Alfalfa to get back into planetary boundaries

2025 world alfalfa congress
FRANCE REIMS-CHÂLONS

Animal nutrition

Session Chairs: Palmonari A. & Nalle M.

Parallel session 4

FROM 03 › TO 06 nov. 2025

Alfalfa to get back into planetary boundaries

2025 world alfalfa congress FRANCE REIMS - CHÂLONS

Development and untilization of new alfalfa products

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FROM 03 › TO 06 nov. 2025

Outlines

1 Background

2 The application of alfalfa leaf meal in sows

3 The application of alfalfa leaf meal in finishing pigs

4 Problems and prospects

01 Part One

Background

Background

China - the largest pig-raising and pork consumption country in the world

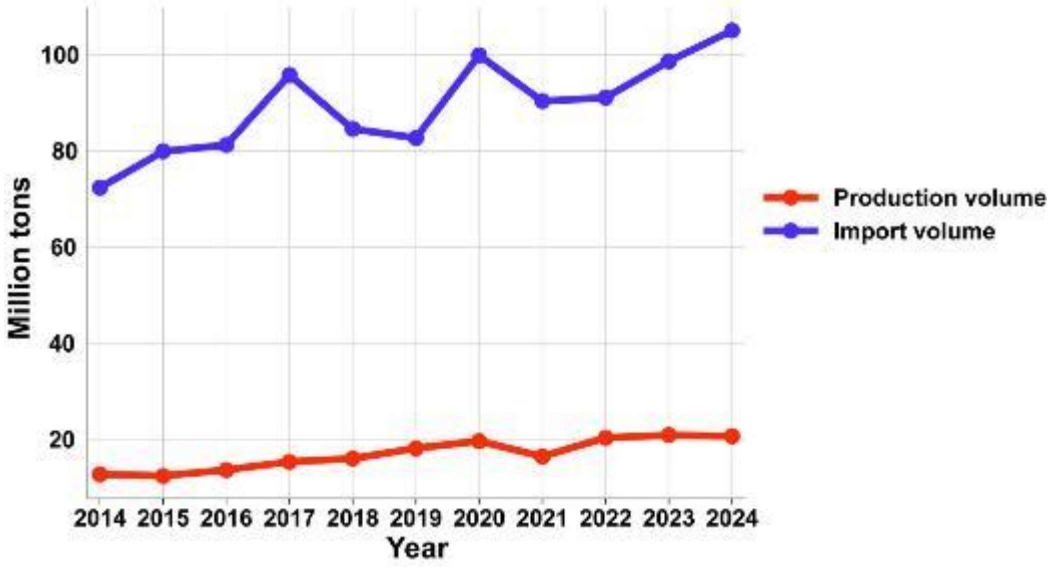
- In 2024, the number of slaughtered live pigs in China was 702.56 million.
- In 2024, China's pork production was 57.06 million tons.
- In 2024, China's pig feed consumption was 143.91 million tons, accounting for 45.7% of the total feed consumption.
- The diet of pigs is based corn-soybean meal. 53% of China's grain is used as feed.



Background

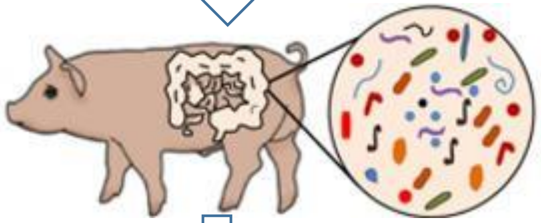
- In 2024, China imported 157.53 million tons of grains, with over 80% being used for feed. The imported grains include 105.03 million tons of soybeans, accounting for 66.7% of the total grain imports.
- The increase in soybean imports has driven up the price of soybean meal and feed cost. A rise of 100 CNY per ton in soybean meal will lead to an increase in feed costs of 15 to 20 CNY. Reducing the use of soybean meal can lower both soybean imports and farming costs.
- In March 2021 and April 2023, the Ministry of Agriculture and Rural Affairs of China respectively released the "Work Plan for Reducing and Replacing Corn and Soybean Meal in Feed" and the "Three-Year Action Plan for Reducing and Replacing Soybean Meal in Feed."
- **It is imperative to find alternatives to soybean meal!**

Trends of soybean production and import volume in China from 2014 to 2024



Background

Prohibition of antibiotics

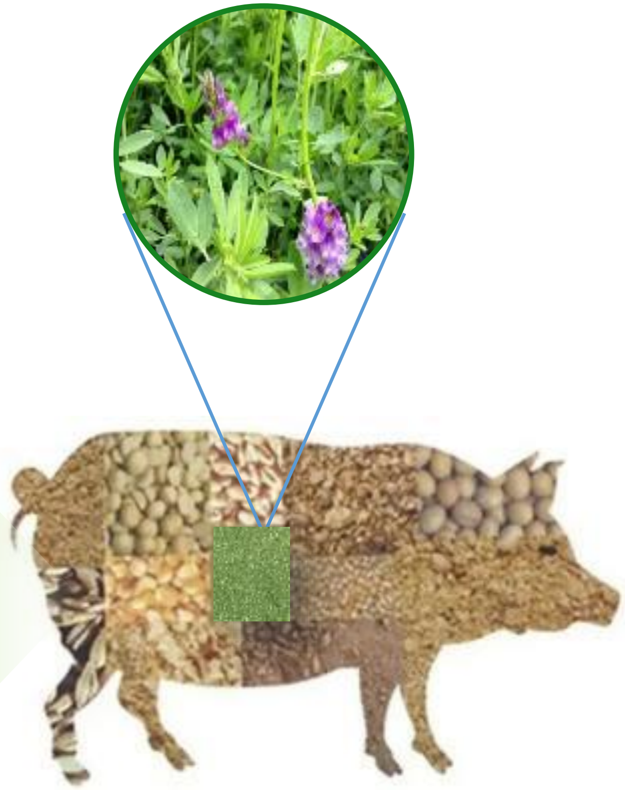


Intestinal health imbalance

- Decrease in reproductive performance of sows
- Increase in diarrhea of piglets
- Decrease in the pork quality of finishing pigs
- Increase in feeding costs

Accelerate the strategy of intestinal microbiota homeostasis

Alfalfa-The ideal candidate

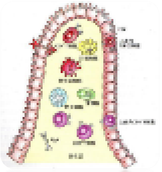


Background

Alfalfa is necessary and essential for pigs!

Nutritional Components and Function of Alfalfa

Nutrients	Function
Protein	Alfalfa protein contains more than 20 types of amino acids, including all essential amino acids for humans and animals; the protein content is about 20%, showing potence to replace soybean meal.
Fatty acids	Alfalfa contains a rich variety of fatty acids, primarily a-linolenic acid, which play an important role in the healthy growth of livestock.
Dietary Fiber	improving intestinal health, promoting intestinal development and the proliferation of beneficial gut bacteria, cleansing the intestines, and reducing constipation.
Saponin	Antioxidant, antibacterial, anti-inflammatory, anti-stress, and cholesterol-lowering ability.
Polysaccharide	Antioxidant ability, anti-tumor, and enhancing immune system.
Flavonoids	Regulating endocrine functions and promoting animal growth and reproduction,which is similar to the action of estrogen.
Unknown Growth Factor	Promoting animal growth and reproduction.
……	…….



The demand of pigs for alfalfa is very big!

- Sows: The sow's number is approximately 44 million, with each sow requiring about 1.2 tons of feed annually. Assuming that 15% of the formula consists of soybean meal and that half of the soybean meal is replaced with alfalfa, about 3.9 million tons of alfalfa will be needed.
- Finishing pigs: Approximately 700 million finishing pigs are slaughtered annually. Each finishing pig requires about 0.3 tons of feed. Assuming that 15% of the formula consists of soybean meal and that half of the soybean meal is replaced with alfalfa, the total requirement of alfalfa will be over 15 million tons.

Background

Alfalfa meal

reproductive performance ↑

gut health ↑

meat quality ↑

The substitution level of alfalfa meal for soybean meal is limited!

Background

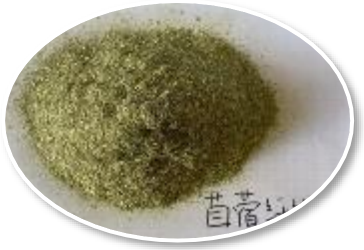
Alfalfa

Separation

Alfalfa leaves

Alfalfa leaf meal:
as feed protein resource

Alfalfa stem



Alfalfa stem meal:
as feed fiber resource

Reproductive performance?

Meat quality?

Intestinal health?

Background

Nutritional levels of different alfalfa products (air-dried basis)

Item	DM（%）	CP（%）	DE（MJ/kg）	CF（%）	EE（%）	NDF（%）	ADF（%）	Ash（%）	Ca（%）	P（%）
Alfalfa meal	92.43±0.14	15.81±0.18	6.95	27.54±0.48	1.65±0.06	43.93±2.99	30.99±0.58	10.28±0.18	0.96±0.02	0.25±0.0019
Alfalfa leaf meal	93.20±0.11	25.56±0.33	7.23	12.75±0.65	2.00±0.41	28.25±3.56	17.56±1.71	15.02±0.24	1.22±0.02	0.29±0.0049
Alfalfa stem meal	92.90±0.1	10.06±0.15	7.49	39.20±0.20	0.45±0.11	59.3±1.27	43.42±0.53	9.82±0.66	0.61±0.06	0.26±0.0042

Note: The separation samples are from alfalfa hay.

The content of crude fiber, neutral detergent fiber, and acid detergent fiber in alfalfa leaf meal is significantly lower than that in alfalfa meal, while the content of crude protein, crude fat, calcium, and phosphorus has significantly increased, with the crude protein content rising by 60-80%.

Item	DM（%）	CP（%）	DE（MJ/kg）	CF（%）	EE（%）	NDF（%）	ADF（%）	Ash（%）	Ca（%）	P（%）
Alfalfa leaf meal	96.48	35.33	7.38	10.96	8.48	27.22	9.54	6.60	1.30	0.39

Note: The separation samples are from fresh alfalfa.

Background

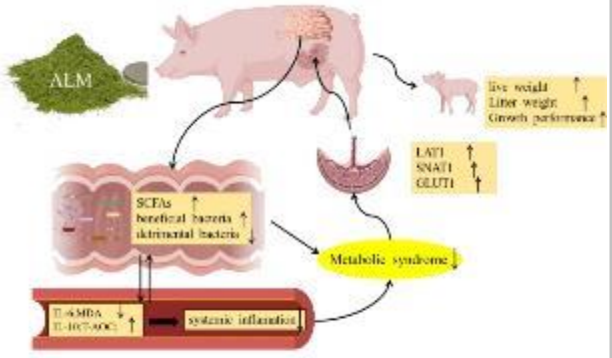
Amino Acid Content of Different Alfalfa Products (Air-Dried Basis)

Amino acids	Alfalfa meal	Alfalfa leaf meal	Alfalfa stem meal
Asp	1.87±0.01	2.63±0.01	1.38±0.04
Thr	0.62±0.00	1.15±0.00	0.37±0.01
Ser	0.67±0.00	1.08±0.00	0.45±0.01
Glu	1.40±0.00	2.64±0.01	0.77±0.02
Gly	0.73±0.00	1.35±0.00	0.42±0.01
Ala	0.77±0.00	1.48±0.00	0.46±0.01
Val	0.83±0.00	1.51±0.03	0.48±0.02
Ile	0.65±0.00	1.22±0.00	0.37±0.01
Leu	1.10±0.00	2.15±0.00	0.61±0.02
Tyr	0.35±0.02	0.79±0.00	0.19±0.01
Phe	0.70±0.01	1.40±0.00	0.39±0.01
Lys	0.82±0.00	1.48±0.00	0.51±0.01
His	0.25±0.00	0.52±0.01	0.15±0.00
Arg	0.60±0.01	1.32±0.00	0.31±0.01
Pro	1.15±0.00	1.32±0.01	0.69±0.01

The amino acid content in alfalfa leaf meal is significantly higher than that in alfalfa meal, with lysine, threonine, leucine, isoleucine, phenylalanine, and tyrosine levels nearly doubling. Therefore, alfalfa leaf meal could theoretically be a new protein feed ingredient.

02 Part Two

The application of alfalfa leaf meal in sows



Effects of alfalfa leaf meal replacing soybean meal with different proportions on reproductive performance of sows

Items	Ctrl	ALM(25%)	ALM(50%)	ALM(75%)	ALM(100%)
Total born piglets	11.44±1.42ab	11.00±1.22ab	10.00±1.29b	10.25±2.22b	12.25±0.96a
Live-born piglets	10.56±1.74	10.60±1.82	9.86±1.46	10.00±2.45	11.75±1.89
Healthy rate of piglets（%）	0.88±0.14	0.94±0.09	0.97±0.05	0.97±0.06	0.88±0.11
IUGR（%）	5.26	7.55	4.35	7.50	6.38

Alfalfa leaf meal replacing 100% soybean meal in pregnant sows' diet increased the total number of born piglets and the number of live-born piglets per litter.

The application of Alfalfa leaf meal in sows

Performance of piglets

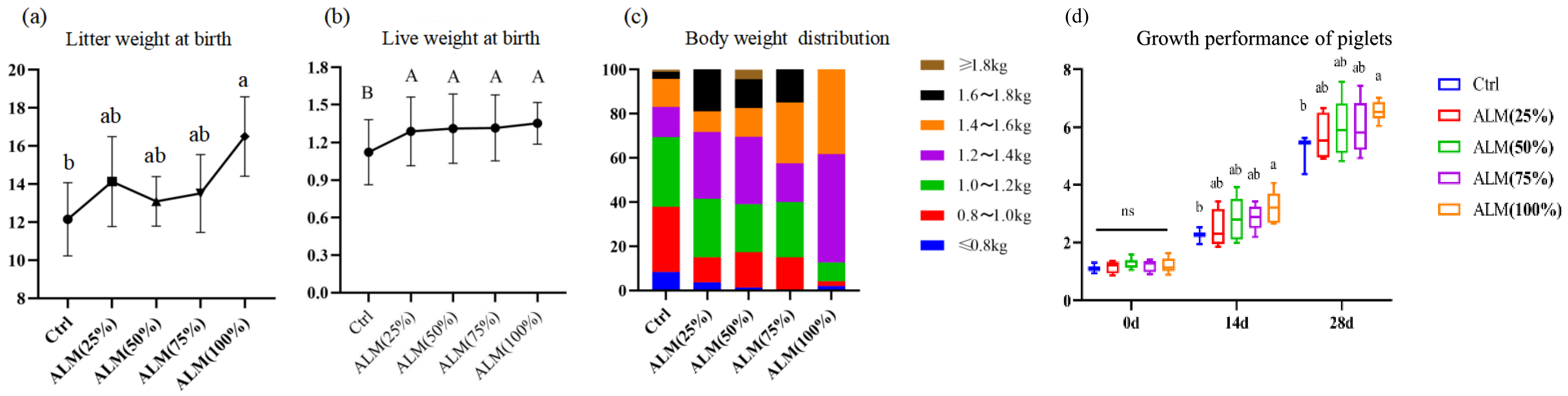
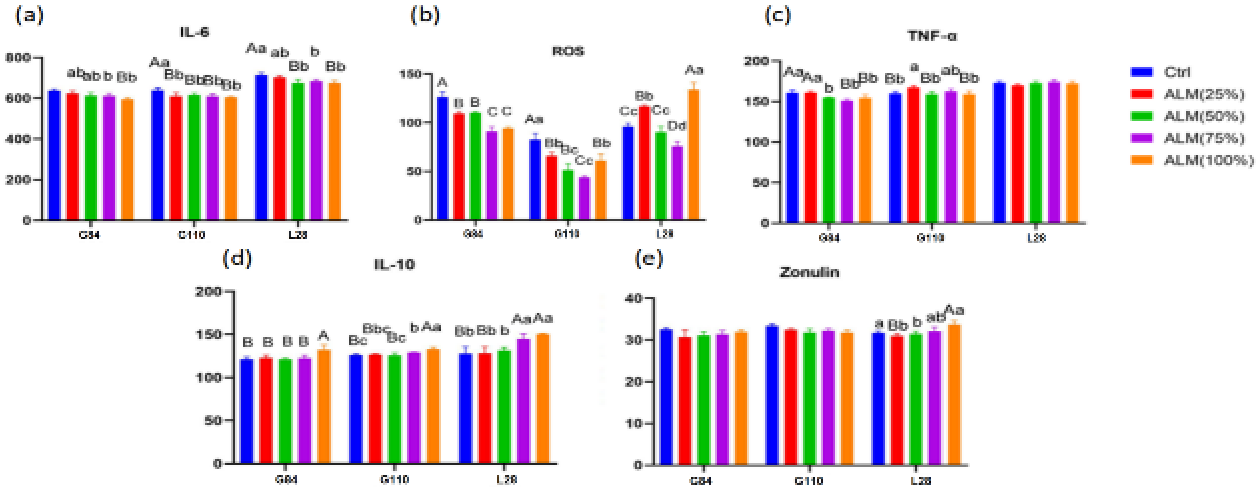


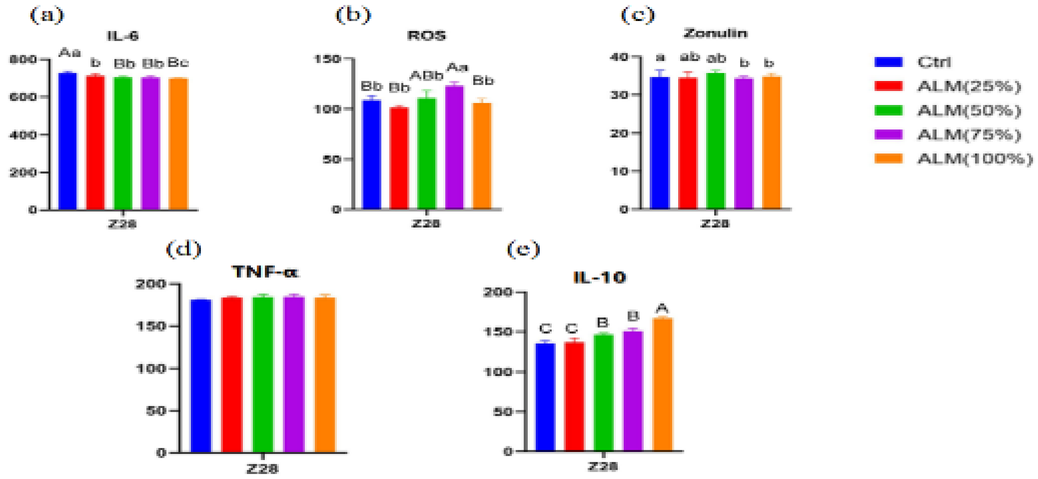
Figure1 Effects of alfalfa leaf meal replacing soybean meal with different proportions on body weight of piglets

- ✓ Alfalfa leaf meal replacing 100% soybean meal in pregnant sows' diet increased the litter weight at birth and improved the uniformity of individual birth weights.
- ✓ The positive effects of alfalfa leaf meal could persist into the lactation period, it also significantly increased the weaning weight of piglets compared to the corn-soybean meal control group.

Systemic inflammation of sows and piglets



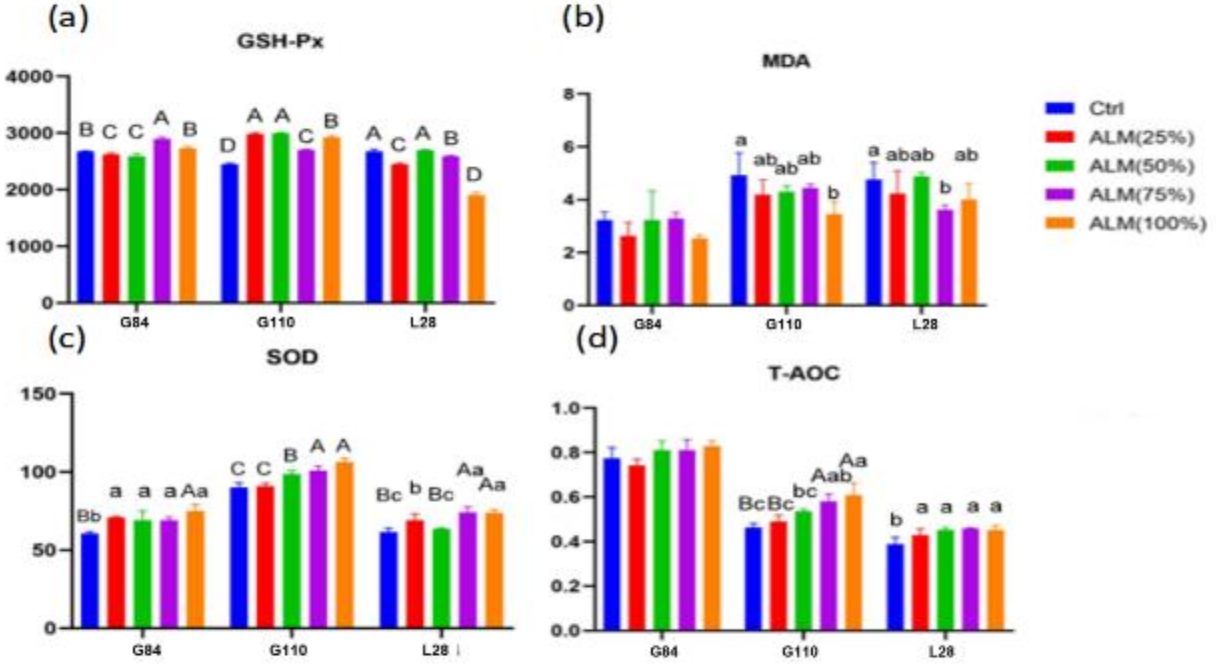
Effects of alfalfa leaf meal replacing soybean meal with different proportions on inflammatory factors of sows



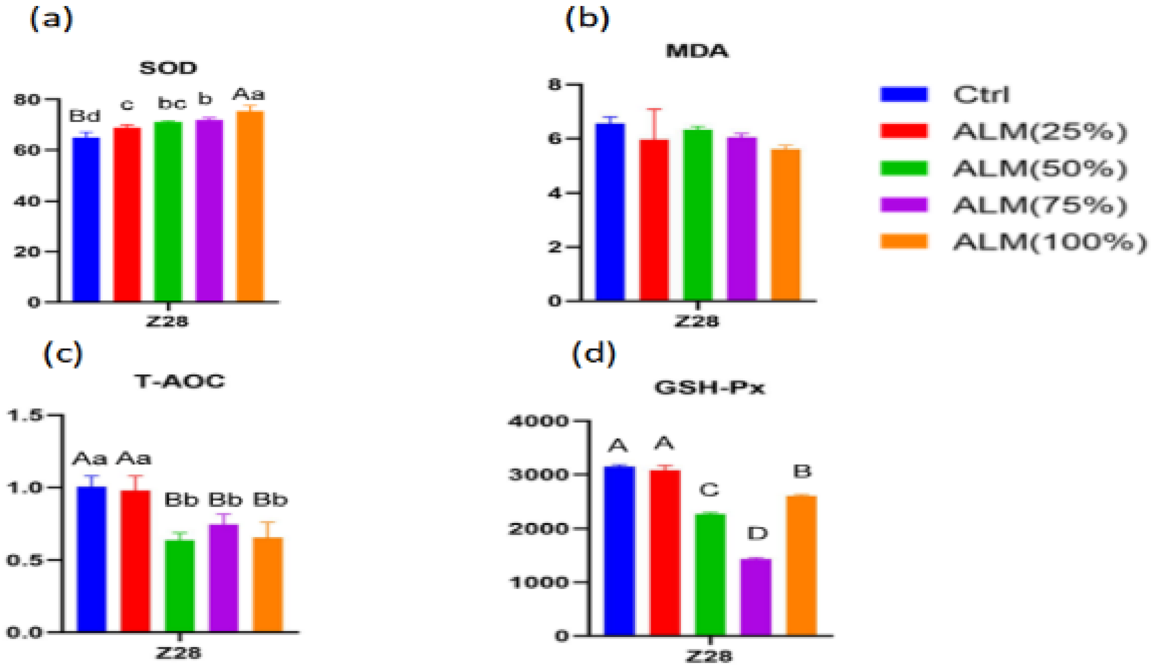
Effects of alfalfa leaf meal replacing soybean meal with different proportions on inflammatory factors of piglets

Alfalfa leaf meal replacing 100% soybean meal in pregnant sows' diet significantly reduced the systemic inflammation.

Antioxidant capacity of sows and piglets



Effects of alfalfa leaf meal replacing soybean meal with different proportions on antioxidant indexes of sows

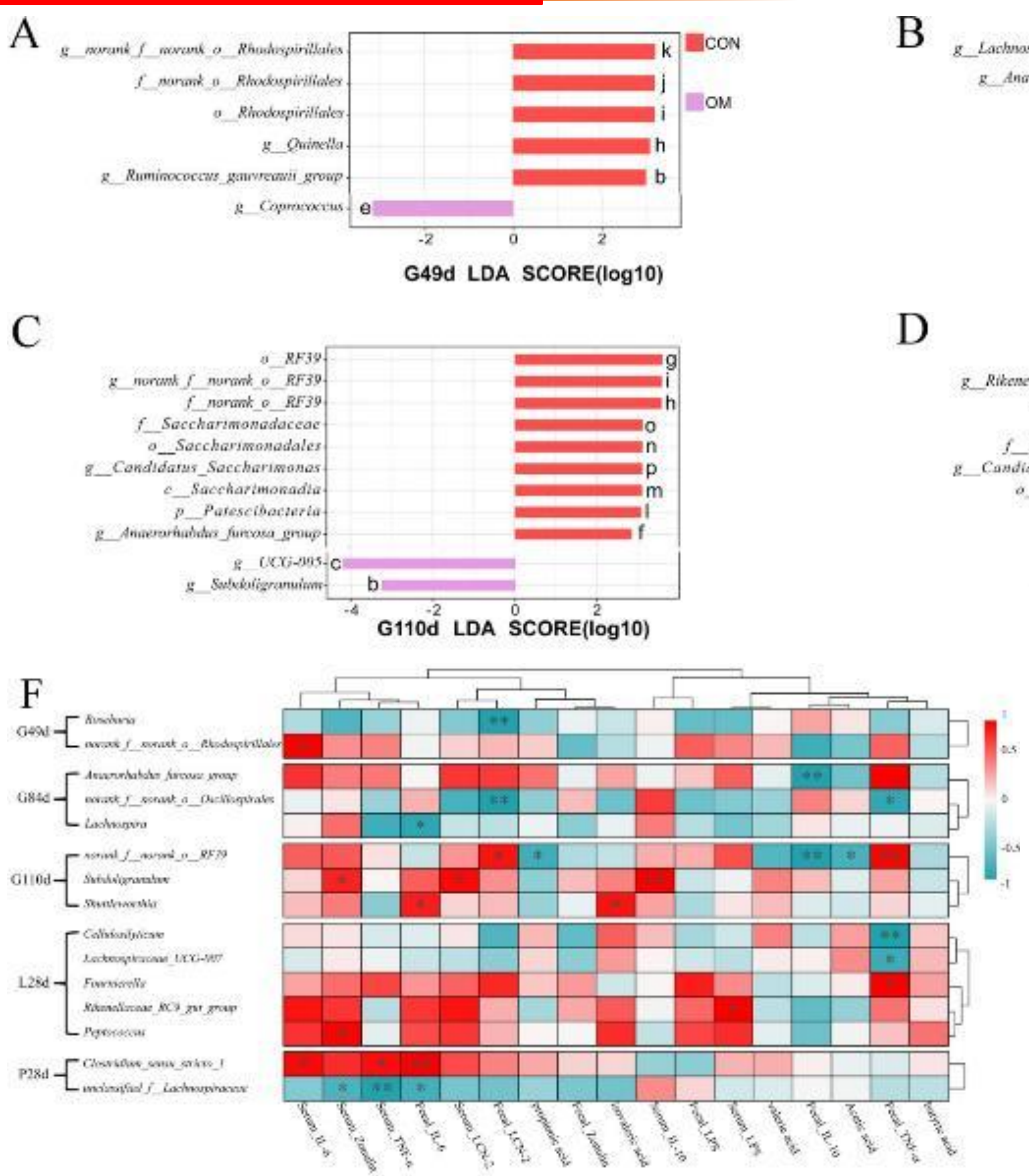


Effects of alfalfa leaf meal replacing soybean meal with different proportions on antioxidant indexes of piglets

Alfalfa leaf meal replacing 100% soybean meal in pregnant sows' diet significantly improved antioxidant capacity of sows and piglets.

The application of Alfalfa leaf meal in sows

Gut microbiota



Analysis of gut microbiota of sows and piglets

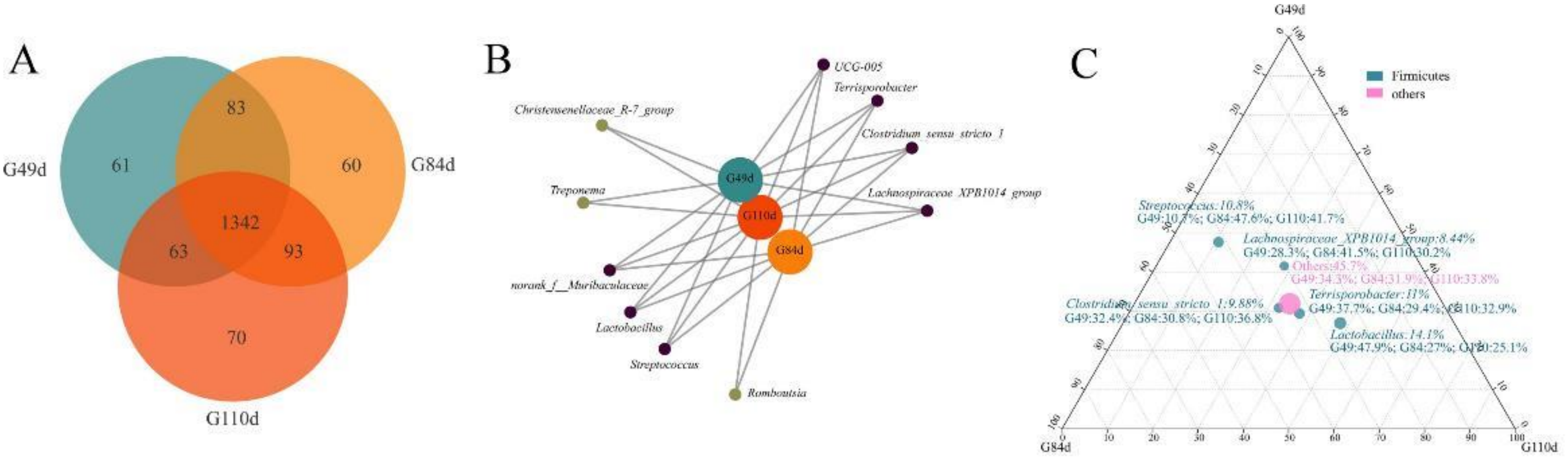
Beneficial bacteria ↑
Coprococcus
Subdoligranulum
Butyricicoccus

Harmful bacteria ↓
Clostridium_sensu_stricto_1
Candidatus_Saccharimonas
Anaerorhabdus_furcosa_group

These microorganisms are associated with fiber degradation, polysaccharide utilization, SCFAs production, and inflammatory response.

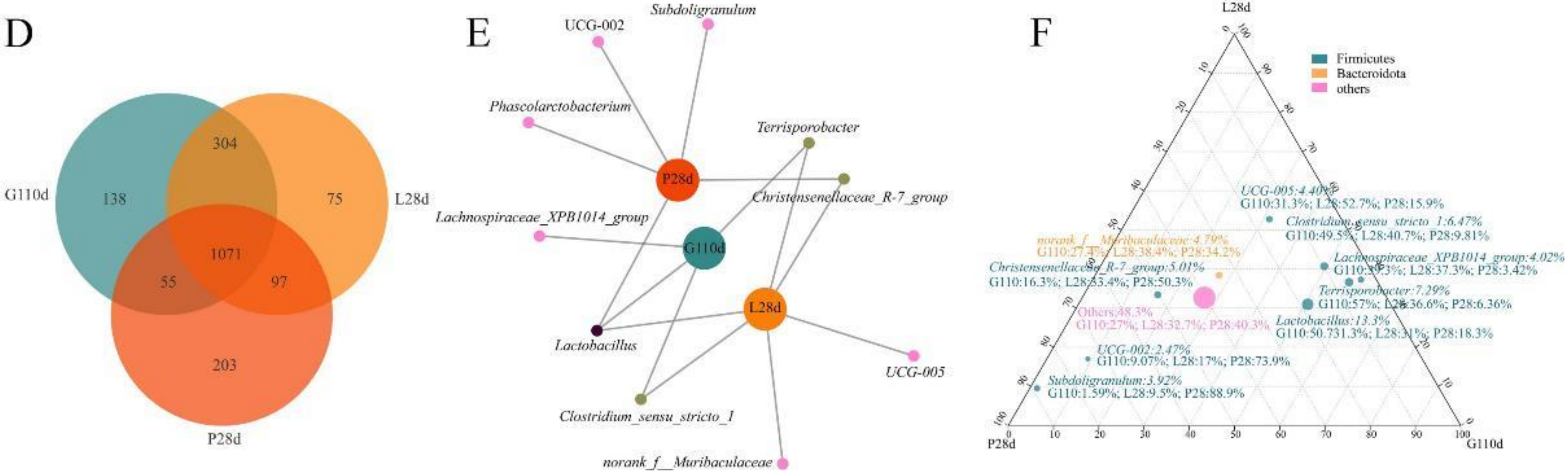
The application of Alfalfa leaf meal in sows

Gut microbiota



Analysis of common/unique gut microorganisms in sows

- Common gut microorganisms during G49d, G84d, G110d: *norank_f__Muribaculaceae, Lactobacillus, Streptococcus, UCG-005, Terrisporobacter, Clostridium_sensu_stricto_1, Lachnospiraceae_XPB1014_group.*
- *Lachnospiraceae_XPB1014_group* and *Lactobacillus* are the main beneficial gut microbiota in sows during gestation, and they may play an essential role in the regulation of sow's prenatal metabolism; *Clostridium_sensu_stricto_1* and *Terrisporobacter*, as the main pathogenic bacteria, maybe the main factors for the occurrence of gut inflammation in sows during gestation.



Analysis of common/unique gut microorganisms in piglets

- Core gut microorganisms spreading from mother to offspring: *Lactobacillus*, *Christensenellaceae_R-7_group*, which produce SCFAs to regulate metabolism and provide energy to the gut epithelium, produce lactic acid to lower gut pH and prevent the growth of pathogenic bacteria, suggesting these gut microbiota play an essential role in the growth and metabolic regulation of piglets.
- Vertical transmission from mother to offspring is very important for piglet's health and growth.

Economic Benefit Analysis

Items	Ctrl	25% Replacement Treatment	50% Replacement Treatment	75% Replacement Treatment	100% Replacement Treatment
Number of piglets per litter	10.63	10.57	9.47	11.18	11.35
Price per piglet, CNY/piece	1000	1000	1000	1000	1000
Piglet revenue, CNY/per litter	10630.63	10568.97	9474.07	11183.33	11347.11
Feed price, CNY/kg	2.87	2.88	2.90	2.92	2.93
Sow feed cost, CNY/piece	1024.95	1026.72	1030.55	1034.83	1035.65
Gross profit, CNY/piece	9605.68	9542.25	8443.52	10148.50	10311.46

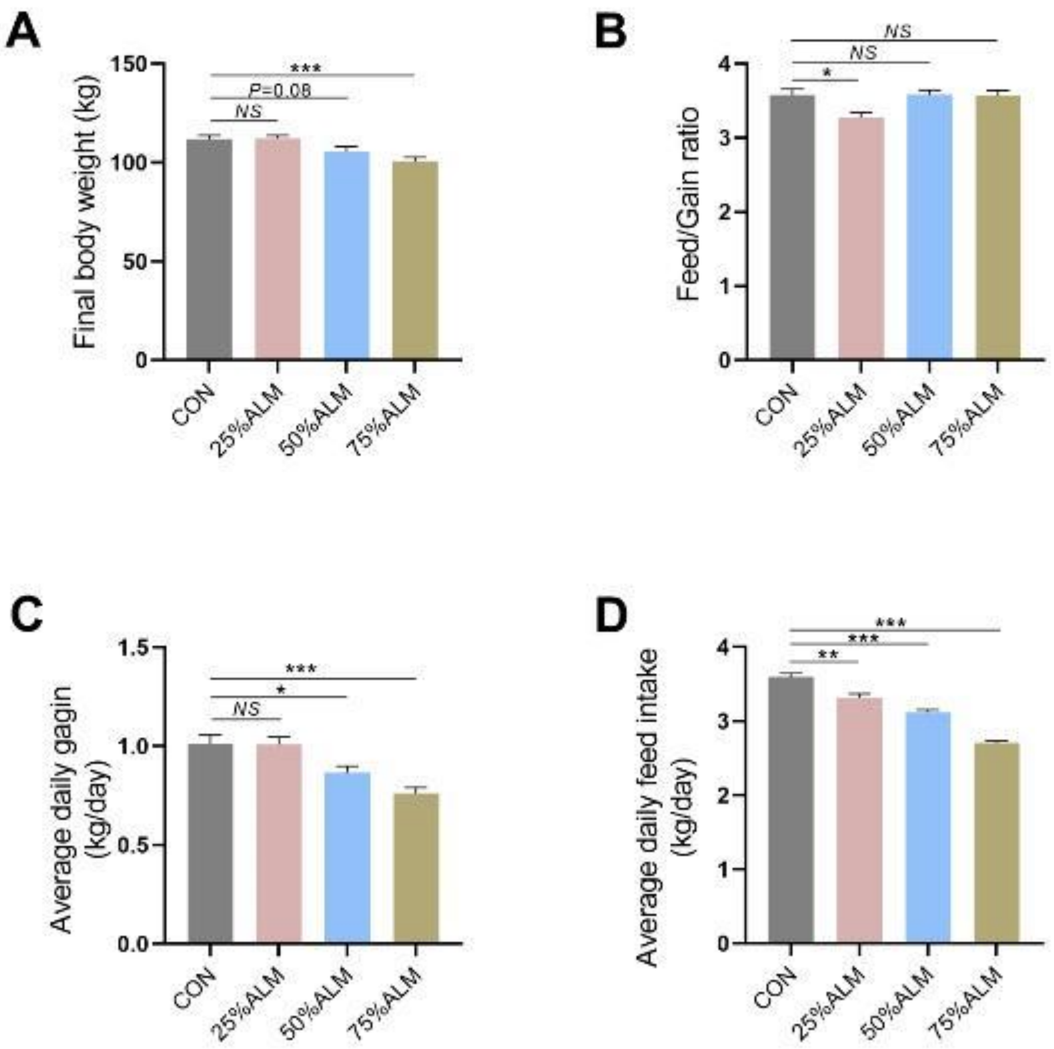
The 100% replacement Treatment had a gross profit of 705.78 CNY per sow higher than that of the control group, with an increase of 6.98%.

03 Part Three

The application of alfalfa leaf meal in finishing pigs

The application of Alfalfa leaf meal in finishing pigs

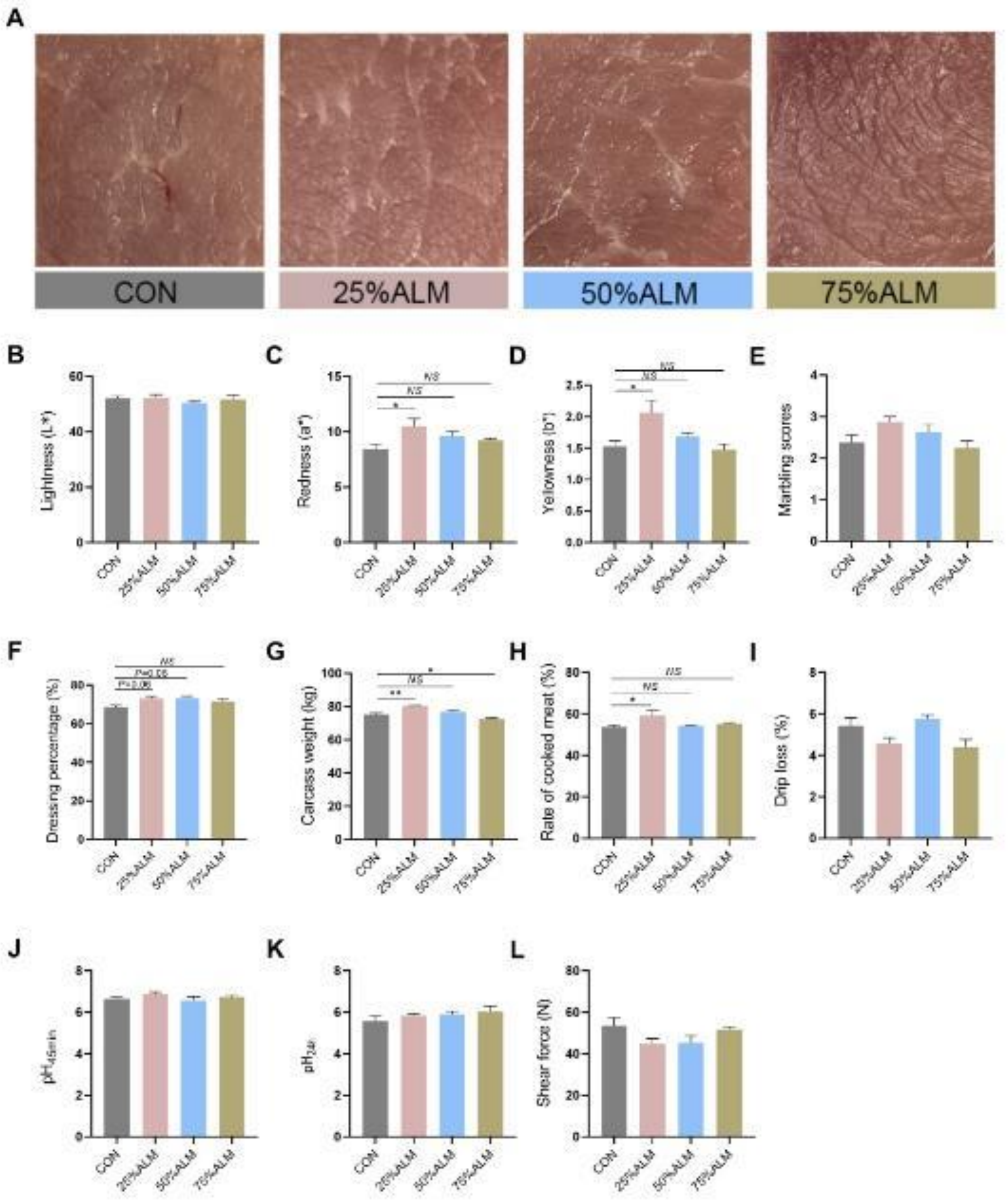
Growth performance

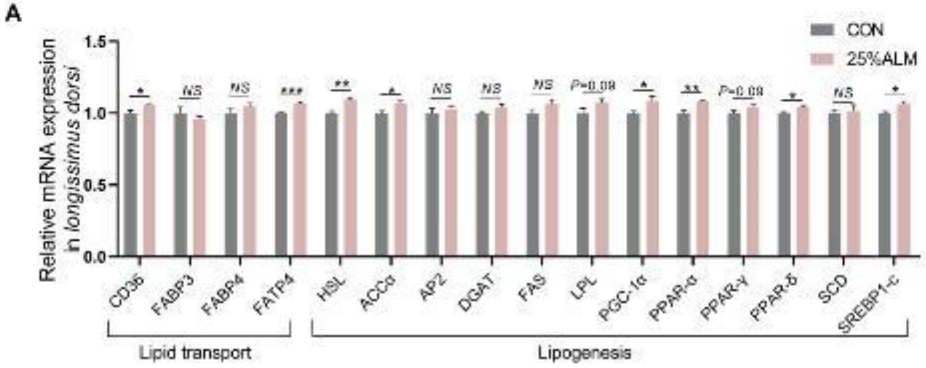


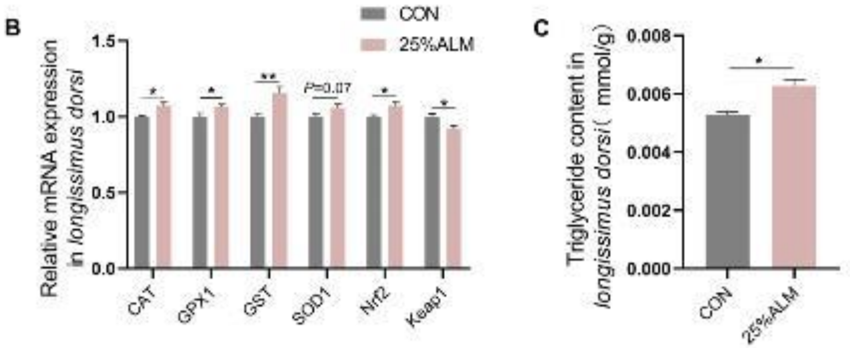
Alfalfa leaf meal replacing 25% soybean meal in diet significantly decreased F/G ratio of finishing pigs.

The application of Alfalfa leaf meal in finishing pigs

Meat quality, lipid synthesis and antioxidant genes







- ALM significantly improved meat quality (carcass weight, dressing percentage, rate of cooked meat, redness) of finishing pigs.
- ALM significantly increased mRNA expression of lipid transport and lipid synthesis genes, as well as antioxidant genes in LD.

The application of Alfalfa leaf meal in finishing pigs

Antioxidant capacity

Antioxidant capacity in *longissimus dorsi, liver and serum* of finishing pigs (%)

Items	CON	25%ALM	SEM	*P*-value
Longissimus dorsi				
T-AOC（μmol/g）	0.014^{b}	0.017^{a}	0.000	0.000
（U/g）	529.01^{b}	633.17^{a}	35.342	0.007
（U/g）	1058.24	1072.58	71.000	0.843
（U/g）	54.40^{b}	72.29^{a}	4.815	0.001
MDA（nmol/g）	66.21^{a}	50.15^{b}	4.351	0.001
Liver				
T-AOC（μmol/g）	0.016^{b}	0.019^{a}	0.001	0.014
GSH-Px（U/g）	435.63^{b}	761.49^{a}	64.081	0.000
SOD（U/g）	897.76^{b}	1152.80^{a}	80.338	0.004
CAT（U/g）	65.69^{b}	78.50^{a}	5.686	0.039
MDA（nmol/g）	74.06^{a}	41.96^{b}	3.907	0.000
Serum				
T-AOC（μmol/L）	0.018^{b}	0.021^{a}	0.001	0.001
GSH-Px（U/L）	730.82^{b}	868.42^{a}	42.885	0.004
SOD（U/L）	1250.45	1256.99	18.359	0.725
CAT（U/L）	75.39^{b}	107.70^{a}	5.703	0.000
MDA（nmol/L）	89.85^{a}	75.52^{b}	5.157	0.011

ALM significantly increased antioxidant capacity of finishing pigs.

The application of Alfalfa leaf meal in finishing pigs

Fatty acids composition

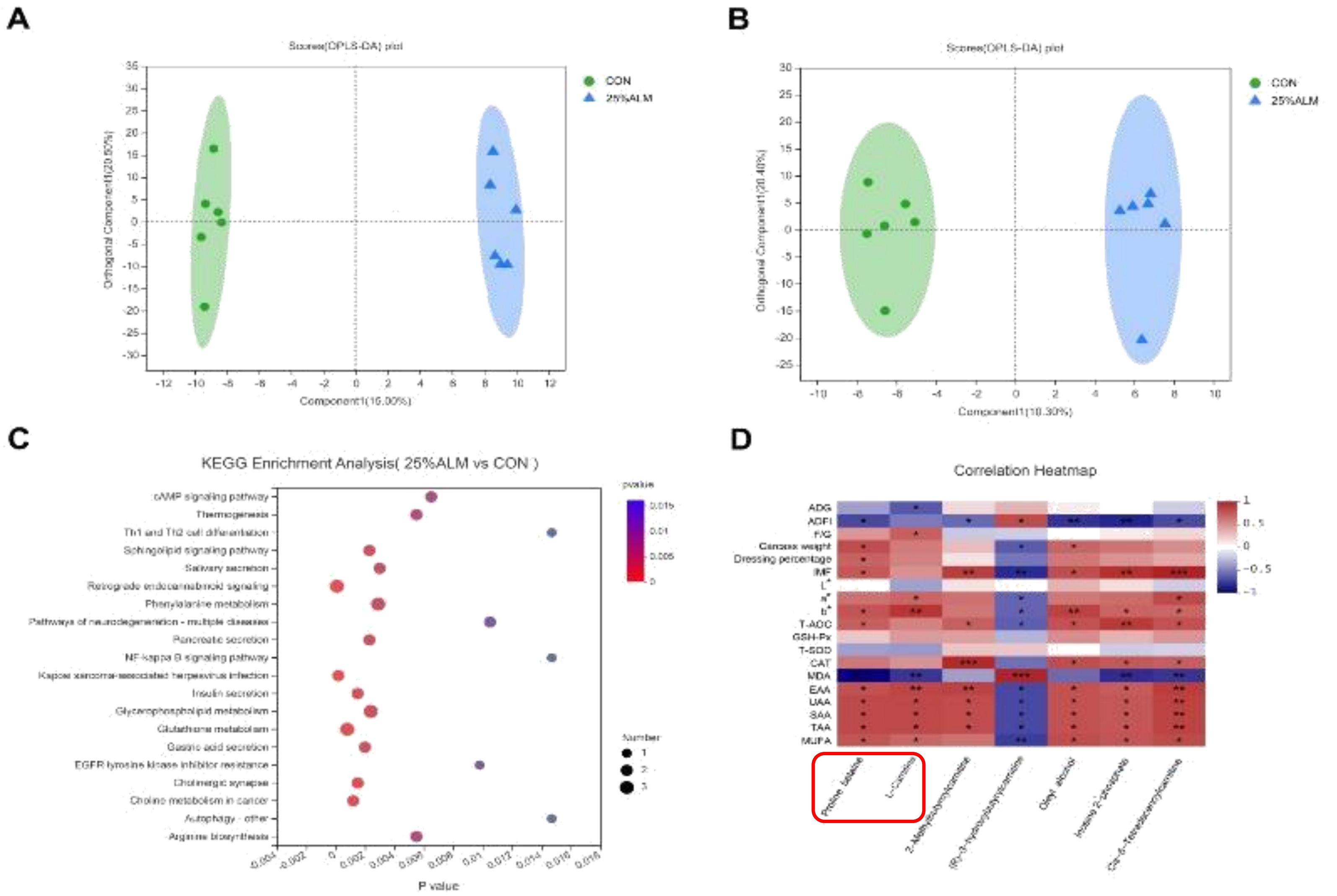
Fatty acid content in *longissimus dorsi* of finishing pigs (%)

Items	CON	25%ALM	SEM	*P-value*
C8:0	0.005	0.006	0.000	0.46
C10:0	0.072b	0.095a	0.009	0.04
C11:0	0.002	0.002	0.000	0.78
C12:0	0.073	0.082	0.008	0.30
C13:0	0.011	0.017	0.008	0.48
C14:0	1.108 b	1.291 a	0.059	0.01
C14:1	0.024 b	0.038 a	0.006	0.04
C15:0	0.039	0.033	0.005	0.23
C16:0	25.680	25.670	0.525	0.99
C16:1	2.929 b	3.437 a	0.119	0.00
C17:0	0.187 a	0.157 b	0.013	0.04
C17:1	0.163	0.158	0.011	0.65
C18:0	13.440 a	11.960 b	0.469	0.01
C18:1	42.050	43.450	0.843	0.13
C18:2	10.170	9.892	1.147	0.81
C18:3n3	0.366 b	0.522 a	0.065	0.04
C18:3n6	0.080	0.074	0.009	0.53
C20:0	0.184 a	0.135 b	0.015	0.01
C20:1	0.653 a	0.584 b	0.037	0.09
C20:2	0.336	0.324	0.035	0.73
C20:3n6	1.863	1.580	0.348	0.43
C20:3n3	0.245	0.208	0.036	0.33
C20:4	0.106	0.113	0.016	0.71
C20:5n3	0.045	0.046	0.009	0.92
C22:0	0.009	0.009	0.000	>0.9
C22:1	0.013	0.012	0.001	0.19
C22:2	0.006	0.007	0.000	0.18
C22:6n3	0.107	0.091	0.009	0.22
C24:1	0.044	0.049	0.006	0.41

ALM affected the composition of fatty acids in LD of pigs, and significantly increased the content of α-linolenic acid (C18:3n3) and other functional fatty acids in LD.

The application of Alfalfa leaf meal in finishing pigs

Muscle metabonomics



- ALM affected some pathways including retrograde endocannabinoid signaling, phenylalanine metabolism, glycophospholipid metabolism and glutathione metabolism.
- Marker differential metabolites, such as proline betaine and L-carnitine, were related to meat quality.

Economic Benefit Analysis

Items	Ctrl	25% Replacement Group	50% Replacement Group	75% Replacement Group
Feed price (CNY/kg)	3.16	3.21	3.19	3.28
Average Daily Intake (kg/d)	3.60	3.31	3.12	2.71
Cost (CNY/piece)	500.59	467.17	437.29	390.58
Pig price (CNY/kg)	13.26	13.26	13.26	13.26
Weight Gain (kg)	44.59	44.39	38.19	33.50
Gross profit (CNY/piece)	90.67	121.44	69.11	53.63

The 25% replacement Treatment had a gross profit of 30.77 CNY per pig higher than that of the control group, with an increase of 33.94%.

04 Part Four

Problems and prospects

Current problems

✓ **Separation equipment**

At present, the separation of alfalfa stems and leaves is manual, which is inefficient and requires a lot of labor. The equipment for automatic separation of alfalfa stems and leaves is urgent need.

✓ **Quality stability**

There is no standardized process for these new products, so the maintaining of quality stability of these new processed alfalfa products need to be further explored.




The application of new alfalfa products has wide prospect!

- ✓ Processed alfalfa products play a crucial role in maintaining swine intestinal health.
- ✓ Alfalfa leaf meal, as a new feed protein resource, has very important significance for the national strategy of soybean meal reduction and substitution.
- ✓ Processed alfalfa products provide an new perspective for the production of high-quality pork.

Thank You！