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Prospects of compressed complete feed blocks as ruminant feed for sustainable livestock production: A review

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Abstract
Effective utilization of available feed resources is the key for economical livestock rearing. Complete feed system is one of the latest developments to exploit the potential of animal feed resources in the best possible way. The concept of feeding complete rations comprising of fibrous crop residues to dairy animals are popular among farmers. The role of complete ration is to provide a blend of the feed ingredients including roughages without giving any choice to the animal for selection of specific ingredient. Complete feed blocks are solidified high density blocks comprising forage, concentrate and other supplementary nutrients in the desired proportion capable to fulfill nutrient requirements of animals. The technology also has the potential to provide complete feed to livestock under emergency Situations created by natural calamities. Production of these types of feeds are very much important for enhancing the productivity of animals and for making use of the available low cost feed material.

Keywords: Compressed complete feed block, ruminants, concept, performance

1. Introduction
Complete feed block is defined as a solid product containing roughage and concentrate in desired proportion capable to fulfil nutrient requirements for the targeted production purpose. They are considered as a catalyst supplement, allowing a fractionated, synchronized and balanced supply of the main nutrients i.e. energy, nitrogen, minerals and vitamins for animals. It is often reported [2] that feed block utilisation in livestock feeding was initiated since the early 1980s. The available feed resources are often low in energy and digestible proteins, and fail in most cases to cover livestock maintenance requirements. They can be better used by the animal if the rumen ecosystem for fermentative digestion can be balanced by supplying deficient nutrients mainly energy and nitrogen [3].

Although complete feed blocks are not new concept, but livestock production in the low rainfall and drought prone areas has revived interest in feed blocks technology as an option to improve animal performance and reduce their feeding cost. The complete feed blocks can be formulated by using straws and diet supplements such as molasses, concentrates, minerals and salt. Such feed blocks can be stored over a long period of time and transported economically over long distances. Complete feed blocks are based on locally available roughages, which are suitable for ruminants and can be useful in maintaining sheep productivity under stall feeding [4]. Complete feed is comprised of forage, concentrate and other supplementary nutrients in the desired proportion capable to fulfil nutrient requirements of animals. The feeding of complete feed stabilises rumen fermentation, minimises fermentation loss and ensures better ammonia utilisation [5]. To obtain improved microbial efficiency from crop residues, the feeding of compressed complete feed-blocks has been recommended by [6-9] have proved the success of complete feed-block feeding in sheep. Complete feed-blocks were also used for strategic prophylactic treatment against nematodes [10] and for the supplementation of deficient nutrients, especially in the extensive systems of sheep and goat production where there is little control over animals. During the last decade, efforts were made to change from the traditional extensive animal farming to an intensive system. Many authors recommended giving feed blocks in dry seasons to ruminants on poor quality fibrous feeds (e.g. straws, low quality hays, stubble, etc.).

2. Advantages of feeding feed blocks

- Simple and efficient technique for long term conservation of crop residues which are available abundantly in one season and scarce in another season.
- Easy to transport and feeding to stall-fed and free grazing animals.
- Reduces use of conventional concentrate feeds, thereby feeding cost would be alleviated.
- Allows a synchronous and fractionated supply of essential nutrients for ruminants fed on low quality roughages.
- Environment pollution may be reduced, because farmers do not have sufficient time between harvesting of matured crop and sowing of next seasonal crop. As a result, crop residues suitable for feeding are being burnt in the field *per se*. The burning of crop residues pollutes the environment.
- Intake of the nutrients is increased in block form of complete diet.

2.1 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.

2.2 Blocks as a vehicle for medicine or nutraceutical 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, nutraceuticals, anthelmintics and herbal extracts may be added in the Densified complete feed blocks to improve their overall nutritional quality.

3. Nutritive value of feed blocks

Feed block formulation depends especially on farmer's objective, animal species and their physiological state for which these supplements are given. Therefore, numerous formulae of feed blocks have been developed. Ingredient nature and proportion in feed blocks are the main factors influencing nutrient content of these supplements and their intake and digestion by ruminant animal and performance would depend also on their degree of hardness. Urea had been included in block formula as a source of non-protein nitrogen and also as a preserver. Recently, [11] included wasted cactus fruit in olive cake-based blocks and noted that the amount of this block consumed by goats although low (less than 150 g DM per head per day) was sufficient to increase the nutritive value of kermes oak foliage-based diet. Date palm by-products have also been used with success as an energy-rich ingredient in blocks given to sheep and goats containing grass hay by [12]. Groundnut straw based complete feed blocks can efficiently be utilised by the sheep [13]. They also reported improved rumen fermentation through yeast supplementation due to stabilised rumen pH, decreased concentrations of lactic acid, ammonia nitrogen, NPN and increased TVFA, total protozoal counts, total nitrogen and TCA precipitable nitrogen.

4. Performance of animals fed on complete feed blocks

4.1 Dry matter intake

Increased DM intake from complete feed block than conventional method of feeding the buffaloes was reported by [14-16] also reported increased intake of DM from dry roughages in the complete feed block than conventional method of feeding. [17] reported that dry matter intake in terms of kg per day, per cent body weight or g per kg $W^{0.75}$ was higher in sheep fed on complete feed block. [18,19] also reported higher DM intake in camel calves. [20] reported that dry matter intake (kg (%) body weight) was significantly higher in complete feed blocks due to increase in nutrient density in block form diets, but this does not affect the digestibility coefficient in various nutrients among different groups. They concluded that complete diets in the form of blocks enhanced the dry matter intake by 14-19% in crossbred heifers [21] in Murrah buffaloes reported that the block form of the diet, which had a mean bulk density 3.60 times greater than its mash form of diet and this higher bulk density resulted in a higher voluntary intake ($P< 0.05$) of DM, contrary to [22] who reported no difference in DMI in Barbari goats fed on complete feed blocks. Similar findings were observed by [6, 23]. DMI was 2.29 and 3.02 kg/d in mash fed complete feed and complete feed block fed crossbred calves, respectively exhibiting about significantly (30%) higher ($P<0.005$) DMI [24]. Conversely, [16] did not find any significant effect on dry matter intake in buffaloes fed chemically treated or untreated wheat straw based complete feed block. In agreement of this [25] observed that the intake of dry matter did not differ significantly ($P<0.05$) among the dietary treatments fed with compressed complete feed block containing deoiled mahua seed cake.

4.2 Utilization of nutrients

Processing of the complete feeds has been reported to improve the nutrient utilization in ruminant animals. Incorporation of crop residues as a roughage source in TMR for ruminants and their further processing (densification/pelleting) is one of the practical ways of improving their utilization. The physical form of the diet can affect the potential rate of consumption with densified/pelletized diets ingested more rapidly than those in mash form. In an experiment carried out by [17] on Corriedale lambs, significant ($P<0.05$) improvement in feed conversion efficiency with marked reduction in cost of production by feeding complete feed block has been reported, while DM/nutrient intake and digestibility of DM/gross nutrients, nutritive value and retention of major minerals did not change between the groups [25]. Reported that the intake and digestibility coefficients of various nutrients *viz*. CP, EE, NDF and ADF were comparable between the dietary treatments fed with compressed complete feed block containing deoiled mahua seed cake. The mean body weights (Kg) as well as mean metabolic body weights ($kgW^{0.75}$) of animals in the two groups were also statistically similar during the experimental period. Similarly, digestibility of DM, CF and EE did not differ significantly among complete block feeding and conventional feeding in buffaloes [14]. However, CP and NFE digestibility was higher in the buffaloes fed on complete feed block. Physical form of complete feed did not reveal any significant effect on the digestibility of dry matter and gross nutrients between the groups, although there were improvements in nutrient digestibility in sheep due to densification of the complete feed [17, 16, 22, 26] also reported the similar results in growing buffaloes, Barbari goats and Magra lambs respectively. DCP and TDN intake in block fed group were not significantly

higher than those fed mash feed [18, 19] in sheep and camel calves, respectively. [16, 22] reported similar results in growing buffaloes and crossbred cows respectively, while [26] reported significantly higher intake of DCP and TDN in sheep fed complete feed blocks [17]. Also concluded that densification of feed into blocks improved daily live weight gain, efficiency of feed utilization and cost of production in hoggets [22]. Reported that digestibility coefficients of various nutrients DM, OM, CP, CF and NFE also did not differ significantly among the mash fed and complete feed block fed barbari goats [21]. Also did not notice significant differences in digestibility of various nutrients in Murrah buffaloes. Similar results were reported by [27] in growing buffalo calves.

4.3 Nitrogen utilisation

Among rumen metabolites ammonia nitrogen was significantly (P<0.05) lower in block fed calves than mash fed calves [20]. They attributed this to proportionate intake of roughage and concentrate. They concluded that feeding of complete feed block is able to substantially reduce ammonia-nitrogen concentration in the rumen ecosystem which in turn protects the body system from excess load of ammonia which has to be recycled [17]. Reported that nitrogen retention was higher in block fed group than mash fed group, while percentage of intake and absorbed nitrogen were similar among the groups. Similar findings were also reported by [26, 22]. Reported that ammonia nitrogen was higher in mash-fed goats than in the block-fed goats. This indicated that the feeding of the complete diet in the form of blocks can slow down the production of ammonia nitrogen in the rumen and thus, prevent the body system from the burden of recycling of excess ammonia. This further strengthens the hypothesis that the block form of a complete diet can substantially protect valuable protein sources from the degradation into NPN compounds inside the rumen ecosystem. For normal microbial activity 5–7 mg NH_3 N/100 ml rumen liquor is required although latter experiments showed that 15–20 mg/100 ml rumen liquor is required for maximum nutrient utilisation [28].

4.4 Live weight gain

Feeding of ruminants with crop residues-based compressed complete feed blocks appears to be the promising feeding system for improving their productivity in agricultural countries like India. Complete feed system improves nutrient utilization that supports higher growth performance and reduces the cost/ kg live weight gain, thus is economical in comparison to conventional feeding system. Several studies have observed the beneficial effect of feeding complete ration on the growth performance of animals.

Complete feed blocks ensured significant (P<0.05) higher live weight gain in crossbred calves fed on complete feed block than the mash fed calves [24]. About 35% higher live weight was noticed in block form of complete diet than mash form [29]. reported higher (P<0.01) ADG and nutrient utilization efficiency in Deccani lambs fed ground paddy straw-based complete diets compared to those fed conventional diet. Similarly [30], reported that complete feed offered to Avikalin lambs under stall feeding system appeared superior to grazing plus supplementation system in terms of intake and animal performance [27] also noticed significantly (P<0.05) higher live weight gain in growing buffalo calves fed on complete feed blocks. This might be due to the higher nutrient intake coupled with the proportionate intake of roughage and concentrate, which ensured an optimum rumen environment for microbial protein synthesis. In another study, [31] observed that supplementation of complete feed in block form to grazing ewes during feed scarcity in semi-arid region helped in sustaining their BWs due to better nutrient availability compared to un supplemented ewes maintained on sole grazing that lost 1.52 kg BW. Similarly Poor quality crop residues like groundnut haulms and red gram bhusa inclusion into complete feeds have also been reported to enhance intake without affecting digestibility, which resulted in improved growth performance and feed conversion efficiency in bucks [32]. However [33], reported no significant difference in ADG (509, 556 and 496 g/day) of crossbred calves fed either wheat straw *ad libitum* and concentrate mixture separately in conventional form or the wheat straw-based complete feed in mash and block form, although the calves fed complete mash feed gained higher BW than calves in other dietary treatment groups.

Inclusion of nutritious non-conventional but safe feed resources in concentrate or roughage component of the complete feed has proved to be beneficial for promoting the growth performance of ruminants [34]. Reported that arhar straw-based complete pellet ration could be fed to goats for optimum weight gain under intensive system of management. Similarly, tapioca leaves and tea waste (45:15) could be incorporated in complete pellet ration for growing kids with no significant effect on average weight gain and feed and protein conversion efficiencies compared to those fed guinea grass-based pellet ration as control [35]. In agreement of this, we [25] have also observed that the fortnightly body weight gain (kg) of both the groups was comparable during feeding trial. The overall average daily gain (g) was statistically non significant (P>0.05) between the groups. The ADG was better in treatment group where animals fed with CCFB containing deoiled mahua seed. This may be due to reduced amount of energy lost as methane which, otherwise might have lost and might have contributed to better ADG. The overall FCE of both the groups was statistically (P>0.05) similar during experimental period.

4.5 Microbial population

The total bacterial population did not differ significantly among the groups fed on mash diet and complete feed block based diet [22]. They reported rumen anaerobic fungal population was slightly higher in block-fed goats than in mash-fed animals. This might be due to the faster consumption of concentrate in mash fed, which in turn reduces the fungal population. Fibrous diets are reported to ensure higher fungal populations in cattle and buffaloes [36]. They also reported lower pH (6.68-6.71) in the mash-fed animals than animals fed on complete feed blocks. The lower pH in mash fed was due to the rapid consumption of concentrate from the mash form of the complete diet where as higher pH (6.83) was mainly due to the proportionate intake of grass and concentrate from the block form of the complete diet. They reported total VFA concentration in the rumen was almost identical (10.10–11.60 meq. /dl SRL) in all the groups of animals. Average anaerobic bacterial population was 6.78×10^9 and 9.31×10^9in groups fed on mash form and block form of complete diets respectively [24, 20] also recorded similar observations in crossbred calves by feeding a complete diet in mash and block form. Anaerobic rumen fungal population (number/ml) 8.52×10^3 and 15.25×10^3 was reported by [24] in crossbred calves fed on mash form and the feed block form of complete diets, respectively. Higher

rumen fungal population lowers protozoal population and lower protozoan population in complete feed block fed calves was due to proportionate intake of roughage and concentrate.

4.6 Improved productive and reproductive performance

Feeding of compressed complete feed blocks has a positive effect on production potential as well as reproduction status of the animals. Compressed complete feed blocks improve dry matter intake and nutrient utilization in livestock, which will reflect in high productivity and sustained reproduction status of animals. It was reported that the growth rate of calves could increase by 25–35%, while the milk yield could increase by 15–20% [37]. There could also be some increase in fat content of milk. After feeding compressed 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 [37], 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 compressed complete feed blocks (CCFB).

4.7 Blood profile

Dietary treatments did not influence the concentration of blood glucose, plasma urea-N and protein [22], when they were given different feed treatments as complete feed block and as separate constituents in barbari goats. Plasma urea-N reflects the dietary CP intake, the ratio of dietary CP to ruminally fermentable OM and also serves as an indicator of ruminal protein supply. Similar plasma urea-N and protein in the their study among treatment groups indicated that protein utilisation was not disturbed due to the replacement of mustard cake protein with LLM and complete feed block did not have adverse effect on blood profile [24]. Also noticed similar results when they fed crossbred calves with mash form of complete feed and compressed complete feed blocks.

5. Conclusion

Compressed Complete Feed Block (CCFB) technology provides scope for incorporation of deficient nutrients, use of unconventional and agro-industrial by products for optimum livestock production and also provides cheaper transportation cost of bulky materials from surplus to scarcity areas. It 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 compressed 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 the 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.

6. Authors' Contributions

This review is a part of MVSc thesis of the first author, who carried out the research under the supervision of second author. All authors have read and approved the final version of the manuscript.

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