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Increasing nutritive value of dry roughages by urea treatment

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Abstract
Cereal straws of wheat, oats, barley, paddy and strovers like sorghum and bajra etc. consists an important significance as it forms the largest proportion of roughage (about 80%) availability. Most of the livestock depends on such fodder alone. The voluntary intake and digestibility of these feeds is also very low thus animals fed on such straws and strovers suffer from malnutrition. Urea treatment is very cheap, simple, scientific and the most successful procedures to improve digestibility of straws and strovers. Optimum rate of application of urea should be in the range of 3-4 kg of urea (3-5% urea) per 100 kg of fodder i.e. 4-5 kg of urea and 60 litres of water per 100 kg of straw. This treatment allows better penetration by rumen microorganisms by weakening the hard cell wall to produce more effective fermentation and liberation of nutrients. Though, there are some factors which need to be considered before processing such as rate of urea, water, treatment period, sealing, environment temperature etc. The advantages in terms of improvement in milk and fat yield, reduction in feed wastage, and improve economy of farmer are promising and encouraging to adopt this method at farmers door.

Keywords: Straws and strovers, digestibility, effective fermentation, rate of urea

Introduction
India contributes a larger share to livestock population of the world. There are about 199 million cattle, 105 million buffaloes, 140 million goats and 71 million sheep (18th Livestock Census, 2007) [1]. Presently, availability of forages and concentrates are unable to supply requirement of such huge population of livestock in India which impedes productivity of animals (Birthal and Rao, 2002) [3]. Available dry roughages alone contribute major part of livestock feeding, which are low in nutrients (Leng and Preston, 1983; Jayasuriya, 1987; Van Soest, 1994) [25, 20, 35]. In developing countries, livestock is usually fed high fibrous feed materials which are characterized by complex carbohydrates or lignin which are low in digestibility. In India, ruminant animals are generally fed on poor quality roughages such as mature grasses, crop residues which are rich in fibre and have less digestible portion.

The animals are suffering from shortage of feeds, roughages as well as concentrates. Deficiency of energy, protein, minerals and vitamins leads to various disorders which affecting livestock industry by reducing production which is of much significance as most of the human population is depends upon livestock for their livelihood. Fermentable energy and protein deficiencies in crop residues coupled with their low digestibility impair intake, ruminal functions and animal productivity. The situation strongly demands the improvement of the nutritive value of such high fibrous roughages through various treatments, for the efficient utilization of existing feed resources. In past, extensive research has been conducted on various methods to improve nutritive quality of these roughages which are abundantly available in India. Various methods includes physical, chemical and biological with or without success are tried in past. However, due to certain reasons mainly economic, these methods of improving nutritive value of feedstuffs have limited acceptance by farmers (Rangnekar, 2005) [30]; other reasons are lack of knowledge and training. Straw are available in most part of the country as a by product of wheat, oat or rice crops. In North India, wheat straw is commonly used, while eastern, western and southern part paddy straw is common (Badve, 1991; Ranjhan, 1999; Kristjanson and Zerbini 1999) [2, 29, 23]. Pre-treatment of straws with urea is one such method which improves nutritive value. But till date this method has not get acceptance from farmers due to unknown reasons. Nutritive value of straws in terms of nutrient composition, digestibility, energy value, and body weight gain of animals was improved significantly by urea treatment. Urea treatment should be done at the start of dry season after harvesting.

Reason behind this is that water and forage supplies are available at this time and the livestock owner has time as well as money for purchasing the urea. Environmental conditions are also favorable as at a start weather is not much hot.

Urea acts as a protein source to the ruminal microorganism by converting nitrogen to protein in their body. After urea treatment excess ammonia evaporates and the remaining ammonia bound to the dry forages during treatment acts as a source of nitrogen for microbial protein synthesis in the rumen. Ammonia is also a good fungicide thus; dry forages can be preserved by urea treatment during the monsoon season and can be stored for longer period. Gupta *et al.* (1988) [13] reported that use of urea up to 5% level is safe, economical and had a significant effect on increasing the crude protein content of wheat straw. The beneficial effect of urea treatment includes increased digestibility by 8-12%, nitrogen content, voluntary intake by 25 - 50% and enhance fattening of animals.

In vitro digestibility increased from 47-53%, and protein content from 11.1- 16%. Increased apparent digestibility of dry and organic matter of roughages treated with urea is reported (Oji and Mowat, 1979; Garret *et al*., 1979) [28, 11]. Treatment of straw with urea increases the crude protein content of the straw by about 2-2.5 times (Waiss *et al*., 1972; Waegepetersen and Thomsen, 1977; Rashiq, 1980) [37, 36, 31]. Urea treatment typically increases DM digestibility by 10-15% (Saadullah *et al*., 1981) [32] and feed intake by 25-35%. Many researchers confirmed the increased feed intake after urea treatment (Lawlor and O'Shea 1979; Gadre 1980; Rashiq 1980) [24, 13, 31]. Narayan *et al*. (2004) [27] reported a higher CP intake in urea treated straw. Hossain and Rehman (1981) [16] reported that 5% urea treated straw provided 0.31 kg more digestible organic matter and produced extra gain of about 60-80 g/day on urea treated straw. Dajayanegra *et al*. (1989) [7] reported that both urea treatment and urea supplementation increased intake, rate of digestion and digestibility of nutrients. Literature indicates that this positive result on CP digestibility support the facts that associative effects of small quantities of supplement such as minerals or proteins enhances rumen fermentation leading to increased intake and digestibility and in turn production performance. Many studies showed a positive effect of urea treatment. There is significant increase in production level. In China, urea treatment is widely used and has been successfully introduced in some villages in Mali.

Research indicated that addition of water is necessary for maximum enzyme activity. Although, it has been reported that urea treatment of straw is possible even with dry wheat straw. However, the protein percentage remains low, because the lower moisture level decreases the hydrolysis of urea to ammonia and binding of nitrogen to fibre (Hadjipanayiotou *et al*., 1993) [15].

Regarding incubation time there are contradictory reports are available. Some researchers said 8 weeks; some says 6 weeks and 4 weeks. From the literature we can conclude that depending upon ambient temperature, an incubation period of four to six weeks is sufficient, with a minimum of four weeks. Length of incubation indicated that as length increases from one week to eight weeks the crude protein values also increased (Cloete and Kritzinger, 1984) [6]. However, Hadjipanaiotou and Economides (1997) [14] reported that under Mediterranean conditions, treatment time of two weeks was required during summer month for maximum response. Kamo and Nakagawasai (1996) reported that the nutritive value of treated wheat straw increased with the air tightness of the storage container.

Mechanism of action

Mechanism of action is based on the fact that due to urea treatment complex carbohydrates such as hemicelluloses and lignin are dissolved, swelling of vegetal matter occurred in aqueous environment thus making easy access to the rumen microbes to degrade it. Other mechanism involve is to reduce the strength of the cell wall, thus easy mastication by the animals and digestion by ruminal microbes as nitrogen content of treated straw is improved. Treatment of dry forages with urea helps in increasing cell wall porosity which makes complex carbohydrates more available to enzymatic hydrolysis (Goto, 1995) [12] by rumen microbes.

Ruminants have the unique ability to convert NPN compounds to a microbial protein of high biological value. Treatment with urea results in degradation of the cellulose and hemi-cellulose which improve the digestibility of dry roughages. The various microbes in the rumen colonized the ingested feed particles. The cellulolytic strains partially degrade or hydrolyse the cellulose and the hemicelluloses. For effective degradation ruminal microbes have to attach themselves to the cell walls of feed particles so that the enzymes can penetrate inside the fibrous structures. However, wheat straws have more proportion of lignified walls, particularly in mature straws. This lignin prevents microbial invasion thus reduces digestibility of straws. Thus, in order to improve cellulolytic fermentation process, the ruminal microorganisms should able to find the nutritive substances which they need for their own growth and development and further enable them to penetrate the cell walls of the straw. Straw produces laxative effect after absorption if degraded properly in rumen. Absorbs more water and animals feels bulky. This serves as energy source to animal by production of volatile fatty acids. As digestibility is improved, productive performance of animals is also improved results in more profit to the farmers. With improved nutrition, the possibility exists to increase small ruminant production and to improve net farm income and living standards. Urea treatment is without any risk. Urea is commercially available as a fertilizer grade urea having 46% nitrogen. Other advantages includes easy transport, store and handle and cheap.

Practically, in the presence of water, urease enzyme and warm temperature urea hydrolyses into ammonia and carbonic gas. Once the hydrolysis is completed one mole of urea generates two moles of ammonia. In other words, 5 kg of urea produces 2.83 kg of ammonia. This ammonia causes alkaline condition which gradually spreads and treats the dry straw. Success of urea treatment is based on the formation of ammonia and fixation in straw directly and modification of straw chemically. Thus, favourable conditions for this should be there to achieve ammonia formation. Factors influencing urea treatment are presence of urease enzyme, rate of urea treatment, moisture content, temperature, length of treatment, degree of sealing, quantity of straw used.

Presence of urease enzyme

Enzyme urease is produced by ureolytic bacteria. These are naturally present in the soil and also, in urine and faeces of humans and animals. Urease is also present in the rumen. Urease is abundant in rural areas (Williams *et al*., 1984 a and b; Yameogo *et al*., 1993) [38, 40]. In tropical countries no additional urease has been reported to be added when urea

treatment is carried out at temperatures above 25 °C, particularly when moisture content is above 25-30% (Williams *et al*., 1984 a and b; Sahaoune *et al*., 1991; Ibrahim *et al*., 1984; Chermiti, 1994) [38, 33, 17, 5].

Therefore, tropical temperatures are ideal for ureolysis and the alkaline treatment if concentrations of 5 kg of urea are dissolved in 50 litres of water and incorporated into every 100 kg of dry forages. This negated the need to add urease enzyme. Sources of urease enzyme are maiden soil, chickpea seed meal, soybean meal, *Acacia* leaves, lucerne leaves, lobia beans, buffalo dung, soil wet with animal urine and sheep faeces etc. (Jayasuriya and Pearce, 1983; Khan *et al*., 1999; Malek *et al*., 2008; Jabbar *et al*., 2009) [20, 22, 26, 18].

Forages used

In practice the main forages to be treated include straw from rice, wheat, oat etc. stalks of maize, sorghum, millet etc. together with local grasses gathered during the dry season, or perhaps hay of mediocre quality such as oats. Although in the present state it is difficult to distinguish between good and poor quality straw and hence no harm will come from treating them and their nutritive value can only be improved.

Rate of application

Optimum rate of application of urea should be in the range of 3-4 kg of urea (3-5% urea) per 100 kg of fodder i.e. 4-5 kg of urea and 60 litres of water per 100 kg of straw. Urea application at higher rates does not significantly increase to the nutritive value of the straws (Schiere and Ibrahim, 1989) [34]. It has been reported that hydrolysis of the urea may stop or falter when large amounts of free ammonia build up within the fodder (Sahanoune, 1990) [33]. This implies that urea treatment at higher rate than that recommended reduces the chances of getting maximum benefit from urea treatment. On the contrary, increases the cost, labour and risk involved in higher ammonia production.

Moisture content

Moisture content of treated straw should not be less than 30%. If more water is used then it is possible that water will be run off and straws will become saturated and soft. Ammonia being hygroscopic in nature, higher water content may trap ammonia thus, making it unable to fix in cell walls of straw. Another drawback is that too much water favour fungal growth due to improper sealing by plastic sheet, deteriorating quality of treated straw. Finally, excess water causes leaching of urea through bottom of pit, if straws absorbs more then over concentration may arise resulting in ammonia toxicity which may be lethal. Optimum moisture level helps to compress the straw materials by driving out the air and increases the contact of ammonia to straw as long as pit is tightly sealed by plastic sheet. Addition of 50 litres of water for 100 kg of straw is suffice in dry seasons. One can add more water depending upon the dry matter of straw used for treating and weather conditions.

Temperature

The alkalinity is accomplished after 7-8 days when temperature is around 30 °C, in subsequent days ureolytic reactions proceeds at normal rate and straw is ready to use by 21-28 days. The ideal temperature for ureolysis ranged from 30-40 °C. Above this temperature range ureolysis is accomplished within few days. Stiefel *et al*. (1990) showed that in India, rice straw treated with 4-5 kg of urea and 60 litres of water per 100 kg of straw, similar treatment efficiency was observed for urea treatment on 8, 5 and even 4 days. Thus, temperature is an important factor apart from the rate of urea and water content. At lower temperatures activity of ureolytic bacteria is reduced which resulted in slow ureolysis and thus takes longer period to get good results.

Degree of sealing

Sealing is of much importance in urea treatment. Sealing prevents losses of urea solution, ammonia gas and instrumental in creating anaerobic environment in pit/heaps thus, preventing growth of fungus and pathogenic microbes. If any leakage is there in sealing all generated ammonia will be escape as it is lighter than air and nutritive value of forage used does not improve.

In fact there is no standard, universal rule which may be applied, rather reasoned methods designed according to specific conditions of each situation (FAO, 1997) [9]. For detailed readers should go through various published literature e.g. Schiere and Ibrahim, 1989, Dolberg *et al*., 1981; Kayouli, 1994 and Chenost, 1989 [34, 8, 21].

Quantity of straw used

Urea treatment of straws is depends on the physical condition of the straw i.e. bulk straw should be chopped or in long stalks, bunches made either manually or by machine, bales. The amount of straw to be treated depends upon the number of animals to be fed and for how long the feed will be given and the material and financial resources available with the farmer.

Length and storage methods of treatment

Urea treated straws or dry forages should be kept sealed form 2-8 weeks of period depending on weather and region. Different types of treatment and storage methods includes pit or trench, semi-embedded trenches, corridor silos, silos made from stalks of millet, sorghum or maize, bamboo panniers, silos made from timber or bamboo, existing but unused buildings, houses and stores, traditional stacks of straw made from bunches, stacks made from bales, covering the stacks with mud etc. for detailed please refer FAO (1997) [9]. The urea treated straw can be conserved for several months as long as it is properly sealed. Once it is opened up, it should be used or after removing required amount it should be sealed immediately.

Conclusion

Urea treatment is a very simple and cheap and scientific technique to improve the nutritive value of dry forages which are generally of low nutritive quality. There are some factors which need to be considered before processing such as rate of urea, water, treatment period, sealing, environment temperature etc. The advantages in terms of improvement in milk and fat yield, reduction in feed wastage, and improve economy of farmer are promising and encouraging to adopt this method at farmers door.

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