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# The Scope of Utilization of Paddy Straw as Alternative Roughage in Equine Diet in India

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**ABSTRACT**

The deep bispecies relationship of humans and horses have started from prehistoric times with horses playing vital roles in societies over the millennia, including ones related to diet, transportation, work, religion, property and commodities, military service, status, and sports. Obviously, horse owners were always keen to search for a better economical, easily available feed without compromising for the nutritive value for their companions. This search had led them to explore various economically available agricultural crop residues to be considered in equine ration. Regarding Asian countries, especially when India is considered, paddy straw is a cheap, easily available crop residue which has been effectively tried in ruminant ration. But the scope of this feed in horse ration is less studied. Current study aimed to review the scope of rice straw in equine diet.

**HIGHLIGHTS**

- Scope of utilisation of paddy straw as alternative roughage in equine diet in India has been discussed.
- Use of paddy straw in lieu of dry forage is economical and has a low nutritive value than wheat and oat hay.

**Keywords:** Equines, equine diet, horses, India, nutritional value, rice straw

Human–horse relationship started from pre-historic periods with varied level of dependence from time to time. While meat may have been the first motivation in the very early stages for domestication, it was later replaced by the roles such as herding, warfare, transportation, communication, agriculture, trade, commerce, pleasure, sport, religion, symbol, status, gift, industry, competition, and recreation (Hausberger *et al*., 2008). Like any other domestic animals, these nimble footed animals are mostly used as companion animals and therapeutic riding programs are getting very much attraction recently (Hausberger *et al*., 2008). In this context, horse nutrition also gains much attention for the horse owners. The most basic requirement in a horse's diet is forage which ideally comes in the form of fresh grass. If grass is not available, free-choice grass hay is the next best choice. However, hay prices are affected by lots of outside factors such as adverse climatic conditions which may lead to manage the feed expenses. This prompted the horse owners to consider locally available and cheap agricultural crop residues as an alternative for hay or grasses. Recently horse owners are considering "rice straw" as an alternative to high hay prices or to keep horses busy. Since there are not many research about the use of paddy straw in equine diet, it is necessary to assess the possibility of incorporation of this crop residue. Hence the current study reviewed the scope of utilisation of paddy straw as alternative roughage in equine diet in India.

## Rice straw its availability and nutritional value

Paddy straw is a versatile by product of rice cultivation in India and in most southeast Asian countries with an

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estimated 200 million tons production. It is the stem part of the rice plant that remains in the paddy after the head portion with rice grain has been harvested. A yield of about 1.0-1.5 tons of paddy straw is expected per ton of paddy harvested (Singh and Gupta, 1970). Though incorporation of paddy straw as an animal feed is an economical decision, the nutritive value, digestibility and animal acceptance rate has to be considered before using the same. The nutritive value of paddy straw depends on variety, time between harvest and storage, plant maturity (i.e., lignin content increases with plant maturity), plant health and weather conditions. Rice straw has low energy with 80% substances which are potentially degradable, high dry matter (DM) contents of 92–96% and low protein content ranging from 3-6% (Shen *et al*., 1998). Low digestible nutrients, low palatability, variable nutritional values, high silica and oxalates, and sometimes presence of adulterants limit their use in animal feeds (Aquino *et al*., 2020). The high cell wall contents neutral detergent fibre (NDF) and acid detergent fibre (ADF) such as degradable carbohydrate fractions (i.e., starch, cellulose and hemicellulose) and lignin limits its use as a bulk or filler in the animal feed (Aquino *et al*., 2020). Normally cellulose can be digested by the ruminants. But the association of cellulose with hemicellulose and lignin makes it more difficult to get digested by the rumen or hindgut fermenters in ruminants and horses respectively (Kumar *et al*., 2020). The type of chemical bond formation between lignin and carbohydrate generally limits the action of microbial enzymes such a hemicellulases and cellulases. Hence it is important to treat the paddy straw to depolymerise / solubilize the lignin and hence to make available cellulose and hemicellulose for the microbial digestion (Kumar *et al.,* 2020). Regarding the minerals and micronutrients, rice straw contains higher amounts of potassium (1.58% of DM), calcium (0.53%), and magnesium (0.24%) and lower amounts of phosphorus (0.12%), sodium (0.13%), iron (0.07%), and manganese (0.07%) (Shen *et al*., 1998). The low phosphorous level in rice straw does not meet the animal requirement for normal growth and fertility (i.e., 0.3%) (Jackson, 1977a). Moreover, the mere presence of all these minerals does not guarantee its bioavailability. For examples though Calcium content of rice straw is enough to meet the animal requirement, studies on paddy straw fed cattle had showed that the animals were on has a negative calcium balance. Sub-optimal cobalt contents from Assam and Orissa and copper deficiency throughout India has been reported in rice straws (Jackson, 1977a). Thus, the routine provision of supplements containing at least these trace minerals would seem to be warranted. Nevertheless, rice straw remains to be a practical fodder if properly treated and supplemented with the essential nutrients. Various treatment methods such as physical, chemical, biological and enzymatic treatments improve the nutritive value of paddy straw to a greater extend. The physical treatments such as grinding, chopping or pelleting though decrease the digestibility of straw; it promotes animal intake and increase passage rate of the feed while pressure steaming separates the different fractions of rice straw, such as hemicellulose, cellulose, lignin, and sugars (Rangnekar *et al*., 1982; Ooshima *et al*., 1984). The various chemicals used for the treatment of straw include sodium hydroxide, ammonia, urea and lime. Among these chemicals, ruminant feeding experiments showed that sodium hydroxide treated straw is better than urea or sodium hydroxide treated straw (Chaudhry and Miller, 1996; Vadiveloo, 2003). However, apart from increasing the degradability ammonia treatment also enhances the nitrogen content and thereby the protein content of the straw (Abou-El-Enin *et al*., 1999). This effectively reduces the cost of protein rich supplements. Inadequacy of reports in equines makes it practically impossible to draw a definitive conclusion. However, while considering the promising results in ruminants, it is better advised to use 1.5% of sodium hydroxide, 1% of urea and 3g of ammonia per 100g of DM. In addition to chemical treatment, biological treatments using enzymes and different microorganisms, such as bacteria and fungi may also help to improve the quality of paddy straw (Aquino *et al*., 2020).

## Comparative analysis of rice straw with other straws and Hay

The quality of rice straw varies considerably from place to place and previous reports show that that crude protein (CP) varies from 2 to 7 per cent and acid detergent fibre (ADF) varies from 41 to 56 per cent on a dry matter (DM) basis (Drake *et al*., 2002). Rice straw cannot be compared with hays such as alfalfa hay in feeding value, however, for it contains only a trace of digestible protein (0.9 per cent), against over 10 per cent for alfalfa hay. The percentage of total digestible matter in the feeds is, 39.4 per cent for rice straw and 48.6 per cent for alfalfa hay (Drake *et al*., 2002).

The value of rice straw in comparison with alfalfa hay is doubtless considerably lower than these figures would indicate, for rice straw contains 33.5 per cent of fibre which is largely indigestible, against 25 per cent for alfalfa hay, and has also twice as much mineral matter, mainly silica, as contained in alfalfa hay (14.5 per cent, and 7.3 per cent, respectively) (Jackson, 1977b; Drake *et al*., 2002). Only 30% of this silica has been absorbed by the animal and excreted in urine as silicic acid (Jackson, 1977a). Though paddy straw is having a high amount of silica than any of the forages, urinary calculi are not, in general, a serious problem (Jackson, 1977a; 1977b). Rice straw differs from other straws in having a high (1–2%) oxalate content and when eaten, this oxalate is broken down in the rumen to carbonates and bicarbonates, absorbed, and then excreted in the urine. The high oxalate content in rice straw may lead to the greater need for calcium supplementation (Talapatra *et al*., 1948). Above all that it is well worth while to utilize rice straw for feeding farm animals, especially horses and mules. Comparison of the energy and nutritive availability of different locally available straws and hay with paddy straw are depicted in Table 1 and 2.

**Equine digestive system and its ability in digesting fibrous diet**

Horses are free ranging herbivores which are phylogenitically adapted to grassland environment (Janis, 1976). Irrespective of this fact, nowadays most of the horses are stall-fed with concentrates and forages alone (Santos *et al*., 2011). The digestive system of horses is more adapted to multiple small feedings for 15-16 hours a day. Horses are mainly hind gut fermenters with caecum and colon largely involved in the microbial digestion of feeds (Santos *et al*., 2011). Though the composition of microbial flora and digestive enzymes involved are different, of his system of fermentation is comparable with that of ruminants. The retention time of feeds in caecum and colon allows the fibre digestion by the microorganisms and to meet the energy requirements (O'Connor-Robison *et al*., 2007). Major portion of the fibre digestion happens by the fibrinolytic bacteria in horse caecum (Al Jassim and Andrews, 2009). Feeding horses with forage diets can play a critical role in the maintenance of normal functioning of the horse digestive tract and can minimise the occurrence of colic, gastric ulcers, hindgut acidosis,

**Table 1:** Comparison of the level of energy obtained from commonly available straws

| Straw | GE | DE | ME | NEm | NEg |
|---|---|---|---|---|---|
| Wheat straw | 4.3 | 1.8 | 1.5 | 0.6 | 0.1 |
| Paddy straw | 4.0 | 1.8 | 1.5 | 0.6 | 0.1 |
| Barley straw | 3.9 | 1.8 | 1.4 | 0.59 | 0.07 |

Adapted and modified from NRC (1982). GE: Gross Energy, DE: Digestible Energy, ME: Metabolizable Energy, NEm: Net Energy for maintenance, NEg: Net Energy for gain.

**Table 2:** Comparison of the nutritive value of straw with wheat hay, a commonly used horse feed in India

| Nutrients | Wheat straw | Paddy straw | Barley straw | Wheat hay |
|---|---|---|---|---|
| DM[1] | 90 | 94.7 | 90.9 | 90.3 |
| CP[2] | 3.6 | 4.6 | 3.8 | 5.4 |
| Crude Ash | 6 | 14.4 | 7.5 | 10.8 |
| Crude fibre | 37.5 | 31.9 | 40.5 | 35.1 |
| NDF[3] | 70.4 | 73.1 | 80.5 | 54.2 |
| ADF[4] | 52 | 41.7 | 48.3 | 39.2 |
| ADL[5] | 7.9 | 2.4 | 6.5 | 5.6 |
| Ca[6] | 0.19 | 0.53 | 4.6 | 0.15 |
| P[7] | 0.09 | 0.12 | 1.0 | |

[1]DM-Dry Matter, [2]CP- Crude Protein, [3]NDF- Neutral Detergent Fiber, [4]ADF –Acid Detergent Fiber, [5]ADL- Acid Detergent Lignin, [6]Ca- Calcium and [7]P- Phosphorus.

and stereotypical behaviours (NRC, 1953). It is important to include high digestibility forage in the feeding of this animal. As far as agricultural wastes are considered, lignocellulosic material forms a major part of this feeds with low nutritional value (Salem *et al*., 2013). Despite of the low protein content, these feeds are potential used as an energy source in animal diet (Salem *et al*., 2013). Paddy straw being a cheap, widely available agricultural waste in Southeast Asian countries, especially India, can be effectively used in the animal ration. Proper physical, chemical and biological processing of paddy straw has helped to improve the digestibility, animal acceptance and protein content of these fibrous feeds (Salem *et al*., 2013). Similarly enzymatic treatments with exogenous fibrolytic enzymes improved digestion of insoluble fibre in horses (Gado *et al*., 2017). Addition of such enzymes will help in breaking the ligno cellulosic bonds in these feeds which are usually not been acted by animal enzymes (Beauchemin *et al.,* 2001). Research have reported that use of exogenous xylanase and cellulase enhances cell wall digestibility in horse forage rations thereby reducing the concentrate requirement (Hainze *et al*., 2003). In addition, there are reports suggesting the use of Natuzyme enzyme has helped for the proper fermentation and gas production of alfalfa hay and wheat straw without affecting the DM digestibility by cecum bacteria in Arabian horse nutrition (Mohammadabadi *et al.,* 2018). This indicates the feasibility of using paddy straw in horse ration after proper treatment.

**Acceptability level and level of incorporation of rice straw in equine diet**

Normally all horses should receive a minimum of 1 percent of their body weight each day in long-fibre forage dry matter (DM) to prevent digestive problems. When horses are allowed to graze freely on pasture or hay, they often eat upto 2.5 percent of their body weight in dry matter daily. In such cases horse may voluntarily consume up to 12.5 kg of dry matter each day. NRC recommended nutritional requirement for different categories of equines are shown in Table 3. Straw in general have low energy per unit weight, low protein, low minerals, etc when compared to forages and hay and hence it is not advised to totally replace them with straw (Harris *et al*., 2017). Though rice straw is less palatable, horses on restricted diet may surely eat it. If the horses are on lush green fodder or highly palatable hays such as alfalfa hay, it may be necessary to get them pretty hungry before they will eat it, or it may be 'chopped and fed with some molasses or grain feed to get them to eat it. When compared to other straws, oat straw is softer and tends to be more palatable to horses than wheat or barley straw or rice straw (Jackson, 1977b). When feeding straw, always make sure your horse has an adequate source of water available to reduce the risk of impaction colic. If horses eat a large volume of straw, lignin fibre accumulates in the digestive system and it can plug (impact) the digestive system which may results in severe colic and even death if not properly treated. For cows with calves, the use of rice straw should not exceed 25% of the total ration, with the remaining 75% being good-quality hay or legumes or a concentrate supplement (Aquino *et al*., 2020). In case of equines, irrespective of the weight of the animal the level of incorporation of paddy straw in equine diet is 1.25 kg on DM basis. However, supplementation is strongly recommended to mitigate the nutritional weakness of rice straw.

Protein supplements increase intake thus increases energy intake: a level of 8 to 10% CP is needed for young stock. Grasses such as Napier grass (*Pennisetum purpureum*) and legumes are also potential protein supplements. Energy supplements such as maize silage and sugarcane molasses can also be used. Wood ash or polysorbate 80 (Tween 80®) treatment added to protein supplementation improved DM disappearance and overall nutritive value (Aquino *et al*., 2020).

**Pros and cons of rice straw feeding for equines**

Equines as herbivore animals can make good use of low-quality roughages by relying on their well-developed hindgut, and they can also digest some amounts of dietary proteins, fats, starches and other soluble carbohydrates through the activity of intestinal digestive enzymes. While feeding leucerne hay in horses, 39.5% crude fiber digestibility and 36.1% acid detergent fiber (ADF) digestibility was observed (Liu *et al*., 2020). Although straw is often not the most palatable source of fiber, most horses will eat it, particularly if they are on a restricted diet (Liu *et al*., 2020). It can easily be mixed in with hay and soaked or steamed if necessary. Straw is high in fiber and has a very low-calorie level compared to other forages as it contains higher proportions of indigestible materials

**Table 3:** Nutrient requirements for different categories of equines

| NRC 2007 | HS[1] 550 kg | DS[2] 400 kg | BM[3] 400 kg | GSBM[4]/ Donkey/ Zanskar 350 | HYS[5]/ YS (MA) 200 kg | HYS 300 kg | MYS[6] GS/ Donkey/ Zanskar 200 KGS | MYS GS/ Donkey/ Zanskar 250 KGS | Ride A[7] 450 kgs | Ride B[8] 400 kgs | Mule MA/half linger | Mule Pony 350 kgs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DE Mcal/d | 24 | 17.4 | 15.4 | 13.5 | 7.5 | 11.1 | 7.5 | 10.8 | 18 | 16 | 18 | 14 |
| Protien g/d | 868.1 | 631.4 | 637.4 | 557.7 | 338.3 | 457.6 | 338.3 | 411.7 | 629.3 | 559.4 | 629.3 | 489.4 |
| Lysine g/d | 37.3 | 27.2 | 27.4 | 24 | 14.6 | 19.7 | 14.6 | 17.7 | 27.1 | 24.1 | 27.1 | 21.1 |
| Ca(g/d) | 33 | 24 | 28.8 | 25.2 | 15.1 | 21.9 | 15.1 | 18.3 | 27 | 24 | 27 | 21 |
| P (g/d) | 19.8 | 14.4 | 21 | 18.4 | 8.4 | 12.2 | 8.4 | 10.2 | 16.2 | 14.4 | 16.2 | 12.6 |

[1]HS-Horse Stallion, [2]DS-Donkey Stallion, [3]BM-Brood Mare, [4]GSBM-General Service Brood Mare, [5]HYS- Horse Young Stock, [6]MYS- Mule Young Stock, [7]Ride A is horse above 157 cm, [8]Ride B is 152cm, GS is General Service animal.

such as lignin and silica. It is great for mixing with good quality hay or haylage to dilute the calories supplied. Straw diet can help to promote weight loss and reduce the risk of issues such as laminitis (Pearson and Merritt, 1991). Although straw has very little buffering capability itself, it is still beneficial for gastric health in the sense that it increases chew time and therefore greater saliva production. Saliva contains bicarbonate which helps to buffer acidity in the horse's digestive tract. In addition, on an average, straw would have a starch level of around 2.5% and WSC (water soluble carbohydrate) of 6.5% in equine ration. Feeding straw in combination with other more nutritious fiber sources keeps the overall calorie intake low, whilst maximising the amount the horse must eat. Encouraging continuous eating of fibrous feeds is a key part of the management of gastric ulcers (Galinelli *et al*., 2019). Other drawbacks/nutritional deficiencies of rice straw must be considered and hence supplementation is needed to meet the animal's nutrient requirements.

## Cost effectiveness of rice straw

Use of paddy straw in lieu of dry forage is economical and has a low nutritive value than wheat and oat hay. Wheat straw, Oat straw and chaff are finer than paddy straw. However, treatment of paddy straw either by mechanical treatments like chopping and grinding or using ammonia or urea is another method to improve the digestibility and nutritive value of this crop residue. India being a vast nation with diversity in agroclimatic conditions rice straw can be introduced as an equine feed where the cultivation of paddy is in abundance and hence its availability of paddy straw as a byproduct only with the view to economize the domestic requirement in discrete pockets along with other available roughages to its local equine population. For a 500 kg animal, 1.25 kg dry matter or 1.4 kg as fed assuming 90% dry matter (10% level of forage not to be exceeded) is allowed. It is advised to slowly introduce the rice straw into ration by replacing small amount of forage to adapt chewing behaviour and reduce the risk of impaction. In addition, adlib water supply and supplementation of essential nutrients which are deficient in rice straw are needed. It is always preferable to do an initial trial with 100 animals under maintenance ration, analyze the outcome and then proceed for a large-scale usage.

## What research says?

There is not much research about the use of paddy straw as equine diet. Research on 40 native-type ponies at pasture in the UK over winter have found that all ponies supplemented with 50% straw lost weight, an average of 27 kg, compared to those just fed hay where only three out of 15 ponies lost weight and the rest gained weight (Dosi *et al*., 2020). Recent research say that straw can be a good option when the animals need to lose weight. Straw is lower in energy when compared with most grass hays, and hence substituting up to 50% of grass hay in the ration with straw, creates a less energy dense ration whilst maintaining adequate forage intake (Drake *et al*., 2002). This will satiate the appetite of the horses and hence can maintain on a restricted diet to achieve weight loss. In addition, since the time horses spend on eating per day is extended, studies suggest that there is less risk of gastric ulcers due to prolonged periods without food (Galinelli *et*

*al*., 2019). But one study in Denmark found that horses fed straw as the sole or predominant forage source were 4.5 times more likely to have gastric ulcers (Luthersson *et al*., 2009). Hence than introducing paddy straw suddenly into a herd, initial trials in animals on maintenance ration are advocated.

## CONCLUSION

Use of paddy straw in lieu of dry forage is economical and has a low nutritive value than wheat and oat hay. Wheat straw, Oat straw and chaff are finer than paddy straw. However, treatment of paddy straw either by mechanical treatments like chopping and grinding or using ammonia or urea is another method to improve the digestibility and nutritive value of this crop residue. India being a vast nation with diversity in agroclimatic conditions rice straw can be introduced as an equine feed where the cultivation of paddy is in abundance and hence its availability of paddy straw as a byproduct only with the view to economize the domestic requirement in discrete pockets along with other available roughages to its local equine population. For a 500kg animal, 1.25 kg dry matter or 1.4 kg as fed assuming 90% dry matter (10% level of forage not to be exceeded) is allowed. It is advised to slowly introduce the rice straw into ration by replacing small amount of forage to adapt chewing behaviour and reduce the risk of impaction. In addition, adlib water supply and supplementation of essential nutrients which are deficient in rice straw are needed. It is always preferable to do an initial trial with 100 animals under maintenance ration, analyze the outcome and then proceed for a large-scale usage.

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