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Use of densified complete feed blocks as ruminant feed for sustainable livestock production: A review

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ABSTRACT

Livestock play a central role in the natural resource-based livelihood in developing countries. The area under green forage crops is shrinking due to increase in human population and urbanization. As a result, the bulk of feeds available for ruminants in these regions are the crop residues. Manufacture of Densified Complete Feed Blocks (DCFBs) is an innovative technology to supply balanced feeds to livestock in the tropics. The first step in the process of making DCFBs is the grinding and mixing of concentrate ingredients separately. This is followed by adding concentrate components to chopped straw in desired proportions along with molasses in a mixer, taking care that mixing is uniform and ingredients are not separated due to gravity. Finally, the desired quantity of straw-concentrate mix is transferred to a hydraulic press to convert the mix into a block. Based on the productivity levels of animals, DCFBs could play an important role in providing balanced rations to livestock in the tropical regions of green forage scarcity. The technology offers a means to increase milk production, decrease in environmental pollutants, increase in income of farmers, decrease in labour requirement and time for feeding and reduction in transportation cost of straw. The technology also has the potential to provide complete feed to livestock under emergency situations created by natural calamities.

Key words: Crop Residue, DCFBs, Feeding Practices, Machine and Formulations of DCFBs.

INTRODUCTION

The livestock industry is an economic enterprise and can also be considered as a "survival enterprise" for millions of people of the world. Among the multiple roles of the livestock industry, nutritional security, income generation and employment are the most important. About 70 percent of the milk producers in India and other developing countries are landless and marginal farmers and the disposable income from milk contributes significantly for sustaining their livelihood. A successful livestock production largely depends on continues supply of adequate, balanced and economic feeding. Feeding alone accounts for more than 70 percent of the total cost of milk production; therefore, balanced feeding of dairy animals can play a pivotal role in a successful dairy development programme worldwide. To maximize profitability from the animals, one needs to ensure that these animals must receive the required quantity of protein, energy, minerals and vitamins, preferably from locally available feed resources.

Dairy animals in India and other tropical countries are fed mainly on by-products of various food crops, oil seeds and locally grown fodder. Due to population pressure the land for fodder production has dwindled alarmingly and the cereal crop residues like paddy straw, wheat straw, sorghum straw etc. have become the major source of feed for large sections of the ruminant population. Improper management of feed resources, especially are the bulky and fibrous crop residues, is another factor contributing to low productivity of ruminant livestock in the tropical regions.

The utilization of crop residues for increased animal protein production has received greater research attention within the past few decade because of the higher quantities of crop residue. Still, a large proportion of the crop residues either remain unutilized or not properly utilized. This results in enormous loss of precious feed resources for the livestock industry. Suitable feeding practices and processing technology would enable the livestock farmer to utilize these resources more effectively resulting in better performance of the animals. In India, there is an acute shortage of quality fodders. The shortage of feed and fodder is a chronic ailment that afflicts the livestock industry. Harsh weather condition and natural calamities also aggravates the problem of shortage of feeds.

During these scarcity periods, there is need for easily available feed that can meet nutritional requirements at low cost and is easy to transport. Nutritive value of poor quality and bulky roughages can be improved by Densified complete Feed Block (Salem and Nefzaoui, 2003).

Densified complete feed block (DCFB) is composed of forage, concentrate and other supplementary nutrients in desired proportions capable to fulfill nutrient

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requirement of an animal. The feeding of complete feed stabilizes rumen fermentation, minimizes fermentation loss and ensures better ammonia utilization (Prasad *et al.,* 2001). This pattern of rumen fermentation enhances utilization of poor quality roughage and improves the palatability of unconventional feeds. Because of seasonal availability and low bulk density, storage, handling and transportation of roughage materials become very difficult.

Thus, complete feed in block form may overcome the above problem and will transport feed resources to deficit region or area of natural calamities cost effectively and can form a part of "scarcity feed banks" for economic and viable livestock production programmes for small and marginal farmers, landless labourers and other weaker sections of the society (Mattoo and Ganai,2004).

Feeding practices for livestock in India at present
Separate feeding of roughage and concentrate: This practice is followed mostly in the rural areas of southern, eastern and western parts of India. The farmers often do not chaff and soak the straws or stovers, and offer them dry and in un-chopped or semi-chopped form. Concentrate components of the ration are given separately. The animals are mostly low producing and are offered different types of crop residues like rice or gram straw, stovers of sorghum, maize or finger millets. Six to seven kg per day of the dry roughage is offered to adult bovines which form approximately 70% of the ration.

Apart from this, small quantity of greens, between 0.5 and 1.0 kg dry matter, limited amount of cakes and brans (rice and/or wheat), non-food grade broken pulses (1–2 kg per day) and some kitchen waste, as the concentrate ingredients are also offered. The un-chopped straw provides complete choice to the animal for selectively consuming the more digestible parts and leaving behind the less digestible parts, which consequently leads to substantial feed wastage (Bhargava, Ørskov and Walli, 1988). In addition, the animal might need to spend more energy for chewing the un-chopped straw, than the chopped straw (Chander, 2011).

Chopped roughage and soaked concentrate mixed together: A simple process of feeding bovines, called "Sani" making, is the most prevalent feeding practice followed in north-western parts of India as well as in Pakistan. The chopped green fodder (maize, oats, sorghum, berseem, alfa alfa) is mixed with chopped straw/stover (wheat, paddy, maize, sorghum), in the proportion of 35–40 : 65–60, on dry matter basis. The mixed forage is sprinkled with some water, which is followed by addition of concentrate ingredients, e.g. oilseed cakes, rice or wheat bran, maize or wheat flour and some legume chunies (broken seeds of pulses with some husk) like Bengal gram (*Cicer arietinum*) or moong (*Vigna radiata*), to the extent of 25–30% of the total ration.

All the ingredients are then mixed and fed to the animals as manually prepared total mixed ration. This definitely is an improvement over the separate feeding of roughage and concentrate. The chopping may save some energy required for chewing, soaking could increase palatability of the feed and consumption of mixed feed increases digestibility of feed by improving rumen function. However, the selection of feed components by the animals could still take place partially and this could lead to some feed wastage (FAO, 2012).

Chopped roughage mechanically mixed with concentrate as mash: Mash can be prepared commercially but animal still has some scope to go for selective consumption leading to feed wastage. In mash form, the concentrate particulate matter is not physically attached with the fodder particles and has the tendency to settle down at the bottom (FAO, 2012).

Chopped roughage and concentrate ingredients mixed and Densified as Complete Feed Block: This noble nutrient delivery system requires proper processing and the commercial manufacture of complete balanced feed involving densification of the mixed feed. Densified complete feed block is an ideal way to give balance feed to bovine. (FAO, 2012)

DCFB technology provides a great potential for an efficient utilization of available crop residues, agro-industrial by-products including fallen tree leaves and forest waste as a low cost feed, as well as ready to eat ruminant diet to meet the prevailing scarcity conditions, which are further aggravated by reoccurring disasters like snow storms in the valley. Straws and other roughages being too bulky, the bulk density of roughage based feed blocks have been found to be 4-5 times more than the original feed. It would increase even more, if mixed with binders and concentrates. The mechanical process of making blocks of such low grade roughages will help to increase bulk density (Singh *et al.*, 2012), improve voluntary feed intake, nutritive value and their utilization (Samanata *et al*., 2003).

Concept of densified complete feed block : Concept of densified complete feeds with fibrous crop residues is a noble way to increase the intake and improve the nutrients utilization. A complete feed block has been defined as a system of feeding all ingredients including roughages, processed and mixed uniformly, to be made available *ad lib* to the animals. It has also been defined as an intimate mixture of processed ingredients presented in a form which precludes selection and which is designed to be the sole source of feed. Complete diet system has been introduced with the aim of simplying the feeding of animals. It is not possible to check the intake of concentrate when animals are fed concentrate and roughage separately. It has been observed that lactating cattle consumed only a very low amount of roughage when given free access to concentrate. This practice is not only expensive but also reduces the butter fat content of the milk (FAO, 2012).

Another drawback is the high variability between the consumption of roughage and concentrate proportions. It has been reported that cows fed concentrate *ad lib* in the early part of lactation were frequently off fed and produced less milk than the cows on controlled concentrate feeding. Depressed percentage of milk fat was observed when a concentrate diet was given as free choice, as compared to complete diet (FAO, 2012).

Flalt *et al*. (1969) clearly confirmed that at the higher level of concentrate consumption, the cow increasingly partitions its energy intake into body tissue without increase in milk yield and with lower energy content. Keeping these difficulties in view, concept of complete feed block evolved.

Operational details of the densified feed block making machine : Complete feed block making machine (Fig 1) is based on compression technology. It can compact all kinds of feed materials to square shape of desired thickness and weight. The machine is powered with a 7.5 to 15 HP electric motor. The working pressure of the machine can be raised up to 6000 psi. The out put capacity of the machine is 30-40 blocks per hour (FAO, 2012).

The machine is simple to operate and only one person (unskilled/semiskilled) is required to regulate entire operation of the machine. Well formed compact blocks of wheat and paddy straw could be obtained with addition of molasses at a compaction pressure of 418.5 kg/cm2. The blocks can retain the shape for long duration. The blocks formed at lower compaction pressure had much higher resiliency, hence less stability. Another important factor is dryness of the straw. Compact blocks could be formed at a natural dried moisture content (10-12%) and 418.5 kg/cm2 pressure (FAO, 2012).

Fig 1: Densified Complete Feed Block Making Machine

The feed densification is an established technology. However, only a Few organizations took the initiative for the development of the prototype machines for block making,, notable among these being Indian Grassland Research Institute (IGFRI), Jhansi UP, (Gupta et .al., 1998); Indian Agricultural Research Institute (IARI), New Delhi (Singh and Jha, 2009) and the Poshak Agrivet Pvt. Ltd, Karnal (Zombade, 2009).

Components of Densified Complete Feed Block

Complete feed block have main two components, Major and Minor. The major components of compressed complete feed blocks are roughage and concentrate, added in different ratios, depending upon the level of production while the minor components of compressed complete feed blocks are micronutrients and feed additives (FAO, 2012).

Roughage part : The roughage part is generally the crop residues such as wheat, ragi or paddy straw, sorghum stalk, sugarcane tops, maize stover. In hilly areas, even the non-conventional forages like forest grasses and tree leaves have been used in place of crop residues. This has been done in the North–Eastern region of India, especially in Nagaland, where the feed blocks, based on tree leaves and dried forest grasses have been successfully fed to Mithun, a bovine species resembling buffaloes (Das, *et al.*, 2009).

Studies have shown that sugarcane bagasse can be used economically as an alternative source of forage to replace 30% of wheat straw in feed block, without any adverse effect on the growth of crossbred calves (Singhal, 2009). A number of trials have also been conducted in the arid regions of India, especially in Rajasthan, where the forage part of the block constituted tree leaves or gram (*Cicer arietinum*) straw (Jakhmola, 2005). Singh, Lohan and Rathee (1998) used dried berseem as a part replacement for wheat straw in the diet of buffalo calves. Nagpal, *et al.*, (2005) used gram straw as a part replacement for wheat straw for crossbred calves, while Nagpal and Arora (2002) successfully used groundnut haulms as part of the roughage in the feed block.

Concentrate part : The second major component of the DCFBs is the concentrate part. The proportion of the straw and concentrate in the block varies with the type of animal to which it is to be fed. As a survival ration for use during natural calamities and disasters, the straw component could be very high. To meet the challenges during emergency situations, straw blocks have generally the following composition: 86 parts straw, 10 parts molasses, 2 parts mineral mixture, 1 part urea and 1 part salt, which could meet the maintenance requirement of the animals. The proportion of straw for animals yielding up to 5–10 kg milk per day should be reduced to 60%, for 10–15 kg milk per day, up to 50% and for 15–20 kg milk per day, up to 40% (FAO, 2012).

A similar kind of range has to be maintained in the crude protein (CP) content of the block, varying from 7–14%, and in the total digestible nutrients (TDN) content varying from 45–65%. A superior quality block of 14 kg has sufficient nutrients for the production of 20 kg of milk per day. Since buffaloes are heavier in weight and their milk having a higher fat content, a 15 kg block of the similar composition is suggested for buffaloes with respect to above three categories. The ingredients of the concentrate mixture are: oil cakes/meals as protein source; molasses, grains, grain by-products as energy sources; and supplements such as bypass protein or bypass fat. Bypass nutrients can be added for the higher yielders to enhance the direct supply of amino acids and fatty acids to the host animal as concentrated protein and energy sources respectively (FAO, 2012).

Micronutrients and feed additives : The third component provides strategic and catalytic supplements, such as micronutrients and other feed additives, for example vitamins, minerals, bentonite (binder), probiotics, enzymes, antioxidants, immune-protective agents, antitoxins and herbal extracts, among others. The varied role of these components in the feed block is to increase the productive and reproductive efficiency of the animal, enhance its immuno-protective ability, reduce helminthic load and decrease ruminal methanogenesis (FAO, 2012).

The steps in the process of making densified complete feed blocks include the formulation of total ration, grinding of concentrate, mixing of the ingredients and addition of the feed additives. This is then followed by mixing of these ingredients and straw in proper proportions along with addition of molasses or other binders. Finally, the weighed quantity of the mixed stuff is transferred into a hydraulic press to get the densified complete feed blocks. Formulation of feed block should consider several aspects. A complete feed block should provide all the nutrients required by the animal. The composition of feed block depends upon the production objectives (maintenance or production) and availability of local feed ingredients. Feed block should include combination of feed ingredients which will provide all the nutrients in appropriate proportion. Local and cheap agro-industrial byproducts should be used to economize feed block. Poor quality roughages like cereal straws, dried tree leaves and dead litter from the forest after mixing with other feed ingredients and /or after treatment may be used to prepare the complete feed blocks. Common salt and mineral supplements should also be mixed to fulfill animal's requirement (FAO, 2012).

Mixing of ingredients is important. The sequence of ingredients mixing depends on their nature. For molasses-urea feed blocks, straw should be treated with molasses first, then successively urea, salt, minerals, cement or quicklime and bran. Hardness of the block is also important to increase the durability of the block. Different binders like cement, lime, molasses, bentonite etc. have been used to make hard blocks. Hardness is assessed by pressing with the thumb in middle of the block. A block is considered soft, medium or good when the thumb penetrates easily, very little or only with great pressure, respectively. Nutritive value of a complete feed block depends on nature and proportions of feed ingredients used. These blocks can be efficiently used during feed scarcity/draughts or during normal feeding. Composition of feed block could be changed according to local conditions and requirement and production of the animal. In future, densified complete feed block will be most important method to provide complete and balanced feed to the animals (FAO, 2012).

Formula of densified complete feed blocks :

1

Ingredients	Per 100 Kg
Cereal	25 %
Wheat or rice bran	37 %
Oil cake	35 %
Mineral mixture	02 %
Salt	01 %
Total	100

2

Ingredients	Per 100 Kg
Mustard cake	25 %
Barley grain	10 %
Leucaena leaf meal	20 %
Wheat bran	32 %
Urea	01 %
Molasses	10 %
Mineral mixture	01 %
Common salt	01 %
Total	100

Use of densified complete feed block : Complete feed block may be used in dry season or winter season to ruminants when their diet is high in fibre. The use of block in wet season may not advantage digestion of ruminants as green forage during this period is relatively high in nitrogen and low in fibre. Precaution should be taken to introduce the block gradually in the diet of ruminants during a transition period of 2 weeks to enable the animals to adapt to this new supplement. This is particularly important when animals have suffered a degree of underfeeding as intake can be more rapid than usual. The best way to restrict intake during the adaptation period is to control the time of feeding. Urea containing feed blocks should not be given to monogastric species or to pre-ruminants calves, young kids and lambs (less than three months of age) as these animals can't use efficiently ammonia generated from urea, therefore their intoxication would occur. Hard block should never broken into small pieces or sprinkled with water before distribution to animals otherwise large amount of blocks thus excessive amount of urea may be consumed by the animals (Salem and Nefzaoui, 2003).

Advantages of the densified complete feed block technology: The densified complete feed block technology offers a variety of benefits to the farmers and the feed manufacturers (Walli, 2011; FAO, 2012). Major advantages of complete feed block are as follows:

Provide a balanced ration to ruminants: Most of the farmers of developing countries are unable to compute a balanced feed for the animal. The densified complete feed block technology is a complete balanced feed which provide balance concentrate and roughage ratio and adequate intake of nutrients. Feeding an animal a balanced ration will improve nutrient supply and their utilization, leading to improved animal productive and reproductive performances.

Densified feed blocks require lesser storage space: The process of densification increases the bulk density of the straw based feed by three times times, and at the same time it reduces its volume by the same proportion. Accordingly, lesser storage space is required to store the bulky feed, especially straw. The farmer could use the saved space for other farm activities.

Densified feed blocks are trouble free and easier to transport: Since the feed blocks occupy approximately one third lesser space and volume than the original components in the uncompressed state, more feed (by weight) can be accommodated and transported within the same space. This makes the transportation of feed block much easier and cheaper than the straw.

Less feed wastage: There are some unpalatable feed ingredients which are otherwise safe, but not consumed by the animals. While feeding densified feed block, the animal is given less opportunity to select feed components, which is helpful in feeding balanced ration to livestock. This reduces the feed wastage and thus, is an efficient delivery system of supplying feed nutrients to the animal, which in itself is economically advantageous to the farmer.

Reduce pollution: In many part of the world, straw is also burnt in the field after harvesting of the grains. If the residual straw left in the field is mechanically collected and converted into densified forage or feed blocks, not only this valuable feed resource could be effectively used, but the emission of green house gases, caused by burning of straw could also be avoided. In addition, the high temperature generated during the burning of straw kills the soil microorganisms, affecting adversely the soil fertility. Also there is less dust pollution when the feed is transported as blocks rather than as loose straw.

Improved productive and reproductive performance: Feeding of densified complete feed blocks has a positive effect on production as well as reproduction of the animals. Densified feed blocks improve dry matter intake and nutrient utilization in livestock. Verma *et. al.*, (1996), feeding compressed complete feed blocks to murrah buffaloes resulted in higher intake of dry matter, digestible dry matter and all other nutrients than feeding the diet in mash form, over and above DCFB also resulted in a higher retention of calcium and phosphorus.

It was observed that the growth rate of calves could increase by 25–35%, while the milk yield could increase by 15–20% (Walli, 2009). There could also be some increase in fat content of milk. After feeding densified complete feed blocks, the milk yield of the animal persists at a higher level over a longer period, resulting in increase in total lactation yield. This may be explained by the fact that the feeding of straw based complete feed blocks eliminates any day to day dietary fluctuations thus providing the rumen microbes a constant supply of the same type of feed/substrates, bringing stability in the rumen environment and making ruminant system overall more efficient.

Because of the faster growth rate, feeding of densified complete feed blocks could result in early maturity and early age at first calving for the animals. The age of heifers at first calving may decrease by about 4–6 months (Walli, 2009), which is a distinct advantage for lowering the cost of rearing animals. As a result of these positive changes, overall reproductive efficiency of the animal also increases. Apart from optimum supply of energy and protein through complete feed block, the animals get proper amount of minerals and vitamins as per their requirement, which enhances reproductive efficiency. The occurrence of reproductive problems such as late maturity, anestrous and repeat breeding condition can also be reduced in animals, which are fed densified complete feed blocks.

Better health status of animal: The optimum supply of nutrients and micro-nutrients through densified complete blocks also has a positive impact on the maintenance of good animal health. The feeding of the blocks provides immunoprotection against infectious diseases and also decreases the occurrence of nutritional deficiency disease as well as metabolic and reproductive disorders.

Development of Feed Banks as predisaster management measure: With the advent of feed block technology, it is possible to set up feed banks nearer to feed deficit areas. Because of easy handling, transportation and storage of the straw based feed blocks, the technology could improve preparedness against natural calamities, and save animals from hunger and death during disaster. The blocks can even be air lifted to the remotest places to avert disasters.

Blocks as a vehicle for medicine or neutraceutical administration: Densified complete blocks may be used as a carrier of several chemicals and prophylactic medicines. There is substantial room for improving the quality of straw based complete feed blocks. Different supplements, newer feed additives, neutraceuticals, anthelminths and herbal extracts may be added in the Densified complete feed blocks to improve their overall nutritional quality.

Better utilization of non-conventional feed ingredients: Unconventional feed ingredients can be incorporated in the densified complete feed blocks. Increased use of un-conventional feedstuffs, thereby feeding cost would be alleviated. Studies have shown that sugarcane bagasse can be used economically as an alternative source of forage to replace 30% of wheat straw in feed block, without any adverse effect on the growth of crossbred calves (Singhal, 2009).

Jakhmola (2005) used tree leaves or gram (Cicer arietinum) straw to as source of the forage in densified complete feed block. Singh *et al.*, (1998) used dried berseem as a partial replacement of wheat straw in the diet of buffalo calves. While Nagpal, *et al*. (2005) used gram straw as a part replacement for wheat straw for crossbred calves, where as Nagpal and Arora (2002) successfully used groundnut haulms as part of the roughage in the feed block. Thus, densified complete feed block is an important strategy for efficient utilization of agro-industrial by- products for economic and sustainable livestock production.

Economic livestock production: The benefit provided by DCFB are easier and lesser storage as well as efficient and trouble free transport of roughage makes the DCFB possible to supply uniform quality of the feed throughout the year, with lesser price fluctuation, as against the large price fluctuation and irregular supply of straw and other feed ingredients in different seasons. Densified complete feed blocks ensures optimum roughage and concentrate ratio, proper supply of nutrients and maximum utilization of nutrients leading to better performance of the animals, which ultimately bring better returns to the farmer.

Thus, the densified compete feed block is an innovative technology, which could play an important role in feeding the balanced rations to ruminant for sustainable livestock production. The technology also has the potential to remove regional disparity in feed availability, as the units can be set up to act as 'Feed or Fodder Banks'. This technology is very much helpful in areas that face an acute shortage of feed or fodder particularly during natural calamites like draught and flood situations.

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