



Introduction to Animal Science

EVALUATION OF FOOD



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Six Basic Nutrients

- Water
- Carbohydrates
- Fats
- Protein
- Mineral
- Vitamins



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Nutrition Terms and Definitions

- **Nutrient** - any feed constituent that functions in the support of life.
- **Concentrate** - feedstuff that is high in energy/ protein and low in fiber, also high in phosphorus and low in calcium.
- **Roughage** - feedstuff that is high in fiber and low in energy, also high in calcium and low in phosphorus.



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Nutrition Terms and Definitions

- **Digestibility** - the amount of various nutrients in a feed that are digested in the digestive tract.
- **Total Digestible Nutrients** = The total of digestible protein + digestible fiber + digestible nitrogen - free extract + digestible crude fat x 2.25



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Water

- Functions
 - Maintenance of normal body temperature
 - Gives shape to cells as a constituent of cytoplasm
 - Part of many metabolic reactions
 - Transports other nutrients
- The most important nutrient of the 6 basic nutrients.
- Producers concern is over quality and quantity of water.



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Water

- Quantities needed are directly related to animal functions i.e.
 - body weight and maintenance
 - reproduction
 - lactation
- May be found bound within the feeds being fed.



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Carbohydrates

- Called nitrogen free extract in the approximate analysis of feedstuffs.
- Carbon chains with hydrogen and oxygen.
- 3 types
 - Sugars
 - Starches
 - Cellulose
- Major source of energy for animals and found in concentrates and roughages.



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Carbohydrates ; Sugars

- Monosaccharides
 - Glucose
 - Fructose
 - Galactose
- Disaccharides
 - Maltose = Fructose + Glucose
 - Lactose = Galactose + Glucose
 - Sucrose = Glucose + Glucose



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Carbohydrates ; Starches

- The most common of the carbohydrates.
- Called polysaccharides.
- Found in the endosperms of seeds and fragile plant tissues.
- Digested by monogastric animals.



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Carbohydrates ; Cellulose

- Most complex of the carbohydrates and the most difficult to digest.
- Ruminant digestion necessary for utilization.
- Major component of roughages from the stems and the more established plant tissues, primarily cell walls.



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Fats

- Commonly called lipids or oils also ether extract in feed analysis.
- Composed of C, H, & O like carbohydrates but the double bonding of the carbon increases the energy level of each molecule
- Contains 2.25 times more energy than an equivalent amount of carbohydrates.



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Fats

- Functions of fats
 - precursors of prostaglandins
 - structural components of cells
- Fat = 3 molecules of fatty acid + 1 molecule of glycerol
- 4 essential fatty acids are linoleic acid, linolenic acid, arachidonic acid, and alpha linolenic acid.



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Evaluate amounts of energy in feed by:

- TDN - Total Digestible Nutrients
- Gross Energy
- Digestible Energy
- Metabolizable Energy
- Net Energy



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Energy Measurement Units

- Calorie - amount of energy required to raise the temperature of 1 gram of water 1 degree C.
- Kilocalorie - equals 1000 calories
- Megacalorie - equals 1000 kilocalories



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Net Energy Divisions

- Net Energy for Maintenance
- Net Energy for Gain
- Net Energy for Lactation



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Protein

- Composed of combinations of amino acids.
- Amino acids are carbon chains with the presence of nitrogen as an amino group and an acid radical and possibly a sulfur atom.
- Protein contains approximately 16% nitrogen in its molecule.
- Amount of nitrogen x 6.25 = % of protein.



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Protein ; 10 essential amino acids

- Phenylalamine
- Valine
- Tryptophan
- Methionine
- Arginine



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Protein ; 10 essential amino acids

- Threonine
- Histodine
- Isoleucine
- Leucine
- Lysine



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Protein ; Amino acids

- Tyrosine can replace up to 50% of the phenylalanine requirement.
- Cystine can replace up to 50% of the methionine requirement.
- Sulfur containing amino acids.
 - Methionine
 - Cystine
 - Cysteine



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Animal uses of protein

- Building blocks for:
 - maintenance and repair of cells
 - growth of bone, muscle, and connective tissue
 - lactation
 - interstitial fluids
- Digestive enzymes formation.
- Cellular matrix for calcium and phosphorus deposition.



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Minerals

- **Macro minerals**

- Calcium
- Phosphorus
- Sodium
- Chlorine
- Potassium
- Magnesium
- Sulfur



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Minerals

- **Micro minerals**

- Cobalt
- Copper
- Iron
- Iodine
- Manganese
- Molybdenum
- Selenium
- Zinc



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Minerals ; Calcium and Phosphorus

- 1 to 1 up to a 2 to 1 ratio of Ca:P.
- Functions:
 - Skeletal development of young and skeletal maintenance for mature animals
 - Milk production
 - Fetal tissues
- Deficiencies are ricketts in young animals and osteoporosis or osteomalacia in older animals.



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Minerals : Sodium, chlorine, and potassium

- Chlorine is the most important of the two because of its presence in blood plasma as NaCl and KCl.
- Chlorine is also a part of the HCl which in the dilute form is the stomach acid in the stomach.
- Potassium concentrations are usually within the cell..



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Minerals ; Na, Cl, & K

- Maintain osmotic relationships between the blood plasma and the red blood cells.
- Perspiring by animals just like humans results in the loss of NaCl during hot weather or exercise.
- Major constituents of the body' s electrolytes.



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Minerals ; Sulfur

- Necessary by the ruminants for the synthesis of the three sulfur containing amino acids.
 - Methionine
 - Cystine
 - Cysteine



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Minerals ; Sulfur

- A component of two B vitamins:
 - Biotin
 - Thiamine
- Deficiency of sulfur will express itself as a protein deficiency: poor performance and general unthrifty condition.



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Minerals ; Magnesium

- Functions
 - Necessary for many enzyme systems
 - Plays a role in carbohydrate metabolism
 - Necessary for the proper functioning of the nervous system.



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Minerals ; Magnesium

- Deficiencies cause grass tetany. Fast growing grasses in early spring or following a droughty summer can cause a poor uptake of magnesium from the soil.
- Symptoms are:
Staggering (“blind staggers”)
Lack of coordination and death.



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Minerals ; Magnesium

- Feed mineral mix containing additional magnesium in the form of magnesium sulfate and magnesium oxide.
- May have a laxative effect on animals if fed in times when tetany is not a problem.
Magnesium salts may be fed to sows in crates for a laxative effect.



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Minerals ; Iron

- Fe is necessary for the production of hemoglobin and it is a part of the hemoglobin molecule.
- Hemoglobin in the red blood cells carries oxygen to tissues and carbon dioxide away from tissues.
- Deficiencies cause anemia in all animals.



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Minerals ; Iron

- Other deficiencies may occur in mature animals which are infected by internal parasites, especially sheep.
- Sow's milk is deficient.
- Animals out on pasture or dry lot may absorb adequate levels from the soil.



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Minerals ; Copper

- Influences iron absorption.
- Necessary for the synthesis of keratin for hair and wool growth.
- Deficiencies
 - Anemia
 - Abnormal wool growth
 - Bleaching of hair in cattle
 - Muscular incoordination



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Minerals ; Manganese

- Involved with enzyme systems of estrus, ovulation, fetal development, udder development, milk production, and growth.
- Requirement are in the mg to kg of diet.
- High levels of Ca and P may increase the requirements.
- Very few deficiencies occur naturally.



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Minerals ; Cobalt

- A component of the Vitamin B12.
- Necessary for rumen synthesis of Vit. B12.
- Deficiencies usually appear as a general malnutrition: poor appetite, slow growing, weakness, and anemic.
- Beef and sheep producers need to supply Co while hog and poultry need to supply B12.



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Minerals ; Molybdenum

- A component of the enzyme, xanthine oxidase which is important to poultry for uric acid formation.
- Stimulates rumen organisms.
- Can improve lamb rate of gain.
- Not usually a problem except with poultry.



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Minerals ; Selenium

- Necessary for Vitamin E absorption and utilization.
- Works with Vit. E for the maintenance of normal cell function and membrane health.
- Deficiencies cause “white muscle disease” in young calves and lambs. Poor growth and decreased fertility in females are also symptoms.



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Minerals ; Selenium

- Droughty conditions in the corn belt will result in selenium deficient corn and soy rations because they are naturally low in Se usually.
- Requirements are not high but necessary.
- Excess are toxic to animals. .1 mg is ok, but 5 mg/kg of ration is to much.



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Minerals ; Zinc

- Prevents parakeratosis, which is a skin disorder. It is easily confused in swine with a rash caused infected lice bites or sucking.
- Promotes wound healing, normal testicular growth and function, and hair and wool growth.
- Deficiencies are generally related to swine, not beef and sheep.



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Minerals ; Fluorine

- Human needs greater in humans than animals for dental care.
- Excesses of fluorine in phosphorus sources may be toxic to animals.
- If watering with city water, check to see if F1 is added so that mineral mix fluorine can be removed.



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Minerals ; Iodine

- Functions to produce thyroxine by the thyroid gland.
- Dairy cattle seem to have a slightly greater need than other animals.
- Deficiency symptoms
 - Goiter
 - Hairless at birth
 - Weak or dead at birth



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Minerals ; Iodine

- Supplemented usually through salt as iodized salt.
- Great Lakes areas are deficient in iodine.
- Too much can be toxic.



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Producers Need:

- Uniformity of animals to be fed.
- Uniformity of degree of condition or finish desired at a selected price.
- Uniformity of feed composition.



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Vitamins

- Organic compounds needed by the body in very small amounts.
- Classified into two groups:
- Fat soluble vitamins
 - A, D, E, & K
- Water soluble vitamins
 - C & B complex



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Vitamin A

- Measured in International Units
- Occurs in plants in the form of carotene. The liver is responsible for the conversion to Vit. A.
- Occurs naturally in fish oils.
- Legumes are naturally high in carotene, especially alfalfa hay, or haylage.



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Vitamin A

- A part of the visual purple of the eye which necessary for night vision.
- Also necessary for normal repro.



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Vitamin D

- Closely associated with Ca and P.
- Sunlight activates the substance ergosterol in skin which synthesizes Vitamin D.
- Necessary for the proper assimilation of Ca & P in the body.
- Helps to prevent rickets (young animals) and osteomalacia (mature animals)
- Measured in International Units



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Vitamin E

- Necessary for normal reproduction.
- Associated with the mineral, selenium.
- Necessary for proper development of the muscular system of fetal and newly borne animals.
- Measured in International Units.



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Vitamin K

- Also known as menadione.
- Necessary for normal blood clotting.
- Blocked by genetic defect of hemophilia.
- Coumadin works as blood thinner.
- Green leafy plants provide vit. K



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B Vitamin Complex

- The B complex deals with metabolic reactions relating to nutrient utilization.
- Biotin
- Choline
- Folacin or Folic acid
- Riboflavin
- Pantothenic acid
- Thiamine
- B6
- B12



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B Complex

- Measured in milligrams. Mg
- Regulates carbohydrate metabolism.
- Hoof and foot condition
- Skin condition
- Growth rate
- Normal fetal growth



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Feed Analysis

- It is the comprehensive evaluation procedure to determine nutrient composition, digestibility, production value, palatability, and the physical or handling characteristics of feeds.
- Provides useful info on harvesting and storage methods to insure quality of feed.



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Three Types of Analytical Methods

- Chemical – chemical extractions
- Biological – animal feed trials
- Microbiological – microbial trials



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Proximate Analysis

- Chemical procedures designed to partition into:
 - Water
 - Ash
 - Crude protein
 - Crude Fiber
 - Ether extract
 - Nitrogen free extract



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Energy in Feeds and of Digestion

- Sources
 - Carbohydrates
 - Fats
 - Protein
- Energy is used for cell maintenance, activity by the animal, reproduction, lactation, and especially finishing.



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Bomb Calorimeter

- Used to measure the energy content of a feedstuff.
- A feedstuff is placed in the bomb calorimeter and ignited under a pressurized atmosphere of oxygen.
- Gross energy of the feedstuff is determined.



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Animal Trials

- Useful to develop feeding standards and recommendations for feeding animals at different levels of production.
- Types of animal trials
 - Feeding trials
 - Digestion trials
 - Metabolism trials



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Feeding Trials

- Used to determine if animals will eat a feedstuff and how they will perform on it.
- Common types:
 - Growth trials
 - Lactation trials
 - Eggs produced



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Digestion Trials

- Used specifically to discover the degree to which a feedstuff is digested and absorbed by the animal.
- Measure chemically all feed uptaken by the animal.
- Measure chemically all feces and urine excreted by the animal.



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Metabolism Trials

- Advanced digestion trials.
- Includes measurement of:
 - Urine
 - Feces
 - Hair loss or feathers
 - Products – milk, eggs,
 - Heat loss
 - Expired air and gasses
 - Skin
 - Sweat



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Ration Formulation

- Nutrient requirements are set by The National Research Council, which is a branch of the National Academy of Science.
- Ration is the amount of feed offered to an animal during a 24 hour period.
- Balanced ration is the amount of feed offered in the most desirable form and in the correct amounts providing all the necessary nutrients for the desired outcome from the animal.



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EVALUATION OF FOODS DIGESTIBILITY



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FACTOR AFFECTING DIGESTIBILITY

- **FOOD COMPOSITION**
- **RATION COMPOSITION**
- **PREPARATION OF FOODS**
- **ENZYME SUPPLEMENTATION OF FOODS**
- **ANIMAL FACTORS**
- **LEVEL OF FEEDING**



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FOOD COMPOSITION

- **CELL WALLS** = HEMICELULOSA, CELLULOSA, LIGNIN
- **CELL CONTENT** = COMPLETELY DIGESTED



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RATION COMPOSITION

THE DIGESTIBILITY OF A FOOD IS INFLUENCED NOT ONLY BY ITS OWN COMPOSITON, BUT BY THE COMPOSITION OF OTHER FOOD CONSUMED WITH IT.



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PREPARATION OF FOODS

- CHOPPING
- CHAFFING
- CRUSHING/GRINDING
- COOKING



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ENZYME SUPPLEMENTATION OF FOODS

ENZYME ADDITION = β - GLUCANASE



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ANIMAL FACTORS

- JENIS PAKAN
- SPECIES
- KUALITAS PAKAN



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LEVEL OF FEEDING

- OFTEN EXPRESSED IN MULTIPLES OF THE QUANTITY OF FOOD REQUIRED BY THE ANIMAL (BODY MAINTENANCE).
- IN NON RUM
 - FEEDING LEVEL RISE 2-3 TIMES MAINTENANCE IN POULTRY
 - 3-4 TIMES MAINTENANCE IN GROWING PIG
 - 4-6 TIMES MAINTENANCE IN LACTATING SOWS.



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EVALUATION OF FOODS THE ENERGY VALUE OF FOOD



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ENERGY SYSTEM FOR PIGS AND POULTRY

- LESS COMPLICATED
 - DIGEST CELLULOSE RELATIVELY SMALL EXTENT
 - UTILISATION OF METABOLISABLE ENERGY DIFFERS TO A RELATIVELY SMALL EXTENT.



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ENERGY SYSTEM FOR PIGS

- A NET ENERGY SYSTEM FOR PIGS WAS INTRODUCED AT THE TIME OF THE STARCH EQUIVALENT SYSTEM FOR RUMINANTS
- INCLUDING FIBROUS BY-PRODUCT FOODS
- AS A MEASURE OF FOOD ENERGY, NET ENERGY WILL BE SUPERIOR TO METABOLISABLE ENERGY (AND DIGESTIBLE ENERGY) IF THERE ARE DIFFERENCES BETWEEN FOODS IN THE EFFICIENCY OF UTILISATION OF METABOLISABLE ENERGY



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ENERGY SYSTEM FOR POULTRY

- THE FIGURES OBTAINED WERE CALLED PRODUCTIVE ENERGY VALUES, IN ORDER TO EMPHASISE THAT THEY WERE NET ENERGY VALUES FOR GROWTH, NOT MAINTENANCE
- THE METABOLISABLE ENERGY OF POULTRY FOODS IS USED WITH REASONABLY CONSTANT EFFICIENCY
- METABOLISABLE ENERGY PROVIDED BY DIETARY FAT HAS BEEN SHOWN TO BE MORE EFFICIENTLY UTILISED THAN THAT SUPPLIED BY CARBOHYDRATE
- METABOLISABLE ENERGY IS VERY EASILY MEASURED IN POULTRY, SINCE FAE-CES AND URINE ARE VOIDED TOGETHER



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ENERGY SYSTEM FOR HORSES

- based on net energy
- the digestive processes of horses, one would expect a poor correlation between digestible and net energy for the range of foods consumed by horses, which includes concentrates and forages such as poor hay, digested by microorganisms in the large intestine
- food such as maize would be mainly digested in the small intestine



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EVALUATION OF FOODS THE PROTEIN VALUE OF FOOD



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- MEASURES OF PROTEIN QUALITY FOR **MONOGASTRIC ANIMALS**

- MEASURES OF PROTEIN USED IN PRACTICE IN THE FEEDING OF **PIGS AND POULTRY**



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PROTEIN EFFICIENCY RATIO (PER)

$$\text{PER} = [\text{GAIN IN BODY WEIGHT (g)}] / [\text{PROTEIN CONSUMED (g)}]$$

NET PROTEIN RATIO

$$\text{NPR} = \frac{[[\text{WEIGHT GAIN OF TPG}] - [\text{WEIGHT LOSS OF NPG}]]}{[\text{WEIGHT OF PROTEIN CONSUMED}]}$$

WHERE, TPG = GROUP GIVEN THE TEST PROTEIN
NPG = GROUP ON PROTEIN – FREE DIET

GROSS PROTEIN VALUE

$$\text{GPV} = A / A^{\circ}$$

WHERE, A = g INCREASED WEIGHT GAIN / g TEST PROTEIN
A^o = g INCREASED WEIGHT GAIN / g CASEIN



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NITROGEN BALANCE

NITROGEN BALANCE ARE SUSCEPTIBLE TO SEVERAL SOURCES OF ERROR:

- INADEQUATE ADAPTATION OF EXPERIMENTAL ANIMALS (DIET & ENVIRONMENT)
- COLLECTION & WEIGHING FAECES & URINE
- STORAGE FAECES & URINE
- PREPARATION & SAMPLING FAECES & URINE FOR CHEMICAL ANALYSIS

BIOLOGICAL VALUE (BV)

$$\text{BV} = \frac{\text{N intake} - (\text{N faecal} - \text{MFN}) - (\text{N urinary} - \text{EUN})}{\text{N intake} - (\text{N faecal} - \text{MFN})}$$

WHERE, MFN = METABOLIC (ENDOGENOUS) FAECAL N
EUN = ENDOGENOUS URINARY N



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TABLE BIOLOGICAL VALUE OF THE PROTEIN IN VARIOUS FOODS FOR MAINTANANCE AND GROWTH FOR THE GROWING PIG

FOOD	BV



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A LINEAR RELATIONSHIP EXISTS BETWEEN NINTROGEN INTAKE & BALANCE :

$$Y = bX - a$$

WHERE ; Y = N BALANCE

X = N ABSORBED

a = N LOSS AT ZERO INTAKE

b = N BALANCE INDEX

ANIMAL PROTEIN

- HIGHER BV
- AA COMPOSITION CONSTANT



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CHEMICAL SCORE

- QUALITY OF PROTEIN IS DECIDED BY AA
- WHEAT PROTEIN, AA ESSENSIAL GREATEST DEFISIT (LYSINE)
- LYSINE IN EGG & WHEAT PROTEIN 72 & 27 g/kg
- CHEMICAL SCORE WHEAT PROTEIN $27/72 = 0.37$.
- SCORES CORRELATE WELL WITH BV FOR RATS & HUMAN BEINGS BUT NOT FOR POULTRY.



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THE ESSENSIAL AMINO ACID INDEX (EAAI)

- CHEMICAL SCORE & ESSENSIAL AA INDEX ARE BASED UPON GROSS AMINO ACID COMPOSITION.
- IN VIVO FOOD & FAECES (CONTAIN VARYING AMOUNTS AA NOT PRESENT IN FOOD).
- METHIONINE & LYSINE TO TAKE PLACE IN THE HIND GUT OF THE PIG.
- CYS, THRE, TRYP DISAPPEAR FROM THE LARGE INTESTINE



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BIOLOGICAL ASSAY OF AVAILABLE AMINO ACIDS

- FOOD PROTEIN (LIVEWEIGHT GAIN, FOOD CONVERSION EFFICIENCY OR NITROGEN RETENTION)
- MAJOR PROBLEM OF CONSTRUCTION DIET =
 - TECHNICAL EXERCISE
 - SUPPLY OF SUITABLE ANIMAL



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MICROBIOLOGICAL ASSAY OF ESSENTIAL AMINO ACIDS

- BASED ON =
 - MEASURING THE GROWTH MO IN CULTURE MEDIA
 - STREPTOCOCCUS ZYMOGENES & TETRAHYMENA PYRIFORMIS
 - FORMER : AFTER AN ACID OR ENZYMIC PREDIGESTION (FOOD PROTEIN)
 - AVAILABLE = LYSINE & METHIONINE
 - LYSINE, MET, TRYP CORRELATE WELL WITH BIOLOGICAL ASSAYS.



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CHEMICAL METHODS

- FDNB – REACTIVE LYSINE (UTILISABLE LYSINE IN FOODS, HAS EPSILON-AMINO GROUPS)
- ALKALINE + FDNB GIVE DNP-LYSINE, COLOROMETRICALLY.
- CEREALS = LYSINE IS LIMITING.
- THE GROSS PROTEIN VALUE IS PROBABLY THE MOST COMMONLY USED BIOLOGICAL METHOD FOR EVALUATING PROTEINS.



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DYE BINDING METHODS

- THE METHOD ARE RAPID & GIVE REPRODUCIBLE RESULTS , ATTEMPTS FOR MEASURING TOTAL BASIC AMINO ACID & REACTIVE LYSINE.

	SAMPLE					
	1	2	3	4	5	6
TOTAL LYSINE (g/100 g)	2.65	2.59	2.82	2.73	3.89	2.68
FDNB-AVAILABLE LYSINE (g/100 g)	2.17	1.91	2.53	2.32	2.57	2.11
HEAL TRULLY DIGESTIBLE LYSINE (g/100 g)	1.72	1.75	1.93	1.97	2.88	2.05



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INTERPRETATION OF AMINO ACID ASSAYS

- EVEN SMALL CHANGES IN THE CONCENTRATION OF ONE OR MORE AA MAY INCREASE THE AMOUNTS OF OTHERS REQUIRED TO MAINTAIN GROWTH RATE.
- CERTAIN ACIDS, TRYP & HISTIDIN (TOXIC)
- ANTAGONISM MAY EXIST BETWEEN SPECIFIC ACID.
- ANTINUTRITIONAL FACTOR.
- CONSIDERABLE EVIDENCE THAT GROWING ANIMALS.



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MEASURES OF FOOD PROTEIN USED IN PRACTICE IN THE FEEDING OF PIGS AND POULTRY

- THE QUALITY OF DIETARY PROTEIN IS INDICATED BY STATING THE CONTENTS OF ALL THE ESSENTIAL AA OR OF THOSE MOST LIKELY TO BE IN DEFICIT.
- PRACTICAL PIG & POULTRY DIETS ARE BASED LARGELY ON CEREALS
- ASSESMENT FOOD SOURCES PROTEIN
- THE MAIN DEFICIENCIES = LYSINE & MET
- IDEAL PROTEIN IS CONCEIVED OS PROVIDING THE ESSENTIAL AA IN THE PROPORTIONS REQUIRED BY THE PIG AND OF HAVING THE CORRECT BALANCE BETWEEN THE ESSENTIAL & NON ESSENTIAL ACIDS.
- THE BALANCE OF AA IN THE IDEAL PROTEIN APPLICABLE TO MAINTENANCE GROWTH
- POULTRY = EVALUATION OF PROTEIN SOURCES IS BASED UPON THE AMOUNTS OF THE 3 MAJOR LIMITING AA (LYS, MET, TRYP).



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