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Horse nutrition: An overview

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Abstract
Presently equines, such as horse, ponies, donkeys and mules are in multifarious uses in the society. Nutrition is a key component of equine health and performance. Horses are non-ruminant herbivores of a type known as a "hindgut fermenter." Ruminants like cattle are foregut fermenters, and digest fibre in plant matter by use of a multi-chambered stomach, whereas horses use microbial fermentation in a part of the digestive system known as the cecum (or caecum) to break down the cellulose. Horse's nutrition and digestive health has the ability to impact everything like Gut health, Overall health, Behaviour, Physical ability, Performance. Like all animals, equines require five main classes of nutrients to survive: water, energy (primarily in the form of fats and carbohydrates), proteins, vitamins, and minerals. Race horses receive the protein, energy, vitamin and other nutrient needed to develop the body of well-trained athletes. The ration should provide 18% CP, 0.95% Ca and 0.85% P. Horses on pasture spend about 60-70% of whole day grazing and in stables also slowly nibble hay if available freely. In stables most horses will eat hourly during day and every 2-3 hours during night regardless of type of feed available from loose hay to blocks/cubes.

Keywords: Horse, hindgut fermenter, race horse, pasture feeding, water, nutrition

Introduction
Equines are maintained for more varied uses like athletes, army, paramilitary forces, and police department for patrolling, mobility, riot control duties and as companion animals. In spite of the road development and introduction of mechanical transport in most parts of the country, economics of haulage of goods and transportation of men and materials are still in favours of pack animals for short distance (Fazili and Kirmani, 2011) [9]. In hilly and mountainous regions like Jammu and Kashmir states, equine continue to play a pivotal role in agriculture, transport, recreation, tourism, besides being used as pack animals in the difficult terrain (Hassan *et al.*, 2016) [12]. Total Population of Horses, Ponies, Mules & Donkeys in the country is 0.55 Million during 2019. Total Population of Horses, Ponies, Mules & Donkeys has decreased by 51.9% over previous Livestock Census (2012) (Anonymous, 2019) [2]. Total population of Horses and ponies in Gujarat state is 21811 thousands during 2019. Total population of Horses and ponies has observed by 23.78% higher in rural area than urban area of Gujarat state and most commonly used in sports (Anonymous, 2019) [2]. Gujarat state is very famous for some important horse breeds like Kathiyawadi and Marvadi (Boradiya *et al.*, 2019) [5].

Nutrition
Equine nutrition is the feeding of horses, ponies, mules, donkeys, and other equines. Correct and balanced nutrition is a critical component of proper horse care. Horses have only one stomach, as do humans. However, unlike humans, they also need to digest plant fibre (largely cellulose) that comes from grass or hay. Horse need to receive at least 1.5% -2% of their body weight as forage or forage substitutes such as hay, hay cubes or other fibres. The mean daily DM intake is 2.5% - 3% of body weight. Equines can use hay and other roughages as nutrient source much more efficiently than other non-ruminants but found shade inferior to cattle. Traditionally good source of roughage should comprise at least 50% of total ration by weight (Jansson & Harris, 2013) [16]. The high energy requirements of competition horses can be met with high quality forage-only diets and this benefits their health, their feeding must sustain a long, productive, disease free athletic and draft purpose life (Ringmark, 2014) [23]. Main site of fermentation in equines are in cecum and large colon where end products of digestion and fermentation are also absorbed.

Microbial fermentation commences at stomach and small intestine marginally however, the grains and grain by-products, starch components balance part are also fermented in large intestine. Therefore, it can be understood that enzymatic degradation of carbohydrates, proteins and fat take place in prececal part of intestine. If any of these nutrients escape small intestine from digestion/absorption they are available for microbial fermentation in large intestine which alters pH of intestine to undesirable levels and lead to serious health hazards. The horse doing light work needs more hay and less energy feed, while the horse doing hard work needs less hay and greater concentrate feed. Horse doing hard work may not be able to eat 3% of their BW, especially if they are fussy eaters, so their appetite should be calculated using 2.5% BW and energy- rich feeds used to provide the required energy level (Piliner, 1996) [21].

Digestive Tract of the Horse

Horses are non-ruminant herbivores (hind-gut fermenters). Their small stomach only has a capacity of 2 to 4 gallons for an average-sized 1000 lb. (Williams, 2004) [26]. The horse's digestive tract can be divided into two divisions: foregut and hindgut. The foregut of horse is made up of the mouth, oesophagus, stomach and small intestine. The hindgut of the horse is comprised of the cecum, large colon, small colon and rectum (Anderson, 2007) [1]. The upper lip of the horse is very sensitive, strong and prehensile and is used during grazing and holding of feed from manger to place ingredients between teeth (Frape, 2004) [10]. Lower lip is used as funnel through which water is sucked. The muscular tongue passes the ingested material to the cheek teeth for grinding (Hembroff, 2006) [13]. Presence of both upper and lower incisors enables them to graze closely by shearing off forage while upper lip helps in removing dust/mud. Lateral and vertical movement of jaws accompanied by profuse salivation enable cheek teeth to fragment long hay blades to 1.6 mm length suitable for swallowing (Elia *et al*., 2010) [8]. Horses are also unique in that they do not have a gall bladder but stimulation of bile results due to presence of HCI in duodenum. The equine stomach has a capacity of 5–15 litres which is relatively small when compared to the large volume of the hindgut (Auer and Stick, 2012) [3]. Roughage stays in stomach for short time as fermentation is possible only in large intestine whereas, concentrates are processed in stomach by enzymes. As a reservoir of alkali it helps preserving ingesta, pH of digesta leaving stomach rapidly rises to more than 7.00. A mature horse has a short, small intestine in length and volume, to facilitate quick availability of enzymatically processed nutrients and accords convenience in moderate to quick mobility. Muller *et al.,* (2008) [18] reported that ingesta entering large intestine consist of fibrous feed residues, undigested starch, proteins, microorganisms, intestinal secretions and tissue debris. At the distal end of ileum one-meter-long blind sac exist in cecum having capacity of 25-35 liters. The entry and exist points of cecum are near to each other. Digesta further passes to right ventral colon from cecum. Right and left segment of ventral colon and left and right segments of dorsal colon constitutes greater colon which is about 3-4-meter-long, having capacity of about 70 litres. All four parts of greater colon are connected with bends or flexures. No digestive enzymes are released in caecum and colon, only microbial fermentation is achieved. Most of the digesta will reach caecum and colon within 3 hours of meal. The horse's gastrointestinal tract is adapted to a fibre-rich-diet and the horse has developed a symbiosis with the hindgut (caecum and colon) microbiota. Most of the nutrients (protein, some carbohydrates and fat) are digested in the small intestine. Microbial fermentation of fibre and starch yields large quantities of acetate, propionate and butyrate. Acetate and butyrate are major end products of fibre whereas, propionate and lactate increase with increasing proportion of undigested starch. Starch is broken down in the small intestine by α-amylase to the disaccharide maltose which is further digested to simple sugars by the enzyme maltase that has a high activity in the horse. The production of α-amylase is limited in the horse thereby affecting starch digestion. Furthermore, monosaccharide's glucose, fructose, galactose, are absorbed and transported in the blood to tissues for energy metabolism or storage (Dyer *et al.,* 2002) [7]. Detoxification of toxic substances occurs in the cecum. It also contains bacteria and protozoa that pass the small intestine to digest fibre and any soluble carbohydrates (Anderson, 2007) [1].

Nutrients

Like all animals, equines require five main classes of nutrients to survive: water, energy (primarily in the form of fats and carbohydrates), proteins, vitamins, and minerals.

- **Water:** Water makes up between 62-68% of a horse's body weight and is essential for life. Horses can only live a few days without water, becoming dangerously dehydrated if they lose 810% of their natural body water, Therefore, it is critically important for horses to have access to a fresh, clean, and adequate supply of water. An average 1,000-pound (450 kg) horse drinks 10 to 12 US gallons (38–45 l) of water per day, more in hot weather, when eating dry forage such as hay, or when consuming high levels of salt, potassium, and magnesium. Horses drink less water in cool weather or when on lush pasture, which has a higher water content. When under hard work, or if a mare is lactating, water requirements may be as much as four times greater than normal.
- **Energy nutrients and protein:** Nutritional sources of energy are fat and carbohydrates. Protein is a critical building block for muscles and other tissues. Horses that are heavily exercised, growing, pregnant or lactating need increased energy and protein in their diet. Fat exists in low levels in plants and can be added to increase the energy density of the diet. Fat has 9 mega calories (38 MJ) per kilogram of energy, which is 2.25 times that of any carbohydrate source. Because Equids have no gall bladder to store large quantities of bile, which flows continuously from the liver directly into the small intestine, fat, though a necessary nutrient, is difficult for them to digest and utilize in large quantities. Carbohydrates, the main energy source in most rations, are usually fed in the form of hay, grass, and grain. Soluble carbohydrates such as starches and sugars are readily broken down to glucose in the small intestine and absorbed. Insoluble carbohydrates, such as fibre (cellulose), are not digested by the horse's own enzymes, but are fermented by microbes in the cecum and large colon to break down and release their energy sources, volatile fatty acids. Soluble carbohydrates are found in nearly every feed source; corn has the highest amount, then barley and oats. Protein is used in all parts of the body, especially muscle, blood, hormones, hooves, and

hair cells. The main building blocks of protein are amino acids. Alfalfa and other legumes in hay are good sources of protein that can be easily added to the diet. Most adult horses only require 8-10% protein in their diet; however, higher protein is important for lactating mares and young growing foals.

- **Vitamins and Minerals:** Horses that are not subjected to hard work or extreme conditions usually have more than adequate amounts of vitamins in their diet if they are receiving fresh, green, leafy forages. Sometimes a vitamin/mineral supplement is needed when feeding low-quality hay, if a horse is under stress (illness, traveling, showing, racing, and so on), or not eating well. Minerals are required for maintenance and function of the skeleton, nerves, and muscles. These include calcium, phosphorus, sodium, potassium, and chloride, and are commonly found in most good-quality feeds. Horses also need trace minerals such as magnesium, selenium, copper, zinc, and iodine. Normally, if adult animals at maintenance levels are consuming fresh hay or are on pasture, they will receive adequate amounts of minerals in their diet, with the exception of sodium chloride (salt), which needs to be provided, preferably free choice. Some pastures are deficient in certain trace minerals, including selenium, zinc, and copper, and in such situations, health problems, including deficiency diseases, may occur if horses' trace mineral intake is not properly supplemented. Calcium and phosphorus are needed in a specific ratio of between 1:1 and 2:1. Adult horses can tolerate up to a 5:1 ratio, foals no more than 3:1. A total ration with a higher ratio of phosphorus than calcium is to be avoided. Over time, imbalance will ultimately lead to a number of possible bone-related problems such as osteoporosis.

Feeds and Supplements

Concentrates and other supplements: Concentrates include all grains and their by-products for which wide variety of concentrates are available in India for feeding of equines. Historically, horses have been free range wild animals. Domestication offered their usefulness to society which has led to restrictions on grazing opportunities and stabling forced owners to feed them various forms of concentrates to compensate their nutrient need deficit resulted due to lack of grazing. On one side it made equine husbandry convenient but in response resulted in several challenges viz., nutritional disorders, systemic disorder, foot ailments and stable vices. All the concentrate ingredients available commercially are not suitable for equines some important are therefore, briefly discussed.

Oats: Most traditional grain fed to equines may be fed whole, rolled or crimped. Processing increases digestibility by 10%. Due to bulky hull oats are the safest of all grains for equines. They form loose mass in the stomach for easy digestion as compared to corn/barley. Even if a horse gains access to grain bin and consumes large quantities danger of digestive trouble is less compared to other grains. Oats may be the 'traditional' cereal fed to working horses but oats are also considered in the UK to be the psychologically heating feed, therefore animals predominantly in light work in the UK are more likely to be fed 'cool mixes' or 'nonheating' products which are 'oat free' (Harris, 1997) [11].

Barley: It is a good grain for equines which can be fed as only grain. It is higher in energy than oats but lower than maize/corn. Rolled, pressed, crushed, or crimped barley improves digestibility but its palatability is lower than oats and corn. Biggest advantage of feeding barley is its fibre content which gives advantage to this grain when compared with other cereals/grains.

Sorghum: It has small hard kernel, therefore, needs to be steam flaked. Dry rolling will not be adequate to make it conducive for feeding to equines. Further, it has tannin which is toxic to some extent and a real cause of questionable palatability. It can be fed with ceiling and care as applicable for corn.

Gram: Gram should be fed as a concentrate. It is a good source of protein, energy and minerals. Most of the owners prefer to feed gram in little quantity once in a day after soaked overnight.

Linseed/Cotton seed meal: Should be fed only to adult animals up to very minimum quantity as both are having respective toxic background and both are low in lysine. They, however, cannot be used as protein supplements. Use in extremely limited quantity will surely improves coat conditions of adult horse especially during winters but their due processing is essential (cooking linseed).

Soya bean meal: It is a palatable protein source with excellent amino acid balance for use in concentrate. It should be fed when pasture or hay is poor in protein content. Requirement of protein are greatest during early growth, and lactation, therefore, it is a good feed ingredient for growing equines. It is an excellent replacement of gram, horse grain and reasonable in cost as compared to gram.

Wheat and Rice: Wheat and Rice are available options but may be fed with due care in limited quantity but generally not advocated due to various constraints.

Wheat bran: Wheat bran is commonly fed to equines. Wheat bran is not laxative to horse's contrary to the established belief but extremely palatable and often offered as wet mash. It helps in water retention and manifests smooth passage of bowel backwards in intestine. Rice bran also can be fed but presence of oxalates compromises overall calcium absorption. Bran is rich in phosphorus, therefore, due balancing of mineral allowances are warranted.

Maize: It is high energy feed useful for equines which are working hard or need extra weight gain. However, starch in corn is less digestible than oats and barley and more easily bypasses small intestine digestion and gets subjected to fermentation and results in colic or laminitis if suddenly fed in large quantity. To achieve maximum digestibility shelled corn may be cracked or rolled before feeding. Corn and cob meal is better for horses than ground and shelled corn since it is more bulky. Gluten is undesirable for equines due to its palatability and high protein. Corn is susceptible to growth of Aspergillus and horses are irreversibly sensitive to aflatoxins, therefore, needs to be offered very carefully. Ceiling of 500 gm/day/adult equines should therefore be exercised while ration formulation.

Molasses: It is frequently added in grain mixture, highly palatable, reduces dustiness of concentrate, readily available fermentable carbohydrates and moisture may increase mould growth in hot weather, whereas it freezes in cold weather. High Potassium content poses problems while balancing feed. It increases stable vices and attract flies which creates annoyance to stabled horses and foot ailments as a result of continuous stamping to keep flies away hence, generally not recommended.

Dible oil: Edible oil is added to balance the increased energy requirements of working horses and animals operating in cold climate and mountainous terrain as energy requirement for maintenance increases manifold in low temperature. It needs to be introduced very slowly. Horse ration usually must contain 3%- 4% fat but it can easily tolerate up to 10% fat when adapted well to progressive elevation of energy contents through slow and progressive introduction. Vegetable edible oils are suitable, however maize oil is best.

Lime stone: High grade lime stone (38% Calcium) may be used as calcium supplement. When Ca and P are needed dicalcium phosphate, steamed bone meal or defluorinated rock phosphate are recommended.

Salt: Salt should be provided if possible in blocks or granular form. Trace mineralized salt bricks which contain iron, iodine, copper, cobalt, magnesium, zinc and selenium should be provided in due proportion as free lick. During hot climate and heavy work when horse sweat a lot mixing of common salt and mineral mixture in ration is always advocate.

Feeds and Supplements

Pasture: Good pasture provides excellent sources of nutrients, opportunity to exercise and cleaning of feet. Historically, equines would graze 20 hours a day and while on pasture will consume seeds, nuts, bark etc. Such pastures are available only in Himalayas and to some to extent in other mountainous areas.

Hay: Common types of hay used for feed of equines include grass hay, which is available in abundance, especially in coastal area of Maharashtra, Gujarat, plateau of Malwa, ravines of Chambal and Indo-Gangetic planes. Anjana grass is predominantly used for making hay. Plants need to be harvested at early stage, should be green, leafy, stems must be soft and pliable, free from mustiness and foreign objects especially roots/soil and blades must terminate with golden brown coloured flowers. Harvested fodder is dried and finally pressed and fastened by wires in cuboid bales. For identifying freshness of stocks status of galvanized baling wires should be checked. Rusty baling wires are indicative of old stocks which loose nutrients.

Silage/Haylage: Though references are available to feed high moisture silage/haylage to equines under ideal conditions, but it is not advocated to feed silage to equine due to their very poor tolerance of mould toxins. Lucerne hay, oat hay, dub grass hay are extensively used as dry roughages and green Lucerne, green maize, green bajara, green jowar, green oats, green barley are used as green fodder for feeding of horses (Wani *et al*., 2014) [24]. A study by (Elia *et al.*, 2010) [8] measured faecal pH in mares fed two different diets in counter balanced order: ad libitum orchard grass hay and a complete pelleted feed, which mainly consisted of soybean hulls, wheat middlings and Lucerne meal. Both diets had similar protein content. Willing *et al.,* (2009) [25] were compared faecal micro biota of Standard bred horses fed either a forage only diet or a traditional forage: concentrate diet, with a starch intake of <1g/kg BW per day. They found that horses showed lower counts and relative abundance of specific bacterial populations that have been associated with the initiation of laminitis when they were fed the forage-only diet. Furthermore, they found a consistently low relative abundance of Streptococcus bovis/equines on the forage-only diet, suggesting that such diets may be preventive of gastrointestinal disorders in horses.

Methods of feeding and feeding frequency

There are three type of feeding methods

1. **Stall feeding:** Daily allowance of concentrate mixture is divided into 2 to 3 parts and fed to horse at 6-8 hours interval. Working horses are generally fed twice while growing foals and lactating mares fed thrice a day. While the growing foals and lactating mares are fed three times in a day. Afterwards mixture of cereal and leguminous fodders are offered.
2. **Grazing**: Horses are allowed grazing on pasture for 6-10 hours daily. Depending upon availability of herbage and physiological stage supplement feed offered.
3. **Use of feeding bag**: The feeding bag used for concentrate mixture. Working horses and ponies used for traction needs to be fed away from home. Concentrate mixture is moistened and filled half of the bag and tied behind the pole after putting in mouth of the horse to enable it's eat comfortably. The bags are used for feeding Race and working horse in the working interval. Buckets are also used for Tonga ponies (Reddy, 2014) [22].

Daily Water Requirement

An adequate intake of clean, fresh water at all times is very important. A loss of 10% of horse body water can leads to digestive disturbances such as colic and founder and a 20% loss results in death. A horse needs 2-4 kg water per kg of feed. The water needs of the animal may be increased considerably by the duration and degree of physical activity, temperature, humidity, the stage of life cycle, the kind and level of diet fed etc.

Table 1: Daily water consumption by different classes of horses (NRC, 2007).

Class	Min (lit)	Max (lit)
Maintenance, 500 Kg (thermo-neutral)	27	36
Maintenance, 500 Kg (Warm environment)	36	68
Lactating mare, 500 Kg	45	68
Working (moderate), 500 Kg	45	54
Working (moderate), 500 Kg (Warm environment)	54	81
Weanling, 300 Kg (thermo-neutral)	27	36

Feeding Frequency

Horses have small stomach which is about 8-9% of total intestinal volumes as compared to bovines where stomach size is about 60% of total volumes of intestine. This limits quantity of consumption in single intake. Therefore, equines need to graze for longer time as compared to bovines.

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 hay if available freely.

In stables most horses will eat hourly during day and every 2-3 hours during night regardless of type of feed available from loose hay to blocks/cubes. It is recommended that, grain mix be fed @ 0.5-0.7 Kg/100 kg body weight for optimum use in three to four attempts during whole day having round the clock availability of forage.

Guidelines of grain feeding are restricted in following manner.

- Divided in equal quantity
- As near the same time each day
- At least twice daily but as many more times as practical
- Horses under intense training/athletic performance must be offered grains 4-5 times a day that too 4-5 hours prior to exercise and must not be fed at least for one hour after exercise.

Feeding of Race Horse

The race horse is trained to compete at its maximum capacity during an approximate 1-3 minute racing period so, the maximum availability and utilization of energy must occur during this short time. Diet must be manipulated to maximize the amount of energy available in the muscle during exercise or racing. It is important that, race horses receive the protein, energy, vitamin and other nutrient needed to develop the body of well-trained athletes. The ration should provide 18% CP, 0.95% Ca and 0.85% P. the concentrate mixture should be at a level of 40-50% of the total feed intake. Use of 5-10% fat and high grain and low forage in diet may be beneficial for the high level performance horse to increase energy density. Reduce total feed intake and decrease intestinal tract volume. Sweating occurs as a horse runs or exercise. Any minerals that are lost in the sweat will increase their need in the diet. The loss of sodium and chloride appears to be a great concern since sweat contains 0.7% salt. If the exercise or running is excessive and prolonged, there may be a significant electrolyte loss. Hence there is a need to keep salt licks in horse stables though minerals are added to the diet. Magnesium is involved in energy release, iron is essential for the formation of haemoglobin, selenium is important for muscle function and iodine is necessary for general metabolism, Vitamin E is considered important for the exercising horse and stress increases the horse's need for vitamin B- complex. Slow release energy feed that are broken down during exercise provide a continuous supply of energy to the working muscle. Hence high digestible fibre sources such as sugar beet pulp, Lucerne chaff and high fat diet are better than grain diet. Fibre in the diet traps water in the large intestine and acts as essential reservoir of fluid which is used to replace sweat loss and to prevent dehydration during a ride (Reddy, 2014) [22].

Conclusions

Population of horses are more in rural area and among multifarious uses, horses are more use for athletic or race purpose. Majority of horse owners practice roughage feeding 3 to 4 times, concentrate feeding 1 time and watering 4 times. Majority of horse owners adopt either stall feeding or stall feeding and grazing in rearing of horses. Majority of horse owners prefer oat hay, Lucerne hay, dub grass hay as roughage and gram, barley, oat and sorghum as concentrate. Chaffing of green and dry fodder as well as electrolyte supplements are not in common practices. Majority of horse owners allow 7-9 hours for grazing per day.

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