BIHAR ANIMAL SCIENCES UNIVERSITY

BIHAR VETERINARY COLLEGE, PATNA

Department of Animal Nutrition

ANN-606

UNIT-I (NON-RUMINANT NUTRITION)

Lecture on

Amino Acids in Poultry and Swine Production

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PG Lecture: 2

Point to be discuss……

- Amino acid requirement in poultry and swine
- Classification of amino acids
- Function of amino acids
- Amino acid imbalances
- Amino acid antagonism
- Amino acid toxicity

Amino Acids

- Organic substances having amino and acid groups.
- Building block of the proteins.
- More than 700 AA occurs in the nature.
- But only 20 alfa amino acids have role in protein synthesis.

Classification of Amino Acids

- **Essential / Indispensable AA**
  - Dietary essential to meet the body requirements
- **Non Essential / Dispensable AA**
  - Body can be synthesize in sufficient amount to meet the requirements
- **Semi Essential AA**
  - Becomes essential under some specific conditions

Poultry		Swine	
EAA	NEAA	EAA	NEAA
Lysine	Alanine	Lysine	Alanine
Methionine	Asparagine	Methionine	Asparagine
Arginine	Aspartate	Tryptophan	Aspartate
Glycine	Cysteine	Threonine	Cysteine
Leucine	Glutamate	Valine	Glutamate
Histidine	Serine	Isoleucine	Serine
Isoleucine	Taurine	Leucine	Taurine
Phenylalanine	Tyrosine	Histidine	Tyrosine
Tryptophan	Proline	Phenylalanine	Proline
Threonine		Arginine	Glycine
Valine			

Isomerism of Amino Acids

- All amino acids have L and D isomers except glycine.
- L-configuration is required for protein synthesis.
- Whereas, D form of AA is precursors of L form AA.
- D-AA oxidases and transaminases plays important role in conversion of D-AA into L-AA.
- The efficacy of D-AA is ranges from 10-100% of L form.
- However, D form of lysine and threonine can't replace L form.

Amino acids and their analogues efficacy (percentage) compared with that of L-isomer in Chicken

Amino acid	Chick
D-lysine	0
D-threonine	0
D-tryptophan	20
D-methionine	90
DL-methionine	95
DL-OH-methionine	80
Keto-methionine	90
N-acetyl-L-methionine	100
D-arginine	0
D-histidine	10
D-leucine	100
D-valine	70
D-isoleucine	0
D-phenylalanine	75
L-OH-phenylalanine	70
Keto-phenylalanine	85
D-tyrosine	100

Amino acid imbalance

- Referred as a change in pattern of AA in the diet triggering depressions in food intake & growth, which are entirely improved by supplementation with first-limiting amino acid, & requirement for a limiting amino acid may be satisfied by use of deficient protein.
- Chicks are more sensitive to an imbalance as the growing rat & prime manifestation of adverse effects are as reduction in food intake which consequently decreased intake of limiting amino acid, leading to reduced growth.

Consequences of amino acid imbalances and their effects

- ✓ In poultry nutrition as substandard utilization by broiler chicks occurs in the diet based on conventional ingredients & supplementation of limiting amino acids can rectify these imbalances.
- ✓ Free AA supplements absorbed more quickly than protein-bound AA.
- ✓ Concentration of free lysine in plasma of pigs amplified, 1-2 h after feeding a diet containing pure lysine, afterward declining.
- ✓ Whereas concentrations of other AA originating from the protein bound fraction of the diet peaked at 2-6 hours postprandial.
- ✓ This lack of synchrony in absorption would cause an amino acid imbalance at the cellular level.

Cont.....

Effect on dry matter intake

- ✓ Depression in food intake is the prime event accountable for the retardation of growth caused by amino acid imbalances.
- ✓ Excess AA arriving in portal circulation after ingesting of an imbalanced diet, stimulate synthesis or suppress breakdown of protein in the liver.
- ✓ Leading to better retention of the limiting amino acid, thus supply of the limiting amino acid for peripheral tissues (muscle) is reduced.
- ✓ Free AA outlines of both muscle & blood plasma become so disturbed as to raise the interference of the appetite-regulating system to reduce food intake, thus growth is reduced.
- ✓ AA imbalance may affect food intake & dietary selection by modulation of neurotransmitters in the brain.

Effect on nutrient utilization

- Amino acid imbalances diminish the competence of protein utilization in farm animals.
- AA from crystalline & protein-bound sources, can reduce inclusive effectiveness of protein utilization in pigs fed once daily.
- Addition of unbalancing mixture comprising leucine, isoleucine & valine to diet limiting in methionine increased N efficiency in growing pigs.

Amino acid antagonisms

- ✓ Amino acid antagonism referred as a deleterious interaction between structurally similar amino acids.
- ✓ The contrary effect created to accommodate the unique and separate effects of lysine and leucine in farm animals.
- ✓ Antagonisms may be triggered by a wide range of analogues occurring naturally in fodder plants as non-protein amino acids.
- ✓ The act of these analogues is targeted at the metabolism and exploitation of specific structurally related essential amino acids.

Cont.....

Amino Acids Interaction

- Lysine and arginine antagonism
- Leucine, isoleucine and valine interaction
- Lysine and electrolytes
- Heat stress and arginine absorption

Cont.....

Lysine–arginine amino acid antagonism

- ✓ Two strains of chicks contrary significantly in their requirements for arginine,
- ✓ Whereas, chicks with a high arginine requirement are less able to tolerate dietary excesses of lysine than chicks with a low requirement for arginine.
- ✓ Excess arginine depressed growth of chicks fed a lysine-deficient diet and effect reversed by supplementary lysine.
- ✓ Avian species are incapable to synthesize arginine, thus predominantly sensitive to the lysine-arginine antagonism.
- ✓ Most important factor in avian of this antagonism is the higher activity of kidney arginase, results in increased catabolism of arginine.

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Ideal Amino Acids Ratio

Amino acid	Broiler chicken and turkey[a]	Layer
Lysine	100	100
Methionine + cysteine	75	85
Threonine	65	70
Valine	80	90
Isoleucine	67	80
Arginine	105	110
Tryptophan	17	24
Histidine	40	
Leucine	105	
Phenylalanine + tyrosine	105	

[a]Values for turkey come from those for broiler chicken; some variations are possible.

Functions of Amino Acids

- Role in nutrient metabolism
- Regulate gene expression
- Role in oxidative defense
- Activate protein synthesis
- Synthesis and secretion of hormones
- For proper immune functions
- Role in acid base balance
- Body homeostasis
- Neurotransmission
- Role in reproduction
- Tissue regeneration

Cont.....

AA regulatio
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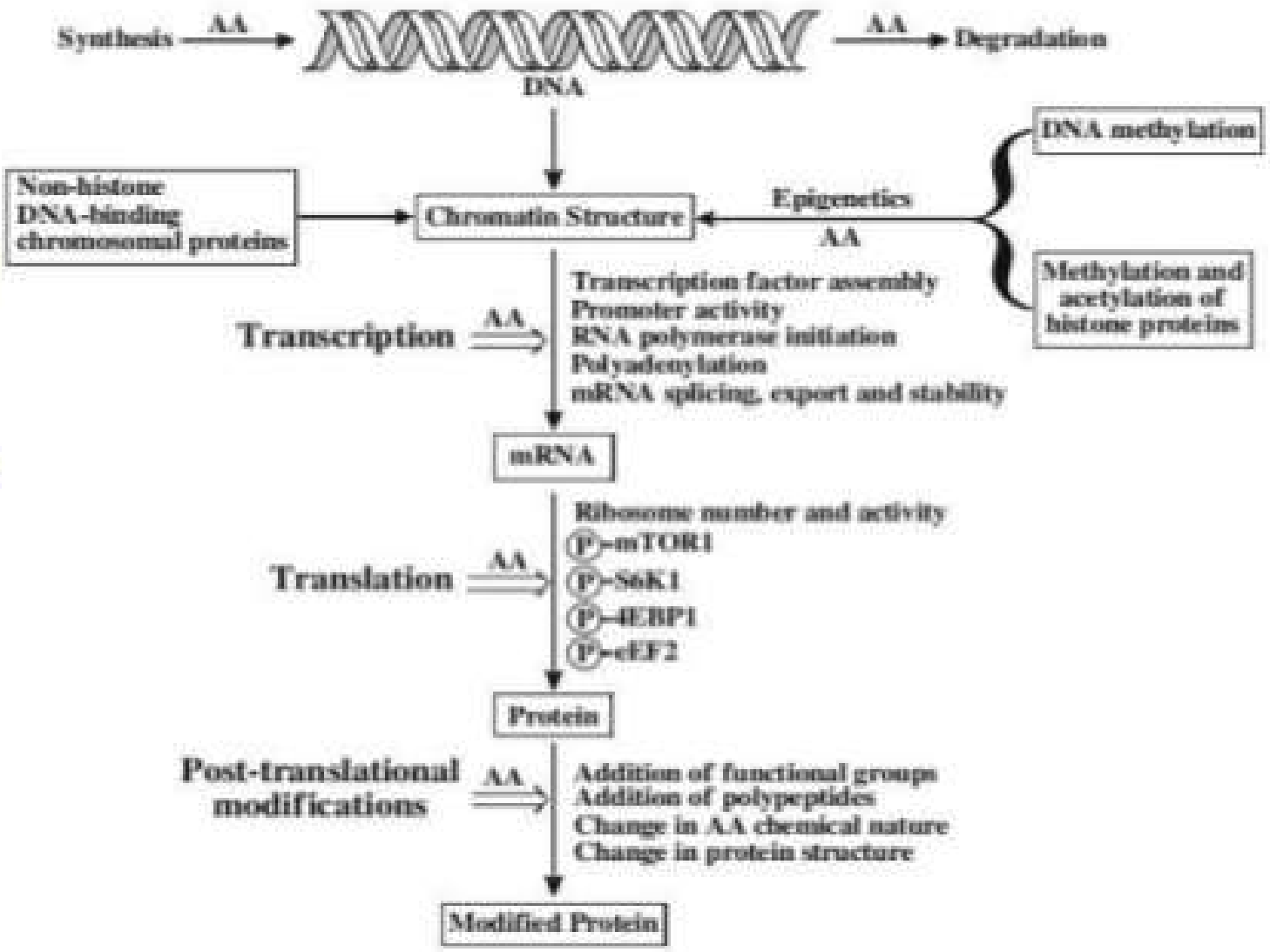
Gene Express



Activation of Protein Synthesis

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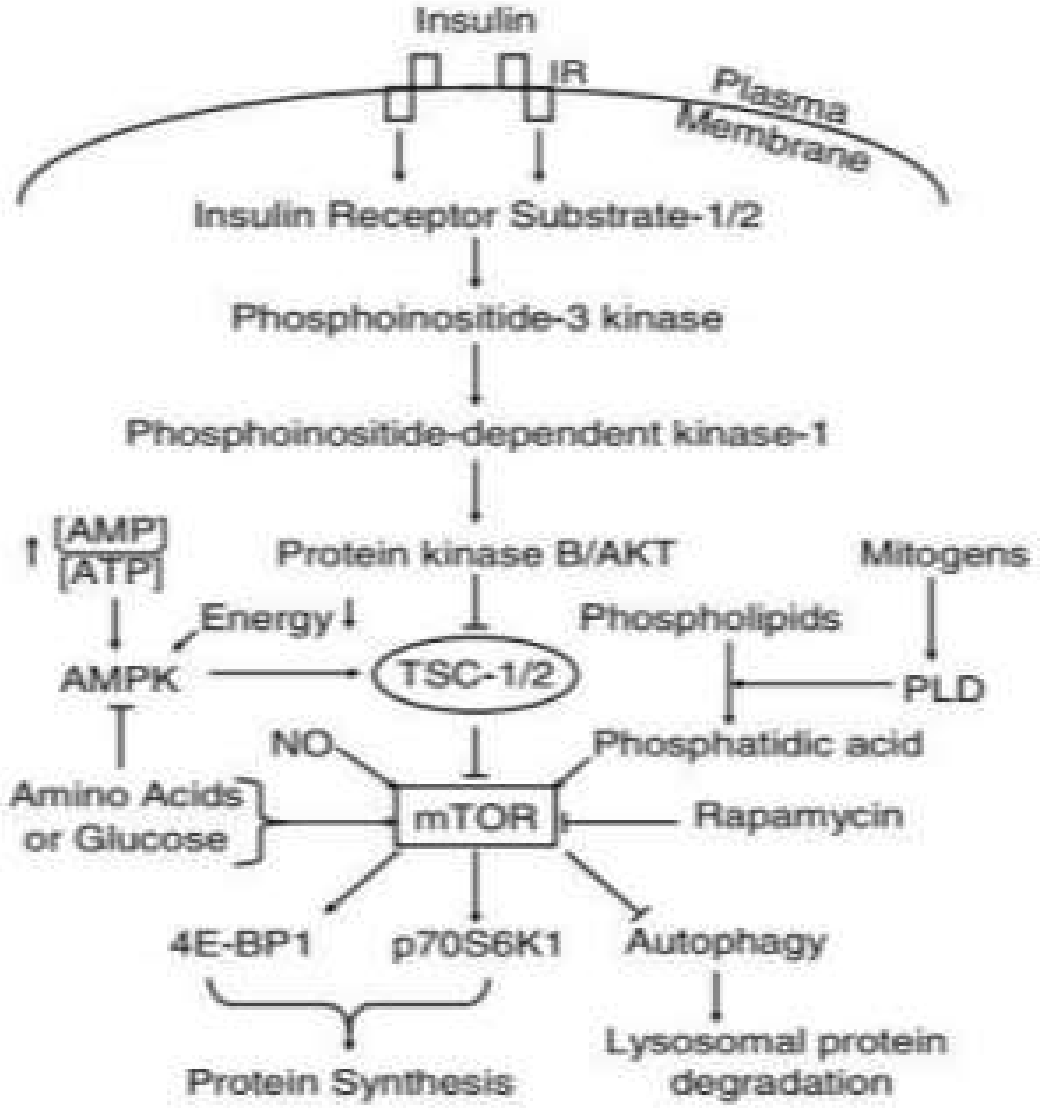

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Synthesis and secretion of hormones

- Tyrosine or phenylalanine is precursor for the synthesis of
  - ✓ Adrenaline
  - ✓ Noradrenaline
  - ✓ Dopamine
  - ✓ Thyroid hormone
- Glutamine and leucine increases insulin release

Cont.....

Synthesis and secretion of hormones

- Arginine is allosteric activator of N-acetylglutamate synthase in mitochondria
- It convert glutamate and acetyl-CoA into N-acetylglutamate
- During fasting Alanine regulating gluconeogenesis and glycolysis by inhibiting pyruvate kinase, glutamate and aspartate regulate glycolysis and cellular redox potential.
- Methionine, glycine, serine and histidine actively participate in one carbon metabolism.

Cont.....

Synthesis and secretion of hormones

- Glutathione is major antioxidant, formed from cysteine, glutamate and glycine.
- Glutamine regulates expression of gene in SI that are related to oxidative defense.
- Methionine is precursors of glutathione and carnitine.

Cont.....

Immune functions

- Glutamine, arginine, methionine & cysteine have role in enhancing immunity.
- Histidine improves immune response of skin.
- Threonine improves immunity of gut.
- Lysine required for proper immune functions.

Cont.....

Amino Acid Catabolism

Reactions	Examples
Transamination	Leucine + α-ketoglutarate ↔ α-ketoisocaproate + glutamate
Deamidation	Glutamine + H_2O → glutamate + NH_4^+
Oxidative deamination	Glutamate + NAD^+ ↔ α-ketoglutarate + NH_3 + NADH + H^+
Decarboxylation	Ornithine → putrescine + CO_2
Hydroxylation	Arginine + O_2 + BH4 + NADPH + H^+ → NO + BH4 + citrulline + $NADP^+$
Reduction	Lysine + α-ketoglutarate + NADPH + H^+ → saccharopine + $NADP^+$
Dehydrogenation	Threonine + NAD^+ → 2-amino-3-ketobutyrate + NADH + H^+
Hydrolysis	Arginine + H_2O → ornithine + urea
Dioxygenation	Cysteine + O_2 → cysteinesulfinate
One-carbon unit transfer	Glycine + MTHF ↔ serine + THF
Condensation	Methionine + Mg-ATP → *S*-adenosylmethionine + Mg-PPi + Pi
Oxidation	Proline + $½O_2$ → pyrroline-5-carboxylate + H_2O
Amidotransferation	Glutamine + F6P ↔ glucosamine-6-phosphate + glutamate
Deaminated oxidation	D-Amino acid + O_2 + H_2O ↔ α-ketoacid + H_2O_2 + NH_3
Dehydration	Serine → aminoacrylate + H_2O
Cleavage	Glycine + NAD^+ + THF ↔ MTHF + CO_2 + NH_3 + NADH + H^+

Cont.....

Specific function of some amino acids

Methionine	Lysine	Threonine	Tryptophan
Protein synthesis	Protein synthesis	Immune functions	Regulate feed intake
Methyl donor in methylation reaction	Regulate NO synthesis	Protein phosphorylation and glycine synthesis	Antioxidant and anti-inflammatory role
Oxidative defense	Immune response	Improve antibody production	Immune functions
Synthesis of cysteine, choline and betaine	Collagen structure and function	Inhibit apoptosis	Reduce liver fat
Osmoregulation	Tissue building	Improve FCR and weight gain	Reduce stress
Cell division		Maintain intestine integrity	Precursor of Niacin

Cont.....

Tyrosine	Arginine	Histidine	Leucine
Protein and energy metabolism	Antioxidant	Protein methylation	Immune response
Immune response	Improve meat quality	Hemoglobin structure and function	Gene expression
Nerve transmission	Hormonal regulation	Allergic reaction	BCAA balance
Skin pigmentation	NH3 detoxification	Immune response	Glutamate dehydrogenase activator
Antioxidant and anti-stress properties	Protein deamination	Vasodilator	
	Reduce stress	Gut functions	

Amino acid toxicity

- Acute growth reduction & specific lesions in organs and tissues of animals may appears due to excesses intake of some AA.
- In farm animals (@40 g/kg diet), methionine is reported to be most growth-depressing AA, whereas, same inclusion level of leucine, isoleucine, and valine do not impair growth.
- Excess threonine in diet reduces chick growth but not in swine, whereas, arginine seems to be more toxic in pig than the fowl.
- Methionine toxicity comprise reduced food intake, depressed nitrogen retention and body weight loss in case of calves.
- Tryptophan toxicity depends on the balance between metabolic stimulation of 3-methylindole and its conjugation with glutathione.

Discussions……..

Questions, if any……??

THANKS