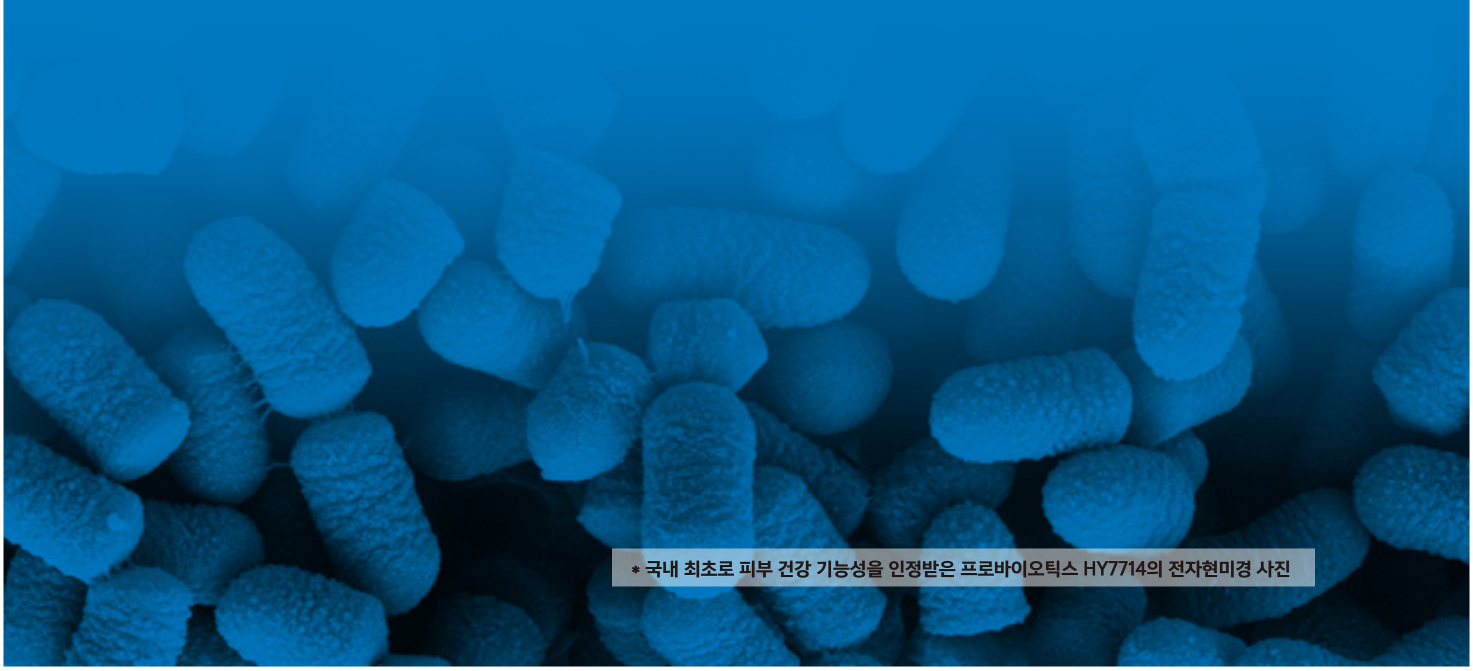

* 국내 최초로 피부 건강 기능성을 인정받은 프로바이오틱스 HY7714의 전자현미경 사진


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03
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