FEEDING OF HORSES

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Part of intestine	Volume per cent
Fore Gut	37
Stomach	9
Small Intestine	27
Hind Gut	63
Cecum	17
Large Colon	35
Small Colon	11

- **NUTRIENT REQUIREMENTS**

Water

- **Dry matter intake - Horses may need 2 to 3 L of water/kg of dry matter intake.**
- **High salt or excess protein contents - Increase water intake.**
- **Environmental temperatures - e.g., need 2 L of water/kg dry feed at -18^{0}C, but need 8 L of water/kg dry feed at 38^{0}C.**
- **Work/exercising - May increase water needs by 20 to 300%.**
- **Lactation.**

Dehydration and electrolyte balance

- Dehydration through sweating can result in the loss of water and electrolytes (mostly, Na & Cl with some K).
- Preventive electrolyte therapy by oral or i.v. administration of 1-3 L of electrolyte solution - Beneficial? No conclusive evidence, but, oral supplementation may be helpful for a heavily sweating endurance horse in a hot or humid environment.
- An adequate water supply, a balanced diet, and a trace mineralized salt on a free-choice should be sufficient in most racing situations.

Energy

- The energy requirements are expressed in mega calories (Mcal) of DE.
- Differences among individuals:
  - Easy keeper - Often used to describe a horse that can maintain body weight on less than the average dietary energy supply.
  - Hard keeper - One requires more than the average dietary energy to maintain body weight
- Energy status: Can be determined by weighing regularly. If not, can use subjective condition scoring system to monitor body condition.
- Based on body fatness using 1 (very thin) to 9 (very fat).
- Most horses should be maintained at a score of at least 4 and not exceeding 7.

Energy requirements for maintenance:

- DE (Mcal/d) = 1.4 + 0.03 × BW, where BW = body weight of the horse (kg).

Energy requirements for growth:

- 1) Weanlings: 1.4 + 0.03 BW + 9 ADG (kg)
- 2) Yearlings: 1.4 + 0.03 BW + 16 ADG (kg)
- 3) Long yearlings: 1.4 + 0.03 BW + 18 ADG (kg)
- 4) 2-yr-olds: 1.4 + 0.03 BW + 20 ADG (kg)

NRC (1989): Energy requirements: Mcal DE/kg gain:

- 4-month weanling: 9.1
- 6-month weanling:11.0
- Yearling:15.5
- Long yearling: 18.4
- 2-yr-old horses:19.6

ENERGY FOR WORK: NRC-2007

- **Light work** :DE (Mcal/d)= (0.0333 × BW) ×1.2
- **Moderate work**: DE (Mcal/d)= (0.0333 × BW) ×1.4
- **Heavy work:** DE (Mcal/d)= (0.0333 × BW) ×1.6
- **Very Heavy work:** DE (Mcal/d)= (0.0333 × BW) ×1.9

Protein

- Protein requirements: Usually expressed as grams of CP required per day.

- Mature horses at maintenance:
  - Have relatively low protein needs and deficiency is rare with an adequate energy.
  - A mature 500-kg horse needs ≈ 660 g/CP/d, which can be supplied by 8 kg of a hay containing 8.25% CP.

- Young horses, lactating mares, and mares in late gestation - Need a diet with higher protein quantity and quality.

- Protein quality:
  - An important consideration in growing horses
  - Lysine seems to be the first limiting amino acid in diets for growing horses, with Threonine being suggested as the second limiting.

MICROBIAL PROTEIN/AMINO ACID SYNTHESIS:

- Unclear on the rate of amino acid synthesis and absorption at the caecum, thus, should provide an adequate amount of dietary indispensable amino acids, especially for growing horses
- Possible that horses can absorb some N (as ammonia?) from the caecum and (or) large intestine, which can be used for the synthesis of dispensable amino acids.
- Similarly, microbes can synthesize some indispensable amino acids, but their absorption by the hindgut might be limited.

BROODMARES: Need protein for the deposition of fetal tissues and milk production.

- If the mare's milk contains about 2.0% protein and a 500-kg mare produces 15 kg of milk/day, about 300 g of protein will be secreted in the milk.
- Conversion is not very efficient, so, perhaps, ≈ 1,430 g of dietary CP is needed.

Estimation of CP requirements (g/day)

- **Maintenance: CP= (40) (Mcal of DE/day)**
- **Stallions : CP= (40) (Mcal of DE/day)**
- **Pregnant mare 9-11months:CP= (44) (Mcal of DE/day)**
- **Lactating mares (Foaling to 3 months):**

➢ **200-299 kg BW CP=** (Maintenance DP) + [(0.04BWx 0.021x1000)/0.65)/0.55]

➢ **300-900 kg BW CP=** (Maintenance DP) + [(0.03BWx 0.021x1000)/0.65)/0.55]

- **Working Horse** CP= (40) (Mcal of DE/day)

Minerals

- **Ca & P :Special importance in horses:**

- The development of quality bone is more important in horses than other livestock species simply because some athletic activity may put more stress on bones.
- The horse's bone: About 35% Ca and 16% P, and deficiencies or imbalances in dietary Ca and P can result in various bone disorders.
- High-P can impair the absorption of Ca, thus, the concentration of P should not exceed the concentration of Ca. Also, must consider availability of Ca and P.
- Obviously, a sufficient amount of vitamin D must be available.

- **Sodium, K, and Cl - Function as electrolytes and essential for all classes:**
- **Most non-working horses obtain enough Na and Cl to meet their needs with their access to a salt block or a "loose" salt mix.**
- **Potassium: Usually met by K found in hay and pasture.**

- **The needs are greater for working horses, lactating mares, and horses that are exposed to high environmental temperatures.**

- **Deficiency: Can reduce a water/feed intake, plus show some unusual oral behavior such as licking of stall surfaces.**

- **Iodine:** Both I deficiency and I toxicity have been reported in horses. The I content of common horse feeds can vary considerably.

- **Iron:** Usually met by the typical feed ingredients, even though the availability of Fe in grains and forages may be low. Fe deficiency signs are rarely reported.

- **Copper:** The level and availability of Cu is very low in many forages, and it is a common practice to formulate grain mixes to contain 20 to 30 mg Cu/kg DM.

- **Zinc:** Forages may also be low in Zn. Zinc deficiency can reduce growth of young horses.

- **Selenium**: Selenium supplementation is often necessary but should be done carefully because of its toxicity.

Estimation of Calcium (Ca) requirements (g/day):

- Maintenance: Ca= 0.04 BW
- Stallions: Ca= (1.22) (Mcal of DE/day)
- Pregnant mare 9-11months: Ca= (1.90) (Mcal of DE/day)
- Lactating Mares: **Foaling to 3 Months**

➢ 200-299 kg BW : Ca= (Maintenance Ca) + [(0.04BWx 1.2)/0.5)]

➢ 200-900 kg BW: Ca= (Maintenance Ca) + (0.03BWx 1.2) 0.5)]

- **Working Horse:** Ca= (1.22) (Mcal of DE/day)

Estimation of phosphorus (P) requirements (g/day):

- **Maintenance :** P= 0.028 BW
- **Stallions:** P= (0.87) (Mcal of DE/day)
- **Pregnant mare 9-11months:** P= (1.41) (Mcal of DE/day)
- **Lactating Mares: Foaling to 3 Months**

➢ **200-299 kg of BW:** P= 0.010 BW+ (0.04BWx 0.75)/0.5)

➢ **300-900 kg BW:** P= 0.010 BW+ (0.03BWx 0.75)/0.45

- **Working Horse** P= 0.87) (Mcal of DE/day)

Vitamins

- **Fat-soluble vitamins:**
- **Vitamin A and E are of the most practical importance in horse diets:**
- **One of the richest sources of β-carotene (precursor of vitamin A) is "green" pasture.**
- **Vitamin E activity:** High in forages with an early stage of maturity, but once a plant is harvested for hay; the vitamin E activity can decrease.
- **Vitamin D:** supplementation of horses kept outside is not necessary.
- **Vitamin K:** Microbes can synthesize compounds with vit. K activity
- **Water-soluble vitamins:**
- A dietary requirement for vitamin C has not been determined.
- Microbes in the hind gut seem to be capable of synthesizing several B vitamins

Estimation of vitamin A requirements (IU/day):

- **Maintenance:** **Vitamin A=30 BW**
- **Pregnant and lactating mares:** **Vitamin A=60 BW**
- **All others : Vitamin A= 45 BW**

FEEDING SYSTEMS IN HORSES

1. Stall feeding:

- **Concentrate mixture: twice daily**
- **Foals & Lactating mares: thrice daily**
- **Fodder: *ad libitum***

2. Grazing: 6-10hrs grazing lands/fallow land/pastures

3.Feeding bags:

- **By horse/mules/donkey/ Tonga owners**
- **Offered Hay/concentrate in bags during rest**

Types of feeds for horses

(1) Roughages, (2) Concentrates, and (3) Mixed feeds.

Roughages include pasture forages, hays, silages, and byproduct feeds that contain a high percentage of fiber.

Concentrates are the energy-rich grains and molasses, the protein- and energy-rich supplements and byproduct feeds, vitamin supplements, and mineral supplements.

Mixed feeds may be either high or low in energy, protein, or fiber; or they may provide “complete” balanced rations.

- **ROUGHAGES**
- Roughages are still important for active horses and may serve as the only feed for idle horses.
- Proper use of good quality roughages reduces the quantity of expensive concentrates needed and provides a plentiful supply of vitamins and minerals.
- There are four main forms of roughages:
- (1) Dry roughages
- (2) Green roughages
- (3) Silages
- (4) Pastures

- **Dry roughages** include hay, straw, and artificially dehydrated forages, which contain about 90 per cent of dry matter.
- **Silages** are formed from green forages such as grass, alfalfa, sorghum, and corn preserved in a silo at dry matter contents of 20 to 50 percent.
- **Green, growing pastures** provide forage that has high water content and only 20 to 30 percent of dry matter.
- **Green roughages:** (1) grasses, and (2) legumes.
- The **grasses** are generally higher in fiber and dry matter than legumes.
- The **legumes** are generally higher in proteins, energy, vitamins, and minerals.

- **Factors affecting-**
- Soil fertility, soil type, and climate influence the productivity and nutrient content of the various grasses and legumes.

- But the most important factor is stage of maturity.

- As a plant grows older, it becomes less leafy, more stemmy, more fibrous, and less digestible.

- Mineral and vitamin levels are also higher in immature grasses and legumes, whether these roughages are in the form of pastures, silage, or hay.

DRY ROUGHAGES

- In general, the best hay for horses is a good quality grass legume mixed hay.

- Because the calcium level in legumes is about six times higher than the phosphorus level, a supplemental source of phosphorus might be needed to balance the Ca: P ratio in a ration high in legumes.

- For hay to grade U.S. 1 or U.S. 2, 25-40 percent of its weight must be leaves.

Daily Roughage Intake

Horses without access to a good source of grazing should receive roughage in mounts equal to about 1 percent of their body weight daily.

Horse owners should make sure daily roughage intake does not go below 0.75 percent of body weight, because inadequate roughage can make horses more susceptible to digestive problems.

When grazing is not available, baled or processed roughage normally represents at least 50 percent of the daily diet for brood mares, horses doing light or moderate work and 2-year-old horses.

Hay for horses

Undoubtedly, obtaining good hay, storing, and feeding can be a major management problem.

Some factors associated with feeding hay:

- Moldy or dusty hay may cause colic and heaves in horses.

- Large amounts of very poor quality hay cane be poorly digested and may not pass the digestive tract, and can cause "impaction and colic?"

- Very high quality clover or small grain hay can be readily digested, and when fed with a high-grain feed, may result in a "loose" feces or colic.

- When a very high-quality hay is fed with grain, perhaps, necessary to feed a poorer quality grass hay?

Legumes hay:

- Higher in the nutrient content than grasses and may be fed by themselves or in combination with grass hays.

- Heavier and more difficult to cure properly, and are, thus, more prone to mold and become dusty.

- Alfalfa hay is more laxative than grass hays and may cause "loose" feces.

Concentrates

When a horse cannot meet its energy and protein needs through forage alone, must provide additional nutrients via concentrated feedstuffs.

Grains

1) Oats:

- Still the most widely used and the most popular grain for horses – Some believe that oats can cause fewer digestive problems than corn, possibly because of its fiber content?

- Heavy (> 32 lb/bu.), bright, or clean oats, which contain a small percentage of hull, are preferred - Best to roll or crush oats for horses with poor teeth or young foals.

- Lower in the energy content than other grains but will cause less trouble with stomach compaction. Dusty oats should be avoided because they may cause colic.

2) Corn:

- Like oats, widely used for horses - Should be cracked, coarsely ground, or preferably rolled.

- Higher in energy vs. oats - Usually mix it with oats, and include less corn than oats in the mixture.

3) Barley:

- Used some in the States (west), but popular in some other countries.

- Should be coarsely ground or preferably rolled, and usually mix it with oats in about equal parts.

4) Wheat, rye, and milo

- Not used much because they become rather doughy and tend to ball up with moisture when ground.
- If used, should be rolled and mixed at a low level with bulky feed such as oats or wheat bran. (Milo has a very hard seed coat!).

Grain by-products:

- Wheat bran - Very valuable for its mild laxative effect and for its bulky nature. Generally used at 5 to 15% of the diet.
- Wheat middlings - Used in pelleted feeds and an economical source of energy.

Protein supplements

1) Linseed meal:

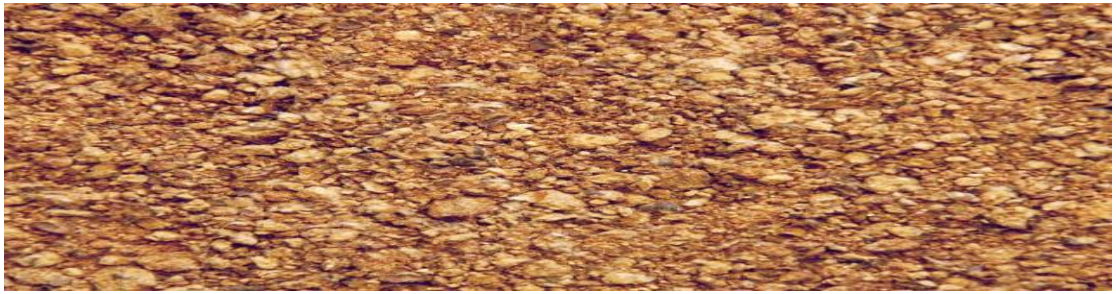
- A popular protein supplement for horse feeding - May contain something that produces bloom and luster in the hair coat?
- Often, pelleted meal is used because of its dustiness - Perhaps, too low in fat after extraction?
- Usually more costly and inferior amino acid composition vs. soybean meal.

2) Soybean meal:

- Also, used quite extensively for horses and may be substituted on an equal protein basis for linseed meal.
- Contains high quality protein and is generally more economical.

3) Cottonseed meal:

- Lower in protein quantity and quality vs. soybean meal.
- May contain gossypol, which may not be toxic to horses, but a maximum of 0,03% for young horses.



4) Milk protein:

- Dried whey or commercial supplements with milk products are often used in a starter diet for foals.

- Rarely used for mature horses because of the cost.

Other miscellaneous feed ingredients

1) Beet pulp:

- High in fiber, but the fiber is well-digested and has fairly high energy value.
- Often, used to replace hay in the diet for horses with heaves (or broken wind, an asthmatic disease of horses).

2) Molasses:

- Including 5 to 10% sweetens the feed and makes it more palatable.
- Also, tends to condition feeds, prevent separation, and reduce dustiness.

3) Dehydrated alfalfa meal

- Include 5 to 10%.
- A good source of vitamins, minerals, protein, and "unidentified factors."

4) Also, rice bran, rice hulls, citrus pulp, or soybean hulls are being used depending on the cost and availability.

Grain feeding

Grain byproducts and grain mix is fed to the horse in following situations:

- When necessary to provide nutrients needed that are not provided in adequate quantity of forage.
- When good quality forage is not available.
- When desired for other reasons viz, athletic performance, work, training, treatment or for catching them.

- Although horses may be gradually adapt to a diet consisting entirely of cereal grains and by-products.

- Greater the proportion of grain in diet, greater is risk of diarrhea, colic, laminitis/founder, exercise myopathy, hyperactivity and obesity.

- It is, therefore, recommended that, not more than one half of grains or concentrate mix may be fed to a horse @ 0.5-0.7kg/100kg BW daily.

Other Ingredients

Minerals:

- Sodium, Cl, and K - Na and Cl needs can be met easily by the addition of salt to a horse diet via plain, iodized, or trace mineralized salt.
- Forages are a good source of K.
- Calcium and P - When diets are low, may be supplemented with limestone, dicalcium phosphate, steamed bone meal, or defluorinated rock phosphate.
- Trace minerals - Usually via commercial trace mineral premixes or trace mineralized salt.

Fats and oils:

- Animal fats and vegetable oils (5 to 10%) can be used as a highly concentrated energy source for horses.

- Vegetable oils are generally more palatable than animal fats.

- Can be used as a source of linoleic acid, to reduce feed dustiness, and to put abloom on the animal hair coat.

Antibiotics

- No information available on the value of antibiotics for horses, but addition of an antibiotic may be helpful for young foals? - Infections, digestive troubles, lack of milk, poor weather, or other stress factors.

- Presently, the Food and Drug Administration allows the use of 85 mg chlortetracycline per head daily for horses up to one year of age for stimulating growth and improving feed efficiency (Jurgen, 2002).

Pelleted Feeds:

- Pellets may be especially useful in creep feeds and diets for weanlings where there is a tendency for horses to separate out the fine particles.
- Pelleted diets containing hay, as well as grain, should contain 60 to 70% coarsely ground hay to decrease problems with colic.
- May be necessary to feed a small amount of unprocessed hay to prevent wood chewing and mane and tail chewing when groups of animals are penned together.

Manufactured Feeds

- Fortified grain mixes - Used widely in the horse industry.
- Include a combination of grain or grain by-products, protein supplement, Ca and P, trace minerals, vitamins, and salt, and others.
- Formulated/ designed to meet the nutrient needs when fed with forage alone.
- Also available in several physical forms, i.e., a coarse mix (aka, sweet feed or textured feed?), pelleted, or extruded.

Most manufactures offer at least three separate formulations:

1. For maintenance or light work horses - Contains about 10 to 12% CP.

2. For performance horses, broodmares, and yearlings - Contains about 13 to 14% CP.

3. For lactating mares, weanlings, and yearlings - Contains 15 to 16% CP.

Supplements:

Designed to satisfy the need for protein, vitamins, and minerals by feeding a small amount every day to horses on lush pastures to satisfy their energy needs.

Complete feeds:

- Useful, when good quality hay or pasture is not available, and in older horses with poor teeth or ones with respiratory allergies to hay.
- Contain a roughage source (alfalfa dehydrated and beet pulp are common) and designed to be fed without any forage - Ones with alfalfa are often pelleted.
- Fiber - Usually at least 12 to 15%, and may be > 20%.

Methods of feeding

- Grain mix and forage are fed at the same time or forage is made available to stabled horses all the time.
- However, due to better palatability they consume grain first followed by forge.
- Mixing of grain and chaffed forage is of no benefit as with ingest, grain portion escape to large intestine having starch contents unexposed to enzymes finally available for fermentation and to cecal acidosis that may result in diarrhea, colic and laminitis.
- Therefore, grain should be separately fed in either feed bags, lipped metal pans or in mangers.
- In no case it should be offered on floor for avoiding sand and soil contamination to prevent impactive colic.

Feeding frequency

- Horses have small stomach which is about 8-9% of total intestinal volume as compared to bovines where stomach size is about 60% of total volume of intestine.
- This limits quality of consumption in single intake.
- Therefore, equines need to graze for longer time as compared to bovines (Frap, 2008).
- Small stomach is advantageous for running jumping and endurance.
- Horses on pasture spend about 60-70% of whole day grazing and in stables also slowly nibble through hay if available freely.
- In stables most horses will eat hourly during day and every 2-3 hourly during night regardless of type of feed available from loose hay to blocks/cubes.

It is, therefore, recommended that, grain mix should be fed @ 0.5-0.7kg/100kg body weight for its optimum use in three to four attempts in whole day with round the clock availability of forage.

Guidelines of grain feeding are restricted in following manner:

- In equally divided quantity.
- As near the same time each day
- As least twice daily but as many more time as practical
- Horses under intense training/ athletic performance must be offered grains 4-5 time a day that too 4-5 hours prior to exercise and must not be fed at least for one hour after exercise engagements. (Lewis, 1995).

Table Diet proportion for horses and expected daily feed consumption

Type of horse	% of total diet		% of body weight intake		
	Roughage %	Concentrate %	Roughage %	Concentrate %	Total
Mature, idle	100	0	1.5- 2.0	0	1.5- 2.0
Pregnant mares	70- 80	20- 30	1.0- 1.5	5- 1.0	1.5- 2.0
Milking mares	50- 65	35- 50	1.0- 2.0	5- 2.0	2.0- 3.0
Performance horses					
Light work	65	35	1.0- 2.0	5- 1.0	1.5- 2.5
Moderate work	50	50	1.0- 2.0	75- 1.5	1.75- 2.5
Intense work	35	65	0.75- 1.5	1.0 -2.0	2.0- 3.0
Growing horses					
Weanling	30	70	0.75- 1.0	1.25- 3.0	2.0- 3.5
Yearling	40	60	1.0- 1.5	1.0- 2.0	2.0- 3.0
2-year-old	50- 65	35- 50	1.0- 1.5	1.0- 1.5	1.75- 2.5

Table. Expected Feed Consumption by Horses (% Body Wt; Air-Day Feed or About 90% DM)

Mature horses	**Forage**	**Concentrate**	**Total**
Maintenance	1.5-2.0	0-0.5	1.5-2.0
Mares late gestation	1.0-1.5	0.5-1.0	1.5-2.0
Mares early lactation	1.0-2.0	1.0-2.0	2.0-3.0
Mares late lactation	1.0-2.0	0.5-1.5	2.0-2.5
Worker horses			
Light work	1.0-2.0	0.5-1.0	1.5-2.5
Moderate work	1.0-2.0	0.75-1.5	1.75-2.5
Intense work	0.75-1.5	1.0-2.0	2.0-3.0
Young horses			
Nursing foal 3 month	0	1.0-2.0	2.5-3.5
Weanling foal 6 month	0.5-1.0	1.5-3.0	2.0-3.5
Yearling foal 12 month	1.0-1.5	1.0-2.0	2.0-3.0
Long yearling 18 month	1.0-1.5	1.0-1.5	2.0-2.5
Two yearling old 24 month	1.0-1.5	1.0-1.5	1.75-2.5

(NRC, 1989)

Feeding management of horses

Feed little and often

- The horse's small digestive tract means that it must eat often and in small amounts.
- Working horses need to be fed at least three times a day – morning, noon and night.
- When fully hand feeding, give a quarter of the concentrate at the morning and noon feeds, and the remaining half at night.

Feed regularly

- Feeding should be at the same time and in the same place every day.
- A horse is a creature of habit, and learns to expect food at set times.

Make ration changes gradually

- Sudden food changes can lead to digestive upsets, especially in grain diets.
- A slow replacement over 7–10 days or longer is required, whether you are changing from one grain to another, or just changing to grain from a new source.

Weigh amounts to feed

- Always weigh the amounts of grain, hay, minerals and so on, because measuring feeds by volume can give poor results.
- Feeds from different sources have different densities.

Mix daily and remove leftovers

- Mix the ration in amounts sufficient for only one day's feeding, to prevent it from souring, turning rancid or attracting flies – any of which can cause digestive upsets.
- Clean any leftover feed out of the trough before each feeding.

Use only the best quality feeds

- Poor-quality, unpalatable, dirty, moldy or contaminated feeds can cause more problems than savings in cost.
- They must not be used.

Reduce grain when horses are not working

- Working horses on high concentrate rations should be fed 50–70% less concentrate when they are not being worked.
- Failure to do this can cause a metabolic disease called azaturia, or 'Monday morning disease', which can be fatal.

Give horses plenty of exercise

- Avoid enclosing horses in restrictive yards for long periods, unless regular exercise is given.
- Exercise periods should be planned to coincide with times of minimal food intake.
- Don’t work the horse until at least 2 hours after its last feed.

Always have clean fresh water available

- Clean, fresh water, free of organic matter and sediment, should be available to horses at all times.
- A horse can drink up to 70 litres a day.
- After heavy work, water should be limited to between 2 and 4 litres until the horse has fully cooled.

FEEDING HORSES

Growing Horses

A. Foals:

- Nutrients from the mare (assuming well-fed) would be adequate during the first 3 to 4 mo.
- But, they begin to eat solid food within a few days and will consume significant amounts of hay, pasture, or grain by 2 months of age.

Weight gain and creep feed:

- Weight gain: 1.2 to 1.6 kg/day in the first mo. and gradually declines to about 1.0 kg/d at 4 mo. of age.
- May want to provide an appropriate creep feed (e.g., 16% CP, 0.9% Ca, and 0.6% P) at about 2 mo. of age, and can be fed about 0.5 kg/mo. of age/day.
- Foals should not be given unlimited access to a creep feed.

Composition of creep ration

Ingredients	Proportion (%)
Barley/Oat/Maize crushed	60
Wheat bran	5
Soybean/GN meal	30
Common Salt	1.5
Dicalcium Phosphate	1
Limestone	1
Brewer’s yeast	0.5
Trace Mineral mixture	1

Weaning:

- Most foals are weaned at 4 to 6 mo. of age
- By 4 mo. of age, the contribution of milk to the total nutrient needs starts to decline, and additional feed is necessary even if the foal is not weaned.
- By 6 mo. of age, milk provides less than 50% of the daily nutrient intake.
- The foals should be consuming 6 to 8 lb (2.7 to 3.6 kg) of feed at weaning time or 5 to 6 mo. of age.
- Weaning can be stressful for many foals, and the reduction in weight gain may be as brief as a week if foals are accustomed to eating substantial amounts of pasture, hay, or grain prior to weaning.

Yearling and 2-yr-old:

- Weight gain during the first 2 yr of life will not affect the final mature size, but may affect the age at which the animal reaches maturity.
- Very rapid rates of growth associated with an increased incidence of bone and joint problems (osteochondrosis, physitis, cervical vertebral malformation, and angular limb deformities)
- Feed diets that have an adequate amount of all required nutrients, not just energy.

- Some additional nutritional factors: Low dietary Ca, low or high dietary P, an unbalanced Ca: P ratio, low dietary Cu, and very high dietary Zn.

- At 1 yr of age or about 800 lb, change to a yearling diet. Possible to start relying on hay and pasture more extensively, but still very important to assure adequate protein, vitamin, and mineral intakes.

- Feed based on the requirements for maintenance and growth that is desired and feeding practice should be based on maintaining the desired condition and development and growth of the horse as the horse goes into training.

Composition of concentrate mixture for growing foals

Ingredients	Proportion in young stock ration		
	6-12 months	12-24 months	24-48 months
Barley crushed	60	60	65
Toasted Soybean/GN /cotton seed meal	25	20	12
Wheat bran	12	17	20
Common Salt	1	1.5	1.5
Dicalcium Phosphate	1.5	1	1
Trace Mineral mixture	0.5	0.5	0.5

Breeding, Gestation & Lactation

- Breeding: Most mares are not bred until 3 to 4 yr of age, whereas successful performance horses may not be bred until 8 yr of age.

- Desirable for mares to have a foal every year, and most mares can be rebred within a few weeks of foaling (no lactational anestrus) - Thus often, gestation & lactation overlap in horses.

- Just like other species, mares will use body reserves to meet the nutrient needs for fetal growth and milk production if they do not consume a sufficient amount of nutrients during gestation and lactation.

Breeding/gestation:

- The recommended maintenance needs for energy and protein should be sufficient during the breeding and early gestation periods, but need additional nutrients during the last 90 d because about 60% of the weight of the fetus develops during that time.
- But, if mares are lactating, they obviously need more nutrients.
- Loss of weight or body condition - Obviously, a clear indication of the inadequate nutritional status.
- Ca - An inadequate Ca intake during lactation may lead to mobilization of Ca from the bone to meet the demands, thus, could have a significant impact on the long-term soundness if continued over several cycles.

- Increase a nutrient intake by 10 to 20% above the maintenance if mares lost the weight during lactation and enter the second trimester of gestation in sub-optimal body condition.

- During a 340-d gestation, a 500-kg mare may gain 50 to 70 kg (foal weighs about 40 to 55 kg at birth. Regular weighing/assessing body condition scores would be helpful.

- Can meet the mare's requirements for late gestation by increasing feed, but they may eat less feed in late gestation, thus necessary to change the composition of the diet, i.e., to increase concentrate.

Lactation

- A mare has just foaled, lactating, and being prepared for breeding.
- Obviously a period of critical nutritional stress and they must be well nourished.
- Mares should be in a good condition prior to foaling so that they can use their "build-up" reserves in the time of need.
- A few days before foaling, provide a bulky diet to reduce potential constipation problems, and allow 7 to 10 d after foaling to bring mares to full feed.
- Mares peak lactation at 3 mo. post-foaling, and a 500-kg mare may produce over 35 lb of milk/d.

Equine athletic performance

•Equines are known for work, i.e. athletic performance and related progressive schooling for long periods before subjecting them for actual physical exertion.

There are three general types of athletic performances:

1. Endurance

•Two hours and more of low intensity exertion requiring aerobic energy production.

•Like covering long distances of 40-120KM, work for more than 6-8 hours turn hours turn around in planes and 4-6 hours in mountainous high altitude areas with load.

2. Middle distance (800-3200 meters)

•Activity for several minutes requiring both aerobic and anacrobic energy metabolism it includes racing.

•Show Jumping, dressage, cross country activity and short distance of cart pulling or 2-3 hours turn around pack duties.

3. Sprint (400 meters or less)

•Activity for a minute or less at 100% exertion intensity requiring primarily anacrobic energy production.

•These are somewhere comparable to marathon, middle distance (0.5 to 2 Km run) and 100/200 Meters sprint.

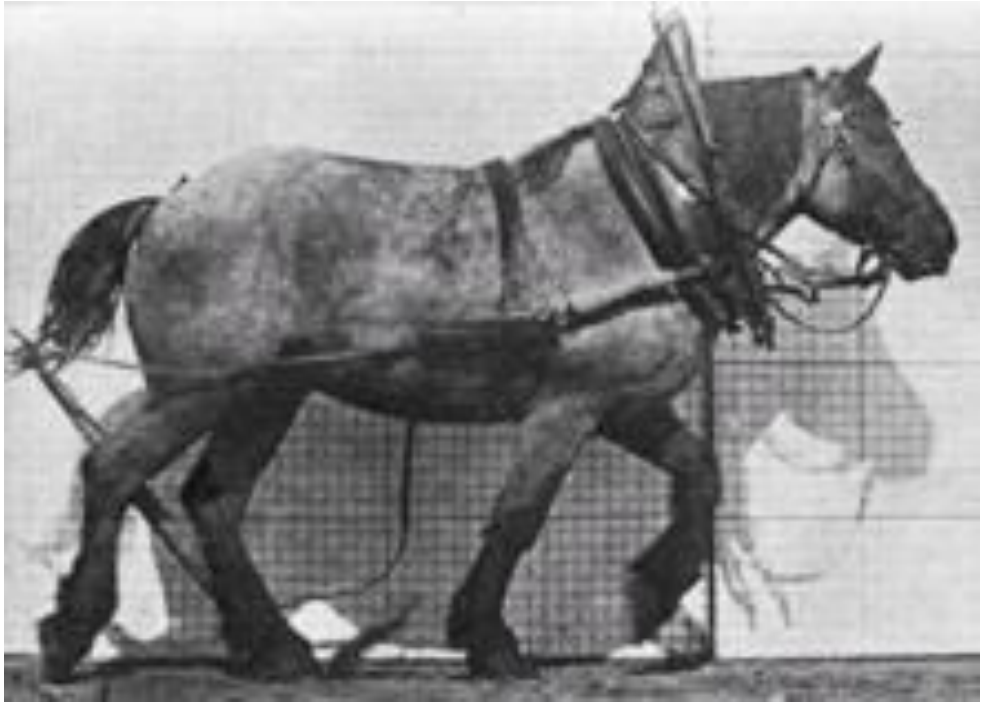
•Further, activities like polo requires sum of all three of these types of activities.

•Show jumping requires both middle distance and sprinting activity, whereas, tent pegging is purely similar to 100/200 meters of sprint (Lewis, 1995).

Types of physical movements

Walk: Walk is four beat gait with large overlap times between phases of limbs and no period of suspension.

- It is slowest gait but is complex because of variability in the overlap and lag time between limbs.



Trot: Trot is two beat symmetric diagonal gait. The variations of saddled horses are collected, working, medium and extended trot, speed of trot increases from collected to extended trot.

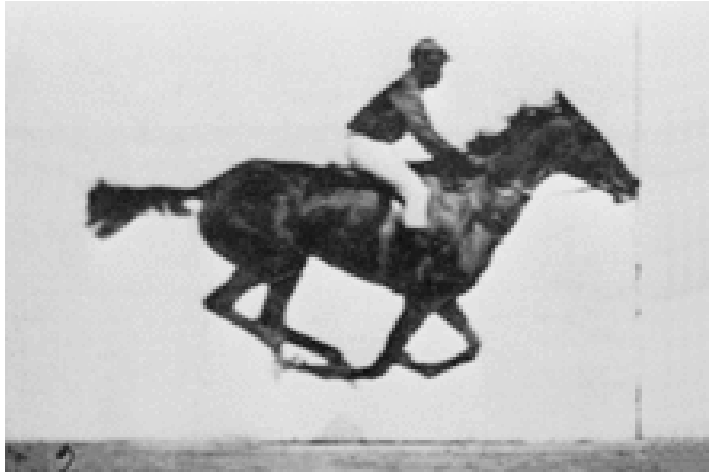
•Passage and piaffe are diagonal exercise derived from collected trot. Harnessed horses/equines express flying trot.

Canter and gallop: Canter and gallop refer to same gait performed at different speed.

- Canter is a slow speed 3 beat gait whereas, gallop is four beat gait performed at a higher speed.

- In canter the stance phase of the diagonal limb pair 9leading hind and trailing fore) are synchronized while at gallop foot fall of the diagonal are dissociated with the leading hind limb contacting the ground before the trailing fore limb.

- Gallop in the fastest gait (Back and Clayton, 2002).



Jump : Jump is a gallop stride in which air borne phase is a long dissociation of the diagonals of the diagonals.

- The foot fall of the jump stride are trailing hind and leading hind at take off then trailing fore and leading fore at landing.

- While take off, the hind limb stance phases are more synchronized than in a normal gallop stride to produce a powerful push off, however, footfall of the fore limbs at landing are not synchronized (Leach *et al.,* 1984).

Energy requirement for athletic performance

- Energy to provide movement is derived from dephosphorylation of ATP to ADP for muscular movement.
- To continue further, ADP must be rephosphorylated to ATP at the rate equal to the rate of ATP usage.
- Creatine phosphate provides instantaneously available source of energy for high intensity exertion but it is adequate for only initial 6 to 8 seconds of maximum muscle exertion.
- For additional activity another means of ATP synthesis is necessary i.e. glycolysis, which is anaerobic metabolism of glucose or glycogen to lactic acid.
- Anaerobic metabolism since produces less ATP (3 ATP) per molecule of glucose it happens rapidly.
- In contrast, aerobic metabolism produces 36 molecules of ATP per molecule of glucose and 120 molecules of ATP from fatty acids in presence of oxygen hence: process is slow (Lewis, 1995).

Body confirmation

- Fast speed of horse while pulling heave loads, tent pegging, or short fast gallop etc require large muscle fibers therefore draft horses look heavy as seen for short distance sprinters, weight lifters or wrestlers whereas, prolonged activity need synchronization of oxygen utilization ability and breathing depth with small muscle fibers.

- Therefore endurance, three day eventing or steeple chasing horses look lean, having clevated lungs capacity as seen in marathon runners with suitable cardio vascular adaptation.

Onset of fatigue

•Fatigue results in decreased activity due to numerous factors in different situations.

Some of these factors are enumerated below:

Elevated muscle lactic acid; Lactic acid induced intracellular acidity coupled with pain and lack of mobility inhibits muscle excitation and energy production, thus causes slowing of the horse towards end of the exercise engagements.

Reduction in muscle glycogen: Intense activity and depletion of muscle glycogen results in fatigue and sudden drop in performance.

Elevated ammonia levels: It takes place as a result of adenosine monophosphate (AMP) deamination with exercise, which inhibits neuromuscular function and aerobic energy production. As a result anaerobic energy production is necessary thereby depletion in glycogen and increase in lactic acid production which establishes early fatigue.

- Water and electrolyte depletion: Water and electrolytes lost through sweat, elevated breathing and hyperthermia may contribute to fatigue.

- Lameness: Lameness altering the normal gait and placing abnormal stress on muscles, bones, tendons and ligaments cause fatigue where recovery phase is weeks rather than days.

Diet and supplements for athletic performance

- Equines need high quantity of energy.
- Easy way is to feed more of concentrates and less of forage to balance out energy needs.
- Relatively high grain and low forage diet is often offered, however, forage must constitute at least half of the diet consumed.
- Further, hay offered needs to be reasonably fresh, old stored forage may compromise intake of Vit A, E, B1 and folacin for anticipated optimum performance.

- Nutrients most needed for the exercising horse are those lost in sweat and used to provide energy and repair of tissues.
- Those lost in sweat can be provided by consumption of good quality water and salt.
- Additional quantity of energy can be provided by fats, carbohydrates or proteins. Fat appears to be preferred source; however, proteins are least preferred source for athletic performance.
- As a result a high fat diet appears to be beneficial and high protein diet detrimental.

Dietary protein

- Proteins are generally expensive source of energy i.e. soybean meal cost more than corn or barley/oats, yet provides less energy, however, contributes to early setting of hyperthermia, excessive sweating and electrolyte loss.

- In addition, excessive loss of water through urine takes place to clear.

- Further, presence of excessive ammonia in stables if not ventilated may result in lack of sleep and respiratory distress.

- Therefore, protein contents of athletic equines are kept limited from 10-16% of dry matter intake to accommodate actual requirements.

Dietary fats

High fat diet provides several benefits which include following:

- Fat increases total energy density without increase in dry matter intake. Vegetable are best.
- Increases quantity of energy available for athletic performance.
- Contributes in increase of muscle glycogen for use during anaerobic cycle while sprints (Oldham *et al.,* 1990).
- As a result high fat diet has been shown to enhance both aerobic and anaerobic performance and brings delay in fatigue.
- A high fat diet appears to be better than either a high starch or a high protein diet for both high speed and moderate physical engagements.

- At high speed muscle glycogen use and plasma lactate concentration were both substantially found lower when horse were consuming high starch and low fat diet.
- Heart rate elevation plays a very important role in determining the state of fatigue.
- A high fat diet (15%) is better than high carbohydrate (40%) or high protein diet (25%) for both high speed and moderate speed engagements.
- However, horse has to be tuned to utilize additional fat allowances well before the final performance with regular schooling exercises at least 11 weeks before actual competitions (Pagan *et al.,* 1987).

Frequency of feeding

- Blood glucose concentration peaks 2 to 3 hours after consumption of grains.
- However, it does not increase with consumption of forage.
- An increase in insulin sets in hypoglycemia during exercise, which decreases endurance and speed.
- Feeding 1.5-2 kg of grain 4 to 5 hours before and allowing free access to forage and water until the exercise engagement begins is recommended.
- Grains produce needed energy with moderate insulin concentration.

- Therefore, utilization of fat will not be altered while the physical exercise is on and hypoglycemia will not be induced during exercise.

- Water and forage consumption maximize quantity of water and electrolytes availability in GI tract to replace the quantity lost during prolonged exercise.

- However, low forage high grain diet decrease GI water and electrolytes storage with risk of failures in endurance/racing/athletic performance (Ralston, 1988).

- Although handicap of GI tract weight due to consumption of forage and water result in some additional pay load on horse while on exercise but holistically such attempts are beneficial.

Sodium bicarbonate

- Sodium Bicarbonate administration is beneficial prior to exercise engagements to buffer high quantity of lactic acid while anaerobic activity.
- Administration of sodium bicarbonate @ 0.45 g/kg body weight mixed in 2 litres of water through stomach tube 3.5 hours before intense exercise engagement controls heart rate, reduces exercise induced metabolic acidosis, results in higher plasma lactate concentration and increases muscle glycogen utilization.

Following advantages are expected:

- Reduced intra cellular acidity.
- Facilitates possibility of increased glycolysis.
- Above two factors permits greater intensity of exertion and delays onset of fatigue.

Thermodynamics

- Energy utilization and heat production greatly increase during exercise.
- At gentle exercise it is 10-20% more than that is produced at rest whereas, during moderate to intense exercise it is elevated up to 40 to 60 times.
- If heat loss is not managed, body temperature elevation may go from 102^0F which is life threatening within very short period from commencement of exercise.
- However, heat dissipation systems in equines are so rich that such situation generally is not achieved.
- Heat produced in muscles is transported to skin through rush of blood to periphery and respiratory system for dissipation.

- Since more blood circulates towards periphery less is available for muscles which onsets fatigue due to decreased oxygen delivery.
- This phenomenon increases more glycogen utilization and lactic acid production.
- Evaporative cooling mechanism from skin accounts for 55 to 60% and from respiratory system 25%, which occurs even at higher ambient temperature than body temperature.
- Balance 15 to 20% of heat dissipation is through convection.
- Evaporation is enhanced by air movement over the body surface.
- However, these are impaired with increase of ambient temperature and relative humidity.

- As long as sum of ambient temp and relative humidity is below 130 units, heat loss from body surface is not a problem when this yardstick exceeds 150 units then loss is severely compromised and there is fear of body temp rising up to lethal limits and if this reaches to 180 units no heat is practically lost from body surface.
- Between 150 to 170 units it should be conducted with great care.
- In addition, schooling also plays an important role in maintenance of thermodynamics.
- Rectal temperature of inadequately prepared horses for physical performances is found elevated 50% more than those horses having proper schooling.
- Evaporation of 1 litre of sweat dissipates 580 kcal of heat which is produced during 7 to 8 minutes of trotting of a fit horse.

- Horses swat contains soluble proteins which have detergent like properties that helps in dispersing sweat droplets into thin film alongside hairs for evaporation.
- This is the reason why horse sweat lathers.
- Wiping of sweat is counter productive for thermodynamics of body as it prevents evaporative cooling, whereas, putting water on the horse enhances evaporation, cooling and early establishment of comforts.
- Rate of sweating is 6.5 to 9 litres/hour for endurance and 10-15 litres/hour for trotting or galloping.
- Extensive quantity of water loss takes place due to excessive sweating which sometime equals to total blood volume.
- If not replaced immediately would result in 7 to 11% dehydration of decrease of body weight up to 12-15% which is fatal.

- Dehydration induced hypovolemia reduces blood flow to both the muscles and skin leads to fatigue or exhaustion.
- Decreased blood flow to skin decreases heat dispersion and forces athletic horses towards heat stress/stroke.
- Sweating results in loss of water, sodium, chloride and potassium in large quantity whereas, calcium and magnesium are lost in less quantity.
- Actually , plasma sodium and potassium range if analyzed in such horses will remain within normal range but depletion in total plasma quantity causes deficit of sodium and potassium, which is dangerous (Lewis, 1995).

Prevention of water and electrolyte depletion

- There are no body reserves of water and electrolytes except which are available in GI tract.
- Therefore, these items are not available when body requires them by feeding before hand, but they can be replaced according to losses.
- To achieve a balance salt licks and water should be available all the time as and when required.
- Horses need 125 g of sodium and 175 g of potassium per day during excessive sweating.
- Therefore, salt licks and grains mixed with salt are offered for 2-3 days after the exercise engagements are over.
- However, salt should not be mixed in feed continuously for prolonged period.

- Salt in any case should not be mixed more than 0.5% of the total diet.
- Before beginning of endurance type activity, GI tract must contain as much water and electrolytes as possible, which can be 6-10% of total body weight.
- This can be increased by offering of forage with availability of salt licks and water, however, decreased by grain and pelleted feed.
- Consumption of forage, water and salt licks before, during and after endurance engagements is beneficial in preventing dehydration and subsequent fatigue.
- To encourage drinking of water during prolonged competitions horses should be offered water during training/schooling.

- It has been noted with concern that horses those drink little water during endurance, particularly during long and difficult physical exertion or during hot and humid weather are less likely to finish exertion engagements or more likely to finish than horses those drink water adequately during prolonged exercise.
- Thus, teaching consuming water while schooling for prolonged engagements are always helpful.
- Cold water should be preferred over hot/warm water as it helps to cool down horse quickly and absorb faster.
- It may not lead to colic/detrimental effect and in contras is quite beneficial (Lewis, 1995).
- During endurance activity if temperature and humidity are high and water source is 1-2 hours away, offering water enroute is of great help to trained horses.

- Feeding some quantity of grains powered with electrolytes and salt will also be very helpful.
- Offering glucose and electrolyte solution while will be of maximum benefit but horse has to be trained for it.
- Heart rate is indicator of adaptation of schooling.
- Properly trained horse having progressive schooling must acquire heart rate of 80-85 BPM following 5-7 minutes of rest after exercise engagements are over.
- Basic Heart Rate indicators are as under:

Rest	30-45 BPM
Walk	80-BPM
Trot	120-140 BPM
Canter	160-200 BPM
Gallop	200 BPM

Working/Performance Horses

- Include horses being trained for various performance events or horses used for roping, cutting, jumping, etc.
- Generally, ridden every day, and thus havea relatively high energy expenditure, but perhaps, no greater demands for protein, Ca, P, most trace minerals, and most fat-soluble vitamins.
- Nutrient requirements - Vary with the type and degree of activity, e.g., racing Quarter Horse running at maximal speed for 400 yd or less vs. Arabian endurance horse competing over distances of 50 to 100miles.

Energy required by performance horses:

- Affected by two primary factors - The intensity of the daily exercise and the duration of the daily exercise.
- Some recommendations for the DE intake are based on general categories of work effort. Increase DE by 25, 50, and 100% above maintenance for horses involved in light, moderate, and intense exercise, respectively
- Horses performing moderate or intense work, cannot consume enough forage to meet their energy needs, thus must increase a concentrate.

- Addition of fat to a concentrate feed can increase energy density without increasing feed/starch intake, and commercially manufactured feeds nowadays contain 4 to8% added fat.
- Also, can be added directly by top dressing.

- Feeding more than 7 lb (3.2 kg) or more of concentrate/day - Should be fed in two to three meals depending on the amount.

- No single meal should exceed 3 kg of concentrate.

- Feeding programs for Thoroughbred and Standard bred racehorses - Often, restrict forage intake the night or morning before a race to decrease bulk in the gastrointestinal tract.

Protein:

- Working horses need more dietary protein than sedentary horses. Reasons:

a) Protein is lost in sweat.

b) Small amount of protein may be broken down during exercise.

c) Horses in training may retain slightly more nitrogen than horses at maintenance.

- The magnitude of the needed increase may be small, and if feed intake is increased to satisfy the energy demand, perhaps, the protein requirement would be almost always satisfied.

Electrolytes & other minerals:

- Horse sweat is very high in Na, K, and Cl, and exercise can result in losses of these minerals.
- Electrolytes cannot be stored in the body, thus the needs must be satisfied on a daily basis.
- Should give a small amount of a balanced supplement at regular intervals during a long ride.
- Little is known about the effect of exercise on the requirement for other minerals, even though it is known that Ca and P intakes are most critical for young horses.
- A reasonable guideline for mineral requirements in exercising horses? - Perhaps, increase the mineral intake (in grams per day) in proportion to the increase in the energy intake.

Vitamins:

•Performance horses may require a higher dietary concentration of some vitamins than sedentary horses.

•Many B vitamins are synthesized by microbes, but it may be better to ensure that by providing, at least, 50% of the need by the diet.

•Important ones: Thiamin, niacin, riboflavin, pantothenic acid, choline, biotin,folic acid, and B12, and also vitamin E.

Water:

•Following a heavy exercise, small quantities (a few swallows) of water should be provided at 5- to 10 min intervals until thirst is quenched.

•By doing that, can prevent digestive disturbances and possibly founder from excessive water intake.