Appendix 1 – Vitamin and Mineral Tables

Functions, Deficiencies, Interrelationships, & Toxicities

Table 1 - Macro Minerals

MINERAL	MAJOR FUNCTION	SOME DEFICIENCY SYMPTOMS	MAJOR INTERRELATIONSHIPS AND TOXICITIES
Sodium (Na) & Chlorine (Cl) - Salt	- Normal Appetite - Meat and Egg Production - Regulation of Body Fluids - Nerve Transmission and Muscle Action	- Reduced Growth and efficiency of feed Utilisation in growing animals - Reduced production and weight loss in adults - Lowered reproduction (infertility in Males and delayed sexual maturity in Females) - Chicks on Cl-deficient diet exhibit nervous symptoms induced by sudden noise	- Salt Toxicity is accentuated with restriction of Water
Calcium (Ca)	- Bone and Teeth Formation - Blood Coagulation - Muscle Contraction - Nerve Function - Cell Permeability - Egg Shell Formation	- Rickets in Young - Bowed Legs in Chicks - Osteomalacia in Adults	- Calcium/Phosphorous Ratio for non-ruminants usually 1:1 - 2:1 - Vitamin D required - Excess Ca reduces absorption and Utilisation of Zn - Excess of Mg decreases Ca absorption
Phosphorous (P)	- Essential for Life - Promotes Bone Growth - Increases Energy Utilisation - Aids Reproduction - Builds Muscle Tissue - Improves Feed Efficiency	- Rickets in young and Osteomalacia in Adults - Stiffness - Poor Appetite - Urinary Problems - Slower Weight Gains - Reduced Conception in Hens - Reduced Meat and Egg Production - Less Resistance to Disease	- Vitamin D required for P assimilation and Utilisation - Excess of Ca and Mg causes decrease in absorption
Magnesium (Mg)	- Essential for Normal Skeletal Development - Reduced Stress - Aids Appetite - Reduces Tissue Irritability	- Vasolidation, with resulting reduction in Blood Pressure - Hyperirritability - Slipped Tendons	- Excess upsets Ca and P metabolism
Potassium (K)	- Required in Every Cell - Muscle Activity - Promotes Feed Intake - Reduces Stress	- Retarded Growth - Unsteady Gait - General Muscle Weakness - Abnormal Heart Beat	- Mg Deficiency results in failure to retain Potassium - resulting in K deficiency - Excessive levels of K interfere with Mg absorption and result in Mg deficiency
Sulfur (S)	- Essential for Life - Promotes of Feed Intake - Essential for Meat and Egg Production - As a component of coenzyme A is important in energy metabolism	- Retarded Growth - Reduced Meat and Egg production	- Related to the Amino Acids cystine and methionine - Related to Biotin, Thiamine and coenzyme A

Table 2 - Macro Minerals

MINERAL	MAJOR FUNCTION	SOME DEFICIENCY SYMPTOMS	MAJOR INTERRELATIONSHIPS AND TOXICITIES
Iodine (I)	- Thyroid Gland Metabolism - Regulation Rate of Body Metabolism and heat production	- Dead in Shell - Delayed Hatch - Incomplete Abdominal Closure - Decreased Performance	- Long Term chronic intake of large amounts of I reduces Thyroid uptake of I - Marked specie differences exist in tolerances to high intakes of I
Iron (Fe)	- A constituent of haemoglobin, the iron containing compound that transports Oxygen - Cellular Oxidations - Metabolism of bone marrow, spleen and liver	- Fe deficiency anaemia - Retarded Growth - Incorrect Feather pigmentation	- Related to haemoglobin - Cu is required for proper Fe metabolism - Pyridoxine deficiency decreases absorption of Fe - Excess interferes with phosphorous absorption
Manganese (Mn)	- Essential for Normal Bone Growth and Reproduction - Activator of Enzyme Systems involved in oxidative phosphorylation, amino acid metabolism, fatty acid metabolism, fatty acid synthesis and cholesterol metabolism.	- Retarded Growth - Lameness, Shortening and Bowing of Legs - Enlarged Joints - Testicle degeneration of Males - Defective ovulation of Females - Slipped Tendons - Peak Death prior to Hatch - Edema, malformations and abnormal feathering	- Excess of Ca and P decreases absorption
Chromium (Cr)	- Insulin like effect on glucose metabolism		-Excess Chromium causes reduced growth and poor egg quality.
Cobalt (Co)	- A component of Vitamin B12		-Excess Cobalt causes reduced growth.
Copper (Cu)	- Required for hemoglobin formation - Essential in Enzyme systems - Feather Development and Pigmentation - Bone Development - Reproduction - Shell Quality	- Nervous symptoms (Ataxie) - Early Embryo Death - Lameness and Swelling of Joints - High incidence of Bone Fractures - Weak Blood Vessels (aortic ruptures) - Incorrect Feather Pigmentation - Enlarged Heart	- Excess of molybdenum in the presence of Sulfate causes a condition that can be cured by administering Copper - Excess of Copper is toxic
Fluorine (F)		- Excesses is more of a concern than deficiency	- High dietary Ca depresses F uptake of bone - F is a cumulative poison -Low quality phosphorus sources may contain unacceptable levels of F.
Molybdenum (Mo)	- Uric Acid Formation	- Toxic levels more of a concern than deficiency	- Mo is related to uric acid formation in Poultry and microbial action in ruminants - Toxic levels of Mo interfere with copper metabolism
Selenium (Se)	- Metabolism of Liver, Kidneys and Muscles - Interacts with Vitamin E absorption and retention - Prevents degeneration and fibrosis of the pancreas in chicks	- Nutritional Muscular Dystrophy in Lambs and Calves - White Muscle Disease - Exudative diatheses in Poultry - Liver Necrosis in Pigs - Mulberry Heart - Reduction in Egg Production and hatchability - High incidence of early Embryonic Death - Deformities Common, including lack of eyes and deformed wings and feet	- Related to Vitamin E Absorption
Silicon (Si)	- Mineralisation process in Bones		- Adverse affects from high Si intake rather than Si deficiency

Table 2 cont. - Macro Minerals

MINERAL	MAJOR FUNCTION	SOME DEFICIENCY SYMPTOMS	MAJOR INTERRELATIONSHIPS AND TOXICITIES
Zinc (Zn)	- Bone and Feather Development - Component of several enzymes including carbonic anhydrase - Required for normal protein synthesis and metabolism	- Loss of Appetite - Stunted Growth - Poor Feather Development - Rough and Thickened Skin - Scaliness on Feet - Hock Enlargement - Slipped Tendons - Shortening and thickening of leg bones - Egg Yield and Hatchability - Feather condition of Offspring	- Excess of Ca reduces absorption and utilisation of Zn - Excess of Zn interferes with Cu metabolism and may cause anaemia

Table 3 - Vitamins Fat Soluble

VITAMIN	MAJOR FUNCTION	SOME DEFICIENCY SYMPTOMS	COMMENTS
Vitamin A	- Bone Growth - Night Vision - Normal Function of Genital System and Fertility - Healthy Tissue - Disease Resistance	- Lesions around the eyes, eyelids stuck together - Poor Egg Production - Poor Hatchability - Sterility in Males and Females - Stunted Growth - Weight Loss and Loss of Appetite - Nervous incoordination - Weak Chicks	- Easily Destroyed by oxidation, therefore easily destroyed in processing and storing - Functions with Calcium, Phosphorous and Magnesium
Vitamin D3	- Aids in assimilation and utilisation of Calcium and Phosphorous - Essential for normal bone growth including the bones of the fetus - Appetite and Feed Efficiency	- Rickets in Young - Osteomalacia in Adults - Reduced Growth - Leg Deformities - Poor Egg Shells - Lowered Hatchability - High Sickness Susceptibility - Defective or Soft Beak in Chicks - Incorrect Feather Pigmentation	- Needs to be in adequate amounts to act as a carrier for Calcium and Phosphorous
Vitamin E	- Works with Selenium - Antioxidant - Prevents Tissue Destruction in the Body - Muscle Structure - Aids in Conception and Reproduction - Improves Weight Gains and Feed Efficiency	- Muscular Dystrophy - White Muscle Disease - Encephalomalacia (Crazy Chick Disease) - Exudative diathesis - Poor Hatchability - High Chick Mortality - Sudden Death	- Utilization of Vitamin E is dependent on adequate Selenium
Vitamin K	- Essential for prothrombin formation - Blood Coagulation	- Prolonged Blood Clotting Time - Generalised Haemorrhages - High Embryonic Mortality	

Table 4 - Vitamins Water Soluble

Water Soluble			
Vitamin B12	- Coenzyme in several enzyme systems - Required for Protein Formation - Aids in the prevention of Anaemia - Eliminates the need for Animal Protein in the Ration	- Retarded Growth - Fail to Hatch Eggs - Anaemia - Slipped Tendon in Chicks	- Related to Folic Acid for metabolism - Works with Co
Biotin	- Component of several enzyme systems - Fatty Acid Synthesis - Protein Synthesis	- Crusting and Scab formation around eyes and beak - Bottoms of Feet rough with haemorrhagic cracks - Curled toes - Low Hatchability	
Choline	- Involved in Nerve Impulses - A component of phospholipids - Donor of methyl groups - Mobilisation of Body Fat through the liver	- Fatty Liver - Slipped Tendon - Kidney Haemorrhaging	- Increased deficiency symptoms associated with low Protein Levels - Works with Niacin

Table 4 – cont. Vitamins Water Soluble

Water Soluble			
Folic Acid (Folacin)	- Related to B12 Metabolism - Metabolic reactions involving incorporation of single carbon units into larger molecules - Formation of erythrocytes and Leucocytes	- Poor Growth - Macrocytic Anaemia - Late Embryonic Death - Beak Deformities - Slipped Tendon - Frizzled and Rough Feathering - Incorrect Pigmentation - Poor Egg Production	
Inositol	Not Known	- Spectacled Eye Appearance in Rats	- Synthesized in Intestines
Niacin (nicotinic acid)	- Constituent of coenzymes - Hydrogen Transport - Energy Metabolism - Egg Production - Yield and Hatchability - Fat Mobilisation through the Liver	- Retarded Growth - Reduced Appetite - Spectacled Eye - Scaliness on Feet - Frizzled and Rough Feathering - Fatty Liver - Hock Enlargement - Bowed Legs - Curled Toes	- Niacin available in most cereal grains is not available to simple stomached animals - Works with Choline
Pantothenic Acid	- Component of coenzyme A - Required for Energy metabolism - Plumage Quality - Viability of Offspring - Egg Production - Hatchability	- Retarded Growth - Poor Feathers - Enteritis - Dermatitis - Embryonic Death - Crusting and Scab Formation around Eyes and Beak - Bottoms of Feet Rough with Haemorrhagic Cracks	- Grain is very deficient in Pantothenic Acid - Of all the B Vitamins it is most likely to be deficient in Dry Lot conditions
Parmino-benzoic Acid	Not Clearly Established	Not Demonstrated in Animals	Abundantly synthesised in the intestines
Pyridoxine (B6)	- Coenzyme in protein and nitrogen metabolism - Involved in Red Blood Cell Formation - Important in endocrine System	- Convulsions - Retarded Growth - Abnormal Feathering - Reduced Egg Laying and Hatchability	
Riboflavin (B2)	- Promotes Growth Functions as a constituent of several enzyme systems - Important in Carbohydrate and Amino Acid metabolism	- Retarded Growth - Curley Toes - Low Hatchability - High Embryonic Mortality during 3rd and 4th Week of Incubation - Low Food Conversion Rate - Poor Chick Quality	- Grains poor source - Many common rations are borderline or deficient.
Thiamine (B1)	- Coenzyme in Energy Metabolism - Promotes Appetite and Growth - Required for Normal Carbohydrate Metabolism - Aids Reproduction - Aids Hatchability	- Reduced Appetite - Weight Loss - Cardiovascular Disturbances - Lowered Body Temperature - Polyneuritis in Chicks (retraction of the head) - Reduced Egg Production in Hens	
Vitamin C	- Callagen Formation - Formation of the intercellular substances of the teeth, bones and soft tissue - Increases resistance to infection	- No problems observed relating to Ostrich	- Ordinary farm rations and body synthesis provide adequate Vitamin C

Ostriches are NOT poultry, however the deficiency signs in poultry are similar to problems seen in Ostrich. The levels and ratios will differ between the species to overcome these deficiencies.

Table 5 - Signs of Nutritional Deficiencies In Poultry Embryos

Reprinted From: NRC Nutrient Requirements of Poultry, 1994 Edition

NUTRIENT	DEFICIENCY SIGNS
Vitamin A	Death at about 48 hours of incubation from failure to develop circulatory system. Deformities of kidneys, eyes, and skeleton.
Vitamin D	Death at about 18-19 days of incubation, with malpositions, soft bones, and/or a defective upper beak.
Vitamin E	Early death at 84-96 hours of incubation, with haemorrhaging and circulatory failure. (Implicated with Selenium)
Vitamin K	Mortality occurs between 18 days, and hatch with variable haemorrhaging.
Thiamin	High embryo mortality during hatch. No other obvious symptoms.
Riboflavin	Mortality peaks at 60 hours, 14 days, and 20 days of incubation, with peaks prominent early as deficiency becomes severe. Altered limb and beak development.
Niacin	Various beak and bone malformations can occur during incubation.
Biotin	High death rate at 19-21 days of incubation. Embryos have parrot beak or skeletal deformities.
Pantothenic Acid	Death appears at 14 days of incubation in severe cases. Variable haemorrhaging and oedema with wiry feathers.
Folic Acid	Mortality at 20 days of incubation. The dead appear normal except for beak malformations.
Vitamin B12	Mortality at 20 days of incubation. Oedema, haemorrhaging, fatty organs, and head between thighs malposition.
Manganese	Peak deaths prior to hatch. Oedema, malformations, abnormal feathering.
Zinc	Deaths prior to hatch. Underdeveloped eyes or missing limbs.
Copper	Deaths at early blood stage. No malformations.
Iodine	Prolongation of hatching time. Incomplete abdominal closure.
Iron	Low blood haemoglobin. Poor embryonic circulation in candled eggs.
Selenium	High incidence of embryo death early in incubation.

Table 6 - Nutrients Associated with Various Signs of Deficiency in Growing Birds

Reference: Nutrient Requirements of Poultry. 1994 Edition

Deficiency Signs	Physical Description	Associated Nutrients
Skin Lesions	Crusting and scab formation around eyes and beak	Biotin, Pantothenic Acid
	Bottoms of feed rough with hemorrhagic cracks	Biotin, Pantothenic Acid
	Scaliness on Feet	Zinc, Niacin
	Lesions around eyes, eyelids stuck together	Vitamin A
Feather Abnormalities	Frizzled and rough	Zinc, Niacin, Pantothenic Acid, Folic Acid
	Incorrect pigmentation (red or brown instead of black or gray)	Vitamin D, Copper, Iron, Folacin
Blood and Vascular	Anaemia	Vitamin B12, Folacin, Iron, Copper
	Fatty Liver	Choline, Niacin
	Enlarged Heart	Copper
Muscle	White Muscle Disease	Vitamin E, Selenium
Bone Disorders	Soft, easily bent bones and beak	Vitamin D, Calcium or Phosphorous
	Hock Enlargement	Niacin, Zinc
	Perosis (slipped tendon)	Biotin, Choline, Vitamin B12, Manganese, Zinc, Folacin
	Bowed Legs	Niacin, Calcium, Phosphorous, Magnesium
	Shortening or thickening of leg bones	Zinc, Manganese
	Curled Toes	Riboflavin, Niacin, Biotin

Table 7 – Nutrient Effects on Egg Production

Reference: NRC Nutrient Requirements of Poultry. 1994 Edition

Nutrient	Response Affected
Vitamin A	Egg Production, hatchability, fertility
Vitamin D	Egg Production, hatchability, fertility, shell quality
Vitamin E	Hatchability
Vitamin K	Hatchability
Thiamine	Hatchability
Riboflavin	Egg Production, hatchability, chick quality
Niacin	Egg Production, egg yield, hatchability
Biotin	Egg Production, egg yield, hatchability
Pantothenic Acid	Egg Production, hatchability, viability of offspring
Folic Acid	Egg Production, hatchability
Vitamin B12	Hatchability
Manganese	Egg Weight, egg production, hatchability, shell quality
Zinc	Egg yield, hatchability, feather condition of offspring
Copper	Shell Quality
Iodine	Hatchability
Iron	Hatchability
Selenium	Egg Production, hatchability