FEED PRODUCTION TECHNOLOGIES FOR SUSTAINABLE LIVESTOCK PRODUCTION IN ARID AREAS

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Published by

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Editorial Committee : M.P. Singh, R.S. Tripathi, B.K. Mathur, M.P. Rajora and S. Roy

Citation: Bohra, H.C., Patel, A.K., Rohilla, P.P. Mathur, B.K., Patil, N.V. and Misra, A.K. 2012. Feed Production Technologies for Sustainable Livestock Production in Arid Areas. Central Arid Zone Research Institute, Jodhpur, India, 38 p.

September 2012

DTP : S.B. Sharma & Harish Purohit

Printed at : Evergreen Printers, Jodhpur

केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद्)
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FOREWORD

Hot arid region is characterized by scanty and erratic rainfall, high temperatures and wind speed causing high evapo-transpiration. Extremes of aridity, frequent droughts and low biomass producing conditions, triggered by climatic change pose serious challange to survival of animals in arid agro-eco system. Despite the harsh environment, livestock farming is the major economic activity contributing substantially to the farmers' income in arid and semi-arid region. With 56.66 million heads of livestock, Rajasthan ranks third in India's animal wealth. Besides milk, the state is one of the principal suppliers of wool, meat and eggs to the adjoining states. Since more than 51% of the livestock of the state is concentrated in the arid areas of western Rajasthan, it is logical to conclude that arid districts provide major share of livestock production. The average animal productivity is low in this region primarily due to scarcity of fodder and other critical nutrients, which are required for maintenance of normal physiological functions, production and reproduction of the animals.

Most of the livestock population in arid region is range managed. Except during monsoon period, the availability of good quality fodder is scarce and animals primarily depend on dry grasses and crop residues, which are very low in essential nutrients. The problem of mineral deficiency is further aggravated due to high calcium and very low phosphorus content. Calcium-phosphorus imbalance adversely affects the availability of calcium as well as phosphorus. The situation is further aggravated during drought years when the crop residues are imported from the neighbouring states. To address feed and fodder scarcity, Central Arid Zone Research Institute (CAZRI), Jodhpur has developed and evaluated appropriate formulations and technologies for production of multi-nutrient feed blocks, multi-nutrient mixture, complete and supplemental fodder blocks using locally available feed resources. The feed block and nutrient mixture supplementation in the animals increased feed and water intakes, regulated rumination, corrected pica, regularized the breeding cycles and improved fertility. The use of complete feed blocks in the lactating cows was found to reduce the cost of milk production compared to conventional feeding system. Supplementation of feed blocks and nutrient mixture increased daily milk yield (20-25%) in cattle and buffaloes maintained under grazing conditions. All these products were accepted at farmer's level. I hope that these process technologies will not only augment livestock productivity in the arid region, but also generate employment in the rural sector.

I am delighted to see this technical bulletin on "Feed Production Technologies for Sustainable Livestock Production in Arid Areas" by Dr. H. C. Bohra and his co-workers. There have been relatively few complete and analytical manuals of such type on technology. Thanks to the sincere efforts of the scientists who have brought their years of experience in giving shape to this bulletin. I hope with this bulletin, researchers, development professionals, field veterinarians, feed manufacturers as well as enterprising livestock farmers will get to share the extensive and deep insights of the process of making such blocks which will builds tomorrow's economy of farmer of arid zone.

Date: September 17, 2012

(M. M. Roy)

PREFACE

This bulletin on production of animal feed products for the livestock of arid areas is an outcome of the multi-location trials carried out under an institutional research project, "Evaluation of Multi-nutrient Feed Block Formulations to Augment Livestock Production in the Arid Zone". The project was initiated in the year 1998 for six years, however, it continued in the production mode for quite a long time. Initially aimed to develop simple and appropriate technology for production of multi-nutrient feed blocks using locally available feed resources and simple gadgets, fabricated by the local artisans but in due course of time, this technology was used for production of multi-nutrient mixtures for browsers, complete and supplemental-feed blocks, Lucerne meal block, mineral licks and total mixed ration for individual and community livestock. Besides this, appropriate process technology for milling of *Prosopis juliflora* pods for production of value added feed products were also developed. The feed products and their production technologies were thoroughly tested at experimental livestock farms and at farmers' fields under various programmes such as NATP's Institute Village Linkage Programme, Farmers' Participatory Action Research Programme (Ministry of Water Resources, Govt. of India), and presently these are being evaluated under Livestock Centric Intervention for Livelihood Improvement in Nagaur District (National Rainfed Area Authority, Planning Commission, Govt. of India) and ICAR funded "National Initiative on Climate Resilient Agriculture" under its technology demonstration component. For regional testing these products were evaluated on Rathi cattle at RRS, CAZRI, Bikaner, Deoni cattle at Veterinary college, Udgir, Maharastra and on farmers' cattle in Ratlam district of Madhya Pradesh. These trials have helped us immensely in improving and developing most appropriate formulations and technologies for production of various feed products described in the bulletin.

CAZRI's feed block production technology is unique as it uses organic binder, whereas, inorganic binders are being used in other places in India and abroad for making blocks. Instead of the common practice of using chemical drying process the baking process in block making is used to avoid ingredient losses due to lump formation. These technologies are now quite popular among the farmers of Pali and Jodhpur districts, who have adopted it to improve their livelihood after receiving proper training and have started producing feed-block and nutrient-mixture on commercial basis and also for feeding their own livestock. Recently, an NGO of Nagaur district has initiated the production of multi-nutrient mixture for livestock.

In view of popularity of these technologies, farmers who wish to prepare various feed products at their own farm using local resources, this bulletin will serve as a practical manual for the farmers and entrepreneurs for their own benefit to feed the animals or for production and sale of feed products in local market.

The authors are grateful to Dr. M. M. Roy, Director, Central Arid Zone Research Institute, Jodhpur for his guidance, encouragement and for providing all necessary help, facilities and support for infrastructure development at the feed-technology unit. Our sincere thanks are also due to our former Directors, Dr. A. S. Faroda, Dr. Pratap Narain and Dr. K. P. R. Vittal who permitted us to take up the project and provided all necessary facilities and encouragement for continuing the research and evaluation of feed products. We are grateful to Dr. Arun Kumar, Dr. M. P. Singh, and Dr. Nisha Patel for reading and commenting on the manuscript for improvement of this bulletin. We also thank Dr. B. C. Mondal, former, Scientist at RRS, CAZRI, Bikaner, Dr. V. M. Salunke of College of Veterinary and Animal Sciences, Udgir, Latur, Maharastra and Dr. A. K. Srivastava of K. V. K., Kalukeda, Ratlam, Madya Pradash, for conducting feeding trials of CAZRI's feed-blocks at their respective stations. Our technical and supporting staff Sarv Shri Pushkar Singh, Devraj, Shankerlal, Hanuman Ram and Mala Ram, deserve our special thanks for all technical help in conducting trials at CAZRI and Sardar Surender Singh of Matharu Engg. Works, Jodhpur for fabricating simple but sturdy, prototype of feed block production machine as conceived by us. We thank all those who directly or indirectly assisted us in conducting the study and bringing out the bulletin. Finally, we would like to thank the publisher for bringing out the bulletin in the stipulated time.

We hope that this manual will be useful for researchers, feed manufacturers, field veterinarians, extension workers, NGOs, innovative farmers and livestock owners who want to adopt these feed-production technologies for employment generation and augmenting livestock productivity in the arid areas.

Date: September 17, 2012 **Authors**

CONTENTS

Introduction

Arid regions cover about 12% geographical area of India spread over 31.7 m ha hot and 7.0 m ha in cold arid region. Nearly 90% of hot arid regions are located in north-western states of Rajasthan (19.6 m ha), Gujarat (6.22 m ha), and Haryana and Punjab (2.75 m ha) with small pockets of 3.13 m ha in Andhra Pradesh and Karnataka. Entire cold arid region is spread in northern states of Jammu and Kashmir and Himachal Pradesh. Hot arid region is characterized by scanty and erratic annual rainfall (<400 mm), high temperatures and strong wind causing high evapo-transpiration (<2000 mm), extremes of aridity and low biomass producing conditions particularly on sandy terrain, low in organic carbon and water holding capacity. In addition, frequent droughts and extreme events triggered by climatic change may pose serious threat to survival in rain fed tropical regions. Demographical pressure of humans (130 persons km^{-2}) and animals (139 heads km^{-2}), developmental activities, paradigm shift to intensive cultivation, over emphasis on production and disregard to conservation of traditional wisdom are resulting in over exploitation and degradation of fragile natural resource base.

Rajasthan state covers 3.42 lakh km^{-2} area, which represents 10.4% of total geographical area of the country. Annual rainfall in the state varies from 100-120 mm in Jaisalmer district to about 1000 mm in some parts of Chittorgarh, Jhalawar and Kota districts. More than 70% of rural population of the state depends upon agriculture and allied activities. Agriculture is risky, due to erratic and low rainfall, especially in arid region and thus animal farming is a major occupation for the livelihood of the rural people. A study conducted by the National Council of Applied Economic Research reported that revenue from milk sale alone accounted for 22% of the family income in the state, and the state contributes 10% of the total milk production in the country. The livestock sector is more labour intensive than crop production and accounts for a major share in rural employment with 4.5% annual growth as compared to 1.75% for all sectors and 1.1% for agriculture. According to State Livestock Policy Document (Anonymous, 2011), the contribution of animal husbandry sector to the GDP of the Rajasthan state has been estimated as 9.16%. About 35% of the income to small and marginal farmers comes from dairy and animal husbandry. In arid areas, the contribution of livestock is as high as 50%. This sector has potential to create employment in rural areas with less investments as compared to other sectors. The importance of the livestock sector, especially in the arid areas, can easily be appreciated from the data on annual employment generation provided by Kalla and Goyal (1986) who estimated that cropping activities provided only 96 standard days $year^{-1} household^{-1}$, while livestock rearing accounted for nearly 300 standard days $year^{-1} household^{-1}$.

Despite the harsh environment, livestock farming is the major economic activity contributing substantially (up to two third of the total earning) to the farmers' income in the arid areas. Although the per unit productivity of livestock in these areas is lower than in the irrigated and rainfed areas, there is inherent potential for drought/heat resistance in the desert livestock. This area provides sturdy draught animals too. A list of important livestock breeds reared in the cold and hot arid areas of our country has been presented in Table 1. The important dairy cattle breeds of Rajasthan desert are *Tharparkar and Rathi*; *Nagori* is the draft breed, and *Kankrej* is the dual purpose cattle breed; buffaloes are mostly of graded-*Murrah* and *Mehsana* breeds. Six distinct sheep breeds viz., *Marwari*, *Magra*, *Nali*, *Pungal, Jaisalmeri* and *Chokla,* four goat breeds viz. *Marwari, Parbatsari and Jhakarana* are native to this region. The goats are primarily used for meat, which is preferred in the greater part of the country, although both *Parbatsari* and *Jhakarana* breeds are known for their reasonably good milk yielding capacity. Apart from this, arid zone is also the home land of world renowned *Malani* breed of horse.

Table 1. Important Livestock Breeds of Indian Arid Zone*

Area	Cattle	Buffalo	Sheep	Goats	Camel	Horse
Hot arid	Tharparkar, Kankrej, Nagori, Rathi (all belong to *Bos indicus* species)	Graded-Murrah, Surti, Mehsana	Marwari, Magra, Nali, Jaisalmeri, Pugal, Chokla, Kheri, Patanwadi	Marwari (Barmeri), Parbatsari, Jhakarana, Kachchhi,	Bikaneri, Jaisalmeri, Kachchhi	Marwari (Malani) Kathiawadi
Cold arid	Yak (*Bos grunniens*), Yakow: *dzo* (male) and *dzomo* (female), crosses of Yak with local Cattle/ Jersey		Malluk, Merino-Malluk hybrids, Changthangi (local name, Changluk), Purik	Chegu, Changthangi (reared for valuable *Pashmina* wool)	Asiatic double-humped camel	Zanskari, Sipti

*Adopted from Punia, 2009; Farooq, M., Director, Animal Husbandry, J & K (personal communication).

According to livestock census (2007) arid Rajasthan harbours 29.11 million animal heads comprising 17.35% cattle, 11.85% buffaloes, 28.96% sheep, 40.19% goats and 1.20% camels, the remaining being mainly equines (Table 2). More than half (51.4%) of total livestock population of Rajasthan inhabits the 12 arid district of the state. This area has recorded 117.20% increase in the livestock numbers within a span of 51 years (1956-2007) implying the region had 117.20% more livestock to be fed in 2007 than in 1956. For last 51 years cattle registered the lowest growth rate (28.9%), whereas, very high growth rates have been registered in sheep (77.5%), goat (234.9%) and buffaloes (347.0%). There are 107 heads of livestock per 100 persons in the arid zone, as against 66 in Rajasthan state and 83 in the whole country. The per capita availability of milk in Rajasthan is 252 g against 112 g in the country. The average wool output per sheep from the desert districts, Rajasthan state and the country is 1.56, 1.30 and 0.88 kg $year^{-1}$, respectively.

Table 2. Livestock Population: Arid and Non-arid Districts of Rajasthan State (in millions)

Region	1956	1961	1966	1972	1977	1983	1988	1992	1997	2003	2007	% change over 51 years
I. Cattle												
Arid	3.92	4.38	4.69	3.48	4.03	4.57	3.39	3.91	4.96	4.12	5.05	28.92
Non-Arid	8.15	8.76	8.43	8.99	8.86	8.93	7.53	7.75	7.20	6.74	7.06	-13.34
Rajasthan	12.07	13.14	13.12	12.47	12.90	13.50	10.92	11.67	12.16	10.85	12.12	0.39
II. Buffaloes												
Arid	0.77	0.97	1.06	1.11	1.38	1.76	1.76	2.30	3.16	3.20	3.45	347.01
Non-Arid	2.67	3.05	3.17	3.48	3.69	4.28	4.58	5.48	6.60	7.24	7.64	186.40
Rajasthan	3.44	4.02	4.22	4.59	5.07	6.04	6.34	7.78	9.76	10.45	11.09	222.44
III. Sheep												
Arid	4.75	4.35	5.54	5.16	6.68	8.77	6.48	8.36	10.49	5.76	8.43	77.51
Non-Arid	2.62	3.01	3.27	3.40	3.26	4.66	3.45	4.13	3.82	4.27	2.76	5.14
Rajasthan	7.37	7.36	8.81	8.56	9.94	13.43	9.93	12.49	14.31	10.03	11.19	51.77
IV. Goat												
Arid	3.49	3.43	4.26	5.81	6.17	7.44	5.42	7.83	9.53	8.37	11.70	234.94
Non-Arid	5.24	4.62	6.07	6.35	6.13	8.04	7.16	7.46	7.41	8.44	9.80	87.17
Rajasthan	8.73	8.05	10.32	12.16	12.31	15.48	12.58	15.28	16.94	16.80	21.50	146.31
V. Camel												
Arid	0.36	0.48	0.56	0.63	0.64	0.64	0.57	0.60	0.53	0.40	0.35	-3.75
Non-Arid	0.07	0.10	0.10	0.12	0.11	0.12	0.15	0.15	0.21	0.10	0.07	-0.78
Rajasthan	0.44	0.57	0.65	0.75	0.75	0.76	0.72	0.75	0.75	0.50	0.42	-3.25
IV. Total												
Arid Districts	13.40	13.72	16.21	16.29	19.02	23.35	17.76	23.18	28.57	21.93	29.11	117.20
Non-Arid Districts	19.02	19.79	21.27	22.59	22.34	26.30	23.15	25.27	25.77	27.14	27.55	44.82
Rajasthan	32.43	33.51	37.48	38.88	41.36	49.65	40.92	48.45	54.35	49.45	56.66	74.74

The livestock sector is of considerable economic significance for arid western Rajasthan. With 56.66 million heads of livestock, Rajasthan ranks third in India in animal wealth, while with respect to cattle, it stands sixth. Besides wool, the state is one of the principal suppliers of meat, eggs and milk to the adjoining states. Since more than 51% of the livestock of the state are concentrated in the arid areas of western Rajasthan, it is logical to conclude that arid districts provide major share of livestock production of the state but average animal productivity is low in this region. It is primarily due to scarcity of good quality fodder and other critical nutrients, which are required for maintenance of normal physiological functions, production and reproduction of the animals.

Most of the livestock population in the state is range managed. Except during monsoon period, the livestock graze on dry grasses in the ranges and pastureland and crop residues in the fallow lands. These range grasses and crop residues are very low in essential nutrients including fermentable energy, protein, minerals and carotene. The problem of mineral deficiency is further aggravated due to high calcium and very low phosphorus content of the crop residues. Calcium-phosphorus imbalance adversely affects the availability of calcium as well as phosphorus. The fodder scarcity is another problem. Even in the normal rainfall years, the dry fodder and green forage availability is 82.1% and 31.6%, respectively (Fig 1). This situation is further aggravated during drought years when the crop residues like straws and stovers are imported from the

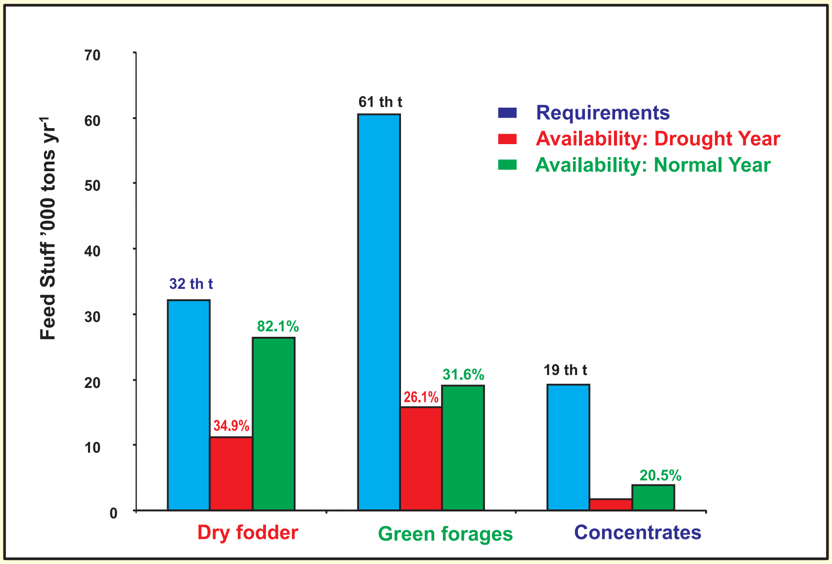

Fig. 1. Feed and Fodder Availability v/s Requirements in Rajasthan during Drought (2002-2003) and Normal Rainfall Years (2001-2002)

neighboring states. To address feed and fodder scarcity, Central Arid Zone Research Institute (CAZRI), Jodhpur has developed formulations and appropriate technologies for production of various feed products viz. multi-nutrient feed block, multi-nutrient feed mixture, total mixed pellet feed, complete fodder block, lucerne meal block and mineral block for supplementation of nutrients to individual and community livestock to maintain their health and productivity under different feed and fodder scarcity conditions.

Multi-nutrient Feed Block

There are different means of supplementation of essential nutrients to the livestock, which mainly survive on roughages. The compact feed block is one of the most appropriate means to do so (Plate 1). Beames (1963) in Australia introduced the concept of feeding compact feed blocks comprised of molasses and urea. Later on this technology was refined and brought to the field to improve productivity of the cattle by Leng and Preston (1983). Sansoucy and coworkers (1986) initiated pioneer work on the technology

Plate. 1. Feed-block Lick for Supplementation of Critical Nutrients to Desert Livestock

of producing urea-molasses blocks in India. This technology, with the assistance of FAO, is being used now in more than 30 countries. In India, feed block technology was first introduced by National Dairy Development Board (NDDB), Anand, Gujarat, which has been adopted by the states' cooperative dairy federations' cattle feed plants. This has thus paved the way for developing appropriate formulations of such blocks at HAU, Hisar, PAU, Ludhiana, IVRI, Izatnagar and also at RAU, Udaipur. However, all these formulations included one or more inorganic binders.

George and Ram (1986) conducted extensive studies on development of formulations and production technology of compact feed block, known as urea-molasses mineral blocks (UMMB). They observed that utilization of crop residues can be enhanced by supplementation of sources of nitrogen, fermentable sugars and minerals, which increase the microbial protein synthesis in the rumen. Further, the livestock feeds can be economized by feeding urea molasses blocks and consumption of concentrate mixture can be curtailed by 40%, with little quantity of cotton seed meal in block supplemented animals. George and Ram (1989) in their feeding trial on *Surti* buffaloes observed that paddy straw consumption increased in block-supplemented group.

On-farm trial indicated that there was an appreciable increase in feed consumption, increase in milk fat and that block supplementation proved economical at village level nutrient supplementation for the buffaloes. On an average the buffalo consumed 350-370 g block day^{-1}. A block of 3 kg lasted for a week. In their earlier formulations they incorporated mineral mixture and cottonseed meal, which were replaced by guar meal and phosphoric acid. They also used fertilizer grade di-ammonium phosphate (DAP) and magnesium oxide. This reduced the cost and improved quality and texture along with the palatability of the block (NDDB, 1996-97). Effect of feeding block *per se* or after soaking in water has been studied at IVRI, Izatnagar (Raman Malik *et al*, 1996). It was found that 400 g day^{-1} block feeding, after soaking in water and then mixing with wheat straw increased *in-vitro* dry matter digestibility (IVDMD) of the wheat straw in rumen of the buffalo. However, looking to the problem of high gas production it was opined that UMMB should be fed as *sani*. Bilala and Murdia (1996) studied the effect of block supplementation in Holestein-Friesian heifers. They found that inclusion of 500 g UMMB day^{-1} with concentrate feed supplementation increased digestibility of almost all dietary nutrients and resulted in higher body weight gain (62.5 *vs* 240 g animal^{-1}day^{-1}). Daily live weight gain was further increased (292 g animal^{-1}day^{-1}) when these animals were offered fish-meal in addition to concentrate with block supplementation.

The above formulations used one or more inorganic materials as binder and the blocks were dried by chemical processes. The gelling of the block was due to the chemical reaction between the soluble salts of calcium and/or magnesium and phosphorus. Some formulations used calcium oxide as a gelling agent. In all the cases heat is generated, which may cause nutrient losses. The sticking of the feed ingredients during gelling process is the major problem of using active inorganic binder. Bentonite used as binder in some of the formulations is non-selective binder, which adsorbs macro- and micro-minerals thereby making the minerals unavailable to the animals. Considering all these points, simple and appropriate formulations (Table 3) and process technology for production of multi-nutrient feed blocks, using organic binder and locally available feed ingredients were developed at CAZRI (Bohra, 2004).

Table 3. Composition and Chemical Constitution of Multi-nutrient Feed Block and Multi-nutrient Mixture

S. No.	Multi-nutrient Feed Block				Multi-nutrient Mixture			
	Ingredient, %		Proximate component, %		Ingredient, %		Proximate component, %	
1.	Molasses	44.5	Dry matter	97.3	Molasses	46.6	Dry matter	96.9
2.	Urea	4.3	Organic matter	78.3	Urea	0.80	Organic matter	78.7
3.	Common salt	4.3	Crude protein	22.9	Common salt	4.5	Crude protein	11.6
4.	Dolomite	4.3	Ether extract	4.1	Dolomite	4.5	Ether extract	4.2
5.	Vitamin-mineral mixture	4.3	Minerals	21.7	Vitamin-mineral mixture	4.5	Minerals	21.3
6.	Wheat bran	32.1	Total carbohydrates	51.3	Wheat bran	33.6	Total carbohydrates	62.9
7.	Guar gum dust	1	Gross energy, kcal	381	Guar gum dust	5.4	Gross energy, kcal	365
8.	Guar meal	5.1			Guar meal			

Dry weight and bulk density of 12 different formulations of compact feed blocks developed at CAZRI are presented in Table 4. The standard feed blocks comprised of wheat bran, sugar cane molasses, urea, vitaminized mineral mixture, dolomite, common salt, de-oiled soyabean meal and guar gum dust, as a binder (Table 3). The standard multi-nutrient feed block comprised of 44.5% molasses, 4.3% each of urea, common salt, dolomite and vitamin mineral mixture, 32.1% wheat bran, 5.1% guar meal and 1% guar gum dust. As such, it contained 2.7% water, and on dry weight basis contained, 78.3%

Table 4. Dry weight (g $100g^{-1}$ fresh wt) and Bulk Density of Various Formulations of Multi-nutrient Feed Blocks

S. No.	Major Constituents		Dry Weight, g $100g^{-1}$ fresh wt	Bulk Density, g cm^{-3}	Bulk density, score
	Energy Sources	Roughages			
Standard	Sugarcane molasses	Wheat bran	88.0	1.25±0.019	B
1.	Sugarbeet molasses	Wheat bran	84.0	0.95±0.019	D
2.	Sugarbeet molasses	Wheat bran+Cotton seeds, ground (5:1)	83.0	0.87±0.022	E
3.	Feed grade *jaggery*, 72.2% aqueous solution	Wheat bran	79.0	1.14±0.010	C
4.	Feed grade *jaggery*, 73.5% aqueous solution	Wheat bran	78.0	1.27±0.018	A
5.	Sugarcane molasses	Barley husk-bran+Guar gum dust, 1.5%	86.0	0.98±0.014	C
6.	Sugarcane molasses	Barley husk-bran+Guar gum dust, 2.5%	89.0	1.15±0.016	C
7.	Sugarcane molasses	Wheat bran+Barley husk-bran (1:1.1)	85.0	1.01±0.010	C
8.	Sugar cane molasses	Malt sprouts	85.0	0.88±0.057	E
9.	Sugarcane molasses	Rice polishings+ Barley husk-bran (3.7:1)	76.0	1.23±0.012	B
10.	Sugarcane molasses	Rice polishings+Barley husk-bran (1:1.25)	82.0	1.21±0.019	B
11.	Sugarcane molasses	*Ardu* leaves+ Wheat bran+Barley husk-bran (1:1.8:1.6)	78.0	0.93±0.010	D
12.	Sugarcane molasses	*Bajra*husk+Rice polishings+ Soyabean meal sol. extracted (1:1:0.5)	81.0	0.86±0.024	E
13.	Mean	-	0.83±0.011	1.06±0.042	-

organic matter, 22.9% crude protein, 4.1% ether extract, 21.7% minerals, 51.3% total carbohydrates, and 381 kcal % gross energy. Like wheat bran, a mixture of wheat and *bajra*-bran can also be used for producing the feed block. The composition of such block contained 52.7% molasses, 6.2% urea, 5.1% each of common salt, dolomite and vitamin mineral mixture, 18.7% each of wheat- and *bajra*-bran, 6.2% guar meal and 1.2% guar gum dust. As such, it contained 14.1% water, and on dry weight basis contained 80.8% organic matter, 23.2% crude protein, 2.2% ether extract, 19.3% minerals, 55.4% total carbohydrates, and 381 kcal % gross energy. The dry weight, volume and bulk density of the standard wheat bran block and of wheat-*bajra* bran block were 2.00 and 2.07 kg $block^{-1}$, 1700 and 1770 cm^{-3}, and 1.17 and 1.17 g cm^{-3}, respectively. It was observed that partial or complete replacement of wheat bran in block formulations with other fibrous feed ingredients like pearled barley milling products, malt sprouts, de-oiled rice bran, *Bajra* husk and *Ardu* (*Ailanthus excelsa*) leaves reduced production cost of the blocks and helped in making low density blocks (Table 4). Though, pressing of such fibrous ingredient containing mixture requires more energy, and instead of being flat its upper pressed layer becomes convex in shape. The blocks having low density are liable to be over consumed by the animals; however, their bulk density can be improved by increasing the level of the binding material. Further evaluation of new feed block formulations showed that the partial or complete replacement of wheat bran with other fibrous materials reduced the bulk density and subsequently elevated compressive strength of the blocks. However, this rule does not hold true in case of the blocks in which the wheat bran is fully replaced by chaffed *Cenchrus ciliaris* grass.

National Dairy Development Board (NDDB), Anand has developed formulation and technology for production of urea molasses lick, named as UROMOL. These licks are presently produced by RCDF, Cattle Feed Plant in Jodhpur (A). The chemical composition and physical characteristics of A and multi-nutrient feed block (MNB), which formulated and produced at Feed Technology Unit, CAZRI Jodhpur (B) were compared (Table 5). The A and B blocks weighed 3.02 kg and 1.87 kg, respectively. As such basis, A and B contained 80.4% and 90.0% dry matter and had 1.43 and 1.16 $g^{-1}cm^{-1}$ bulk density, 1.15 and 1.05 $g^{-1}cm^{-3}$ dry weight density, 15.8 and 100 $kg^{-1}cm^{-3}$ compressive strength, 7.0 and 6.8 pH, and 5.19 and 6.37, 100 g^{-1} soluble salts, respectively. A feeding trial was conducted to evaluate acceptability of A & B in sheep. For the purpose, 8 Marwari rams of comparable body weights were divided into two groups (T_1 and T_2). Animals of both the groups were offered wheat straw and water *ad lib.* In addition, the sheep of T_1 group had free access to A and of T_2 group had free access to B-block. Their

Table 5. Comparison of NDDB's UROMOL and CAZRI's Multi-nutrient Feed Block

S. No.	Trait	NDDB's UROMOL (A)	CAZRI's Multi-nutrient block (B)
1.	Weight, kg	3.02	1.87
2.	Dry matter, %	80.4-84.1	90.0-95.5
3.	Bulk density, g cm^{-3}	1.43	1.16
4.	Dry weight density	1.15	1.05
5.	Compressive strength, kg^{-1} cm^{-2}	15.8	100 (6.3 times)
6.	pH	7.0	6.8
7.	Total soluble salts, $100g^{-1}$	5.19	6.37

body weight was recorded twice a week. The result of the trial indicated that the sheep of T_1 group consumed daily 170.9±15.87 g lick-A, $animal^{-1}$ day^{-1} and of group T_2 consumed daily 342.1±13.2 g block-B, $animal^{-1}day^{-1}$. Wheat straw intake, though not significantly, but slightly higher in T_1 (0.740±0.0662 kg $animal^{-1}day^{-1}$) than in T_2 group of animals (0.688±0.0080 kg $animal^{-1}day^{-1}$) but water intake was appreciably higher in T_2 (3.2±0.07, l $animal^{-1}day^{-1}$) than the T_1 group of animals (2.8±0.07, l $animal^{-1}day^{-1}$). A decreasing trend in the live weight was recorded in the sheep offered A-lick, whereas, increasing trend was noticed in the live weight of the sheep offered B-block. Thus CAZRI's multi-nutrient feed block (B) proved to be better than the RCDF's UROMOL in sheep. The compressive strength of CAZRI's block was 6.3 times of the NDDB's UROMOL lick, indicated the superiority of former over the latter type of lick (Bohra *et al,* 1999).

Calcium oxide (CaO) is being used as binder and gelling agents in several formulations. Experiments were conducted to assess effect of incorporation of CaO in standard feed block (ST) formulation @ 25, 50, 75, 100 and 150 g per block, and pressed blocks dried in the solar dryer. On dry matter basis these blocks contained, 1.2, 2.4, 3.6, 4.7 and 7.0% CaO. The dry weight of ST, and CaO containing blocks was 2110, and 2055, 2090, 2100, 2130 and 2160 g, respectively; volume, 1817 and 1956, 1925, 1829, 2011 and 2227 cm^3, respectively, and bulk density was 1.17 and 1.07, 1.10, 1.18, 1.08 and 1.00 g cm^3, respectively. The data indicated that the bulk density of block contained 75 g, i.e., 3.6% CaO was highest and it was comparable with the standard feed block. Amongst all the formulations tried, it was observed that the rate of drying was fast ($R^2 = 0.9425$) where 3.6% CaO was incorporated. Calcium oxide incorporation also improved the texture of the blocks. In another trial, magnesium oxide (MgO) was added at the rate of 0, 4.1, 9.6, 17.5 and 22.75% of total weight of the block. The fresh weight of these blocks was 2.30, 2.45, 2.60, 2.85 and 3.30 kg, respectively, with dry weight of 2.00, 2.20, 2.37, 2.60 and 3.1 kg, respectively. Their bulk density was observed as 1.08, 1.22, 1.37, 1.41 and 1.47 g cm^3, respectively. With increasing level of MgO, the texture of the blocks improved and their colour changed from dark to light gray with increase in bulk density.

Experiment was conducted to explore the possibility of replacing molasses. wheat bran and guar meal/de-oiled soybean meal in standard formulation blocks (A) with maize starch industry by-products. For this purpose standard formulation blocks (A) were compared with (B) where various maize starch industry by-products (viz., maize extractives, maize gluten feed and maize gluten meal) were added. The A and B blocks weighed 1.89 and 1.80 kg, had 2085 and 1939 cm^{-3} volume and 0.91 and 0.93 $g^{-1}cm^{-3}$ bulk density, respectively. The quality of blocks made of Maize Starch Industry by-products was comparable with the standard blocks, contained molasses and wheat bran but former was lighter in colour.

Feeding trial conducted on sheep revealed higher acceptability of feed block with increased dry feed and water intake (Table 6). Wheat straw intake in *Marwari* sheep was found appreciably high (535 g day^{-1} and 2.0 100 kg^{-1} live weight) in block supplemented group when compared to the animal who was offered wheat straw alone (436 g day^{-1} and 1.86 kg 100 kg^{-1} live weight). The total dry matter intake including block in former group of the animal was 2.6 kg 100 kg^{-1} live weight day^{-1}. The block supplemented animals drank 2.7 lit water daily (10.1, l 100 kg^{-1} live weights day^{-1}); whereas, the animals fed wheat straw alone drank 2.3 lit water (9.8, l 100 kg^{-1} live weight day^{-1}). During 4-months feeding trial, the block-supplemented group recorded 3.6% gain in the live weight; whereas, the live weight of sheep fed on wheat straw alone was reduced by 8.6%. The average clean wool yield in block-supplemented group was 635 g $clip^{-1}$, whereas, wheat straw fed sheep recorded only 593 g wool $clip^{-1}$ (Bohra *et al*, 2001). Rohilla *et al* (2011) recorded higher live weight gain in block supplemented Marwari lambs than those maintained on grazing only.

Table 6. Effect of Feed-Block Supplementation in Sheep

S. No.	Trait	Control Wheat straw (WS)	Experimental (WS+Block)	% increase
1.	Live weight, kg			
	Initial	-	25.8±1.6	-
	After 17th week	-	26.7±2.9	-
	% change in 17 weeks	-	+3.6	-
2.	Intake			
	Wheat-straw, g $sheep^{-1}day^{-1}$	463±22.3	535±21.7	15.6
	Wheat-straw+block, g $sheep^{-1}day^{-1}$	463±22.3	707±51.5	52.7
	Feed block, g $sheep^{-1}day^{-1}$	-	244	
	Water, l $sheep^{-1}day^{-1}$	2.3+0.22	2.7±0.22	17.4
3.	Feed (kg): Water (lit)	1:5.3	1:3.8	
4.	Clean fleece wt, g $sheep^{-1}clip^{-1}$	593±79.1	635±15.0	7.1

Rathi heifers, which had free access to the feed block could consume 678 g block day^{-1}. In another feeding trial, *Rathi* heifers were first offered 300 g block (B) day^{-1}, which was slowly increased to 500 g day^{-1}, and finally to 700 g $animal^{-1}day^{-1}$. Another group was offered wheat straw alone (WS). The WS and B+WS group of animals consumed 2.93 kg $animal^{-1}$ day^{-1} and 3.01 kg wheat straw $animal^{-1}day^{-1}$ and drank, 10.8 and 14.0, l water, $animal^{-1}$ day^{-1}, respectively. The average daily dry matter intake, including block in the B+WS group was 3.7 kg $animal^{-1}$ day^{-1}. The daily dry matter intake, per 100 kg body weight in WS and B+WS group was 1.56 and 2.05 kg, and water intake, 5.6 and 7.8, l 100 kg^{-1} body weight day^{-1}, respectively, however, the feed (kg): water (lit) ratio in these animals did not differ significantly; it was 1: 3.7 and 1: 3.8 in WS and B+WS animals, respectively, and the digestibility coefficient for the DM in these animals was 44.3 and 48.3%, respectively (Table 7). A group of *Rathi* cows (average live weight 313 kg) who were maintained on *Lasiurus sindicus* pasture and offered 1.5 kg RCDF pelleted feed daily, when provided free access to the block, on an average, a cow licked 332 g block cow^{-1} day^{-1}. During 5 weeks feeding, the block supplemented group gained 3.5%, whereas, non-supplemental cows maintained on grazing and concentrates, recorded 1.9% gain over their initial live weight.

Table 7. Effect of Supplementation of Feed-Block in Rathi Heifers

Trait	Control	Experimental	%, increase
Live weight, kg	195±31.9	187±25.4	-
Wheat-straw intake, g animal^{-1}day^{-1}	1.56±0.13	1.68±0.08	7.7
Block intake, kg animal^{-1}day^{-1}	-	0.700	-
Total intake, kg animal^{-1}day^{-1}	1.56±0.13	2.05±0.13	31.4
Water intake, l animal^{-1}day^{-1}	5.6±0.47	7.8±0.64	39.3
Feed (kg):water (lit) intake	1:3.7	1:3.8	-
DM digestibility, %	44.3±1.1	48.3±7.1	9.0

A digestibility trial was conducted to evaluate the effect of feed block supplementation in *Rathi* cattle (Table 8). One group of cattle had free access to wheat straw and water (WS), whereas the second group, in addition to these, offered 700 g block animal^{-1}day^{-1} (B+WS). The feed block (10% urea) on dry matter basis, contained 81.7% organic matter, 18.3% total ash, 26.9% crude protein, 0.4% ether extractives, 54.4% total carbohydrates, 15.6% cell wall constituents and 5.1% acid detergent fibre. These values for the wheat straw were 90.0, 9.1, 3.1, 0.4, 54.4, 15.6 and 5.1%, respectively. The daily dry matter, crude protein and water intake in WS and B+WS group were 2.93 and 3.96 kg, 97 and 274 g and, 11 and 14, l animal^{-1}day^{-1}, respectively. The digestibility coefficients for dry matter, organic matter, total carbohydrates, crude protein, ether extractives, neutral detergent fibre (NDF) and acid detergent fibre (ADF) in WS and B+WS offered animals were, 44.3 and 48.3; 52.3 and 53.1; 54.4 and 54.0; <0.0 and 43.9; 49.7 and 42.0; 46.5 and 45.8; and 37.5 and 36.7%, respectively. The estimated digestible crude protein value of wheat straw and the feed block was <0.0 and 22.4%, respectively (Mondal and Bohra, 2001).

A proto-type solar dryer made-up of plywood with outer lining of an aluminum sheet and coated with the black paint from inside was designed, and its efficacy to dry the blocks was assessed. The maximum temperature of its inner chamber during winter and

Table 8. Effect of Supplementation of Feed-Block in Rathi Cattle

Chemical Composition, %			Digestibility Coefficient, %		Intake		
Constituent	Wheat straw	Feed block	Control*	Experimental**	Trait	Control	Experimental
Dry matter	-	-	44.3	48.3	Body Wt., kg	194	186
Organic matter (Ash)	90.9 (9.1)	81.7 (18.3)	52.3	53.1	Dry matter intake, kg animal^{-1}day^{-1}	2.93	3.69
Ether extract	0.82	0.42	49.7	42.0	Water, l animal^{-1}day^{-1}	11	14
Crude protein	3.1	26.9	-	43.9	Crude protein, g animal^{-1}day^{-1}	97	274
Total carbohydrates	86.9	54.4	54.4	54.0	Digestible crude protein	0.00	3.33
Neutral detergent fibre	78.8	15.6	46.5	45.8	Total digestible nutrients	48.1	48.8
Acid detergent fibre	53.9	5.1	37.5	36.7	-		

*Offered wheat straw, **Offered wheat straw and feed block; Digestible Crude Protein & Total Digestible Nutrients of the block: 16.5% and 53.3%.

summer was 65°C and 75°C, respectively. The drying efficacy of electric and solar dryer was compared. The temperature of non-draft type electric oven varied between 65°C and 70°C. It accommodated 12 blocks, whereas, the proto-type solar dryer could accommodate 4 blocks. Its diurnal temperature varied between 26°C and 78°C. Under both the conditions, it took 4 days to completely dry the blocks. The electric consumption in drying 12 blocks was 8 units (i.e., Rs. 1.35 block^{-1}). In case of prototype solar dryer, the approximate cost of installation comes to Rs. 1000/- without any recurring expenditure. The blocks dried in both the dryers did not differ in quality or texture except the fact that those dried in the electric dryer were dark gray in colour, whereas, the solar-dried had reddish tinge.

Production Process Technology

CAZRI's multi-nutrient feed block production technology involves mixing of locally available feed ingredients with machines, which can easily be fabricated by local artisans (Plate 2). Plant product of significant nutritional worth is used as a binder (guar gum dust), which forbids unwanted lump formation. Since the binder is chemically inert

Plate. 2. Feed-block Ingredients and Production

material hence there is no exothermic reaction during mixing of the ingredients. This facilitates manual mixing of block ingredients. Products can be dried under the sun light or in the solar drier, and finished product maintains its quality. It has been observed that its acceptance is not adversely affected with the time. The principal feed ingredients, which are used for production of standard formulation feed block, and alternative feed ingredients have been listed in Table 9. Detailed, step-by-step production of multi-nutrient feed block has been shown in Plate 3. Feed block production technology involves: A. manual mixing (or mixing in electric operated mixer) of feed-ingredients, B. pressing in screw type press (or power driven hydraulic press), C. drying in open sun (solar/electric/gas operated dryer) and packing in printed wrapper then finally kept in an appropriate paper box. For production of 50 blocks of 2 kg each, 52 kg molasses, 5 kg urea dissolved in 5.0 l water, 37.5 kg wheat bran, 6.0 kg guar meal, 5.0 kg each of common salt, vitamin-mineral mixture and dolomite, along with 1.2 kg guar gum dust/powdered fenugreek seeds, used as a binder, is required. It has been stated that

Table 9. Principal and Alternative Feed-ingredients of Multi-nutrient Feed Block and Nutrient-mixture

S. No.	Principal Feed-ingredient	Alternate Feed-ingredient (s)
1.	Sugarcane molasses	Sugarbeet molasses/cattle feed grade *jaggery*/maize strip liquor (maize starch industry by-product)
2.	Urea	-
3.	Common salt	-
4.	Dolomite	Calcite/low silica-dried marble slurry
5.	Mineral mixture containing, amino acids and vitamins (A, D, E)	Mineral mixture containing vitamin A/Mineral mixture containing calcium and phosphorus
6.	Wheat bran	Rice polishings and/or deoiled rice bran, Pearl barley by-products/Malt sprouts/ Dried *Neem* or *Ardu* leaves, seed free powdered *Prosopis juliflora* or *Acacia tortilis* pods/ground *dhaman* grass, Mixture of *bajra* grain husk and rice polishing/Maize gluten feed
7.	De-oiled soybean meal	Guar meal: korma or churi/any cake of oil bearing seed/Cotton seed whole, ground/ Maize gluten meal
8.	Organic binder (guar gum dust)	1. Organic: Fenugreek seeds, ground 2. Inorganic: Calcium oxide/Magnesium oxide Cement/Bentonite or sodium bentonate/Gypsum

establishment of feed block production unit at farmers' level in a village was found economical (Rohilla *et al*, 2011). The initial cost of establishment of village level production of 20 blocks day^{-1} (including cost of feed ingredients required for production of 100 blocks) comes to Rs. 40,000. It excluded the cost of land and infrastructures. The production can be initiated in ventilated, asbestos shade of approximately 70'x20', in which 2, 15'x20' spaces situated at each end of the shade, can be used for storing the ingredients and finished blocks, and a central space of approximately 40'x20', provided with three phase electric connection is required for housing ingredient mixer, block press and draught type electric oven, can work as production unit. The cost of production of 100 blocks using feed grade *jaggery* (J) and sugarcane molasses (SCM) comes to Rs. 1460/- and Rs. 1310/-, respectively. Assuming that a person can produce 20 blocks daily and if working days in the year are considered to be 300, the annual profit on production of 600 blocks (20 blocks x 30 days) comes to Rs. 32,400/- (Rs. 2700/- per month) and Rs. 41,400/- (Rs. 3450/- per month) if J and SCM, respectively, are used for block production.

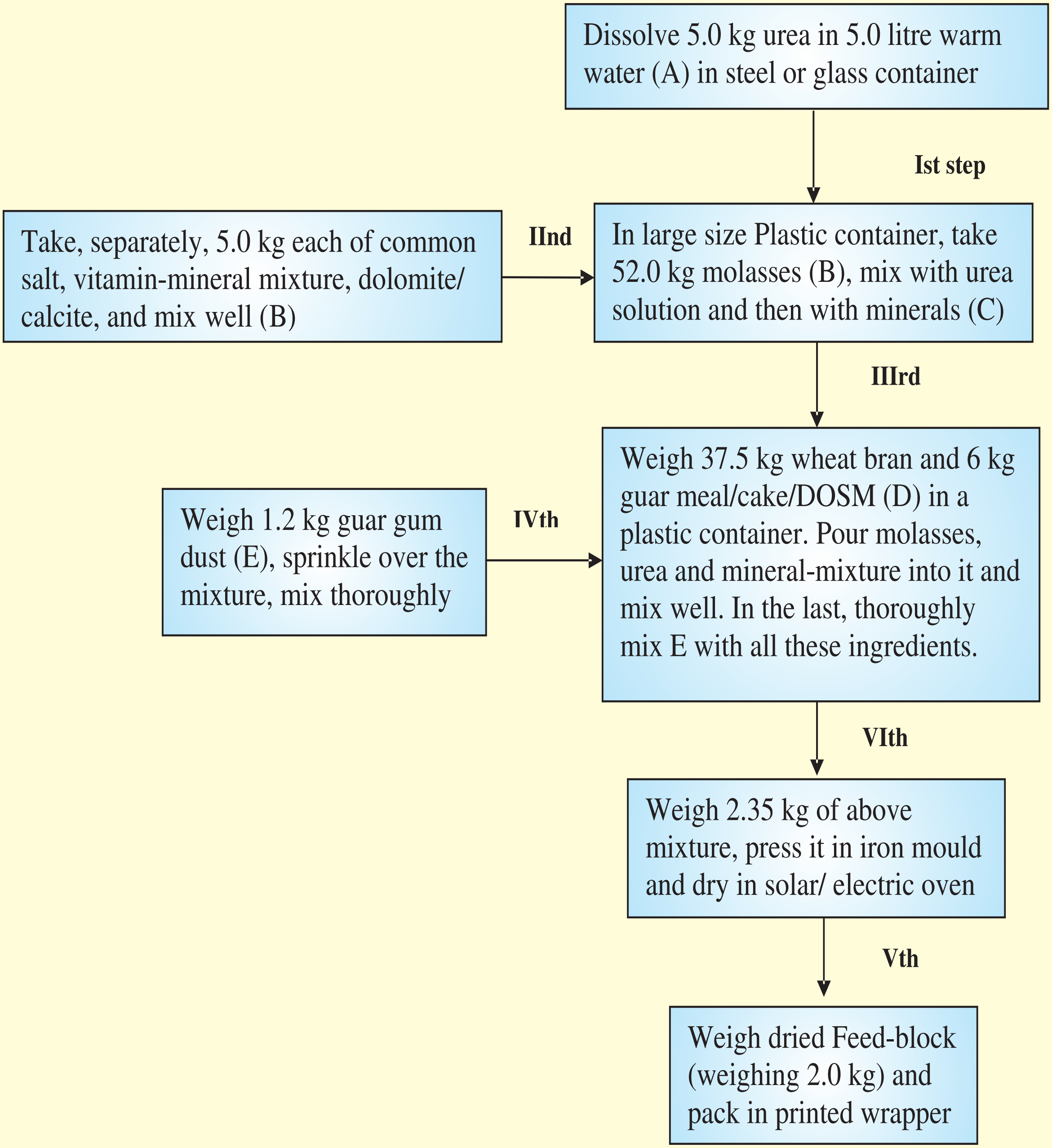

Plate. 3. Flow Chart Representing Production of 100 kg (50 Nos.) Multi-nutrient Feed Blocks

Multi-nutrient Mixture

In spite of the fact that the feed blocks are well accepted by the livestock of all the categories and its immense use in supplementation of essential nutrients, these are unsuitable for the browsers like goats who instead of licking such blocks try to bite it due to thier nibbling habit. Formulation and technology for production of multi-nutrient mixture have been standardized for such type of animals. It involves mixing of all desired ingredients shown in Table 3, and then spread over polythene sheet under the sun for drying. After proper drying it can be offered to the animals (Plate 4). The standard formulation of multi-nutrient mixture is comprised of 46.6% molasses, 0.80% urea, 4.5% each of common salt, dolomite and vitamin-mineral mixture, 33.6% wheat bran and 5.4% guar meal. It on fresh weight basis, contains 3.1% moisture and on dry weight basis, contains 78.7% organic matter, 11.6% crude protein, 4.2% ether extract, 21.3% minerals, 62.9% total carbohydrates, and 365 kcal% gross energy. Standard concentrate mash feed (18% CP and 76% TDN) can be prepared by mixing 20% barley- and 10% *bajra*-ground, 15% each rice- and wheat-bran, 10% cotton seed cake, 15% guar meal, 5% green gram- and 7% Bengal gram-*chuni*, 2% vitamin-mineral mixture and 1% common salt. This concentrate feed can be given to lactating cow @ 1 kg/2.5 kg daily milk production, and to a buffalo @ 1 kg/2.0 kg daily milk production. A feeding trials conducted on Marwari kids and does proved worth of nutrient-mixture in maintaining health and productivity of these animals as indicated in Table 10 (Rohilla *et al,* 2003; Rohilla *et al,* 2004). Rohilla *et al* (2009) have further recorded that supplementation of nutrient-mixture with probiotics is more advantageous in kids and lactating does than feeding probiotics alone. Marwari ewes supplemented with nutrient-mixture produced more milk animal^{-1}day^{-1} and recorded prolonged lactation period (Table 11). Daily weight gain in lambs of nutrient-mixture supplemented ewes was also appreciably higher than the lambs borne and suckled by the control group of ewes (Rohilla *et al,* 2004; 2011).

Plate. 4. Multi-nutrient Mixture is Beneficial in both Small and Large Ruminants

Table 10. Multi-nutrient Mixture (MNM) Supplementation in Marwari Goats

Trait	Weaned Kids (MNM Supplemented), 75 g animal^{-1}day^{-1}		Lactating Does (MNM Supplemented), 150 g animal^{-1}day^{-1}	
Live weight				
Initial, kg animal^{-1}	12.7±0.85	12.3±1.25	26.2±1.38	25.8±0.93
After 90 days, kg animal^{-1}	18.2±2.43	19.3±3.23	30.5±1.55	31.1±1.16
% Increase	43	57	16.2	21
Feed intake				
g animal^{-1}day^{-1}	386±12.9	467±20.4	520±18.6	619±15.5
% Increase		21		19%
Water intake, l animal^{-1}day^{-1}	1.0±0.06	1.2±0.09	1.2±0.07	1.7±0.05
% Increase		20		42
Milk yield, l animal^{-1}day^{-1}			1.19±0.055	1.32±0.097
% Increase				15.3

Table 11. Multi-NutrientMixture (MNM) Supplementation in Marwari Ewes

Trait	Range-managed (RM)	RM+100 g Nutrient-mixture, animal^{-1}day^{-1}	RM+200 g Nutrient-mixture, animal^{-1}day^{-1}
Weight of lambs, kg animal-^{1}			
Birth weight	2.2±0.04	2.3±0.05	2.2±0.09
8-weeks weight	8.2±0.07	9.3±0.06	9.9±0.04
% Increase	-	10.4	18.3
Weight of ewes, kg animal-^{1}			
After parturition	25.0±1.24	25.5±2.45	25.3±1.4
8-week parturition	30.8±1.55	32.5±0.93	33.8±1.3
% Increase	-	4.2	7.4
Milk yield, ml animal-^{1} day-^{1}			
1st week	290±10.5	295±8.9	300±12.4
8th week	395±19.8	500±20.3	575±16.5
% Increase	-	16	28

Mineral-block

Formulation and process technology for production of mineral blocks has also been standardized. Five formulations were tried. the basic ingredients in which were; common salt, vitamin-mineral mixer, dolomite, *jaggery*/molasses, urea, maize flour and guar gum dust. Formulations 1, 2, 3, and 5, had common salt and vitamin-mineral mixture in 2:1 ratio, whereas the formulation No. 4 had the ratio of 3:1. In formulation 1, maize flour and guar gum were added @ 24.7 and 1.2%, respectively, with molasses to facilitate the binding of the ingredients. In No. 2, neither molasses nor guar gum dust was added but in No. 3 guar gum dust was added @ 1.6%. In both 3 and 4, 300 ml water was added to facilitate mixing of salt and mineral mixture. In No. 3 and 4, binder was added @ 0.8% level. A 50% *jaggery* solution was also incorporated in No. 3 and 4. In No.5 dolomite was also incorporated. In No. 4 guar gum dust was added in the last, whereas, in No. 5 it was added before adding dolomite, guar gum dust and *jaggery* solution. The fresh and dry weight of No. 1, 2, 3, 4 and 5 formulation blocks were 2.66 and 2.38; 1.77 and 1.63; 1.78 and 1.47, 2.54 and 2.40 and 2.54 and 2.40 kg, respectively. The bulk density of these mineralized salt licks was 1.5, 1.8, 1.3, 1.5 and 1.9 $g^{-1}cm^{-3}$, respectively. Formulation No. 2 and 3 were brittle, and No. 4 and 5 were soft and sticky in nature due to addition of *jaggery*. The block made as per formulation No. 1 (Plate 5). was found most appropriate than rest of the formulations (Bohra, 1999). Recently, a technology for production of 25-30 kg mineral block has been developed, which can be used for supplementation of macro- and micro-minerals, vitamins along with non-protein nitrogen and fermentable sugars to the range foraging livestock on community basis. Such blocks can conveniently be kept near the water holes, and after quenching their thirst the animals may lick the block to get the critical nutrients. The technology involves mixing of common salt (51.0%), vitamin-mineral mixture (12.8%), dolomite (12.8%), feed grade *jaggery* (12.8%) and urea (1.5%) dissolved in water (5.2%), guar meal (5.1%), lime (2.6 %) and guar gum dust (1.5%) and then pressed in the cylindrical iron mould with hammer (Plate 6). The compressed ingredient-mixture is then dried in the sun, which can be used as a lick (Plate 6) for supplementation of macro- and micro-minerals to community livestock. Common salt and mineral-mixture are the major components of the mineral blocks. As per the BIS Type-I mineral mixture (with common salt), it should contains, <5.0% moisture, >22.0% non-iodised, common salt, >18.0% calcium, >9.0% phosphorus, >5.0% magnesium, >0.4% iron, >0.02.0% iodine as KI, >0.06% copper, >0.1% manganese, >0.009% cobalt, >0.05% fluorine, >0.3% zinc, >0.4% sulphur and <3.0% acid insoluble ash. It can be prepared by thoroughly mixing finally pulverized

Plate. 5. Vitamin-mineral Salt Lick

Plate. 6. Salt-lick Production for Mineral Supplementation in Community Livestock

20.5% calcium carbonate (Ca=40.0%), 49.0% di-calcium phosphate (Ca=20%, P=18.5%), 0.24% copper sulphate (Cu=25.0%, S=13.8%), 0.043% cobalt sulphate.$7H_2O$ (Co=21.0%, S=11.4%), ferrous sulphate.$7H_2O$ (Fe=21.0%, S=11.8%), 0.4% manganese sulphate (Mn=25.0%, S=19.0%), 8.3% Magnesium oxide (Mg=60.3%), 0.02% potassium iodide (K=23.5%, I=76.46%), 22.0% common salt (Na=39.3%, Cl=60.7%) and 0.834% zinc sulphate.H_2O (Zn=36.0%, S=18.0%) . Similarly, BIS Type-II mineral mixture (without common salt) should possess <5.0% moisture, >23.0% calcium, >12.0% phosphorus, >6.5% magnesium, >0.5% iron, >0.026.0% iodine as KI, >0.077% copper, >0.12% manganese, >0.012% cobalt, >0.012% fluorine, >0.38% zinc, >0.5% sulphur and <2.5% acid insoluble ash. In these mineral mixtures, appropriate quantities of vitamins (A, D_3, E) should be added.

Fortified Complete Fodder Block

Crop residues and dry grasses are short of essential nutrients including fermentable energy, protein, most of the macro- and micro-minerals including phosphorus and carotene, which are precursors of vitamin A, high in structural carbohydrates and calcium. Calcium-phosphorus imbalances adversely affect the availability of calcium as well as the phosphorus and other micro-minerals. Their palatability and digestibility are also low. Such crop residues can be converted into valued feeds by incorporation of required feed ingredients and then compressed to produce a 2-kg block (Plate 7).

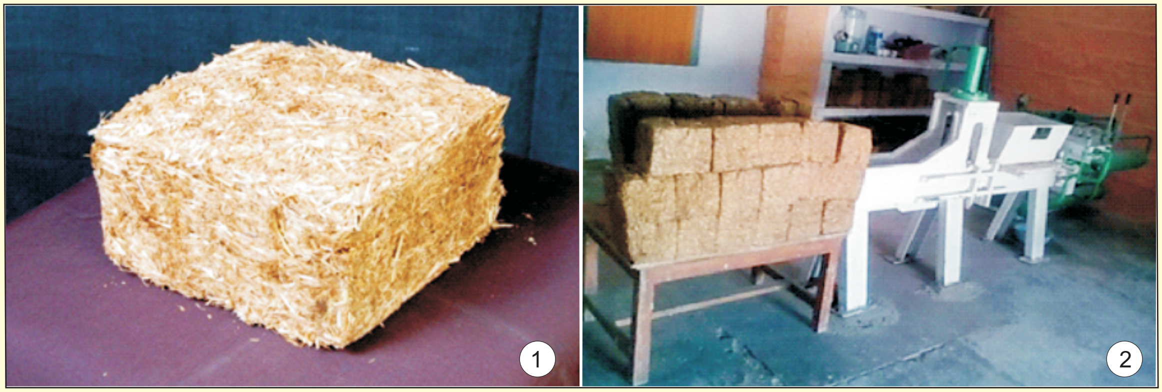

Plate. 7. Production of Fodder Block

For production of complete fodder blocks, first a concentrate mixture containing 45.8% molasses, 2.64% urea with 4.4% each of common salt, dolomite, vitamin-mineral mixture, 33% wheat bran and 5.3% guar meal is prepared. Thirty parts of the mixture so produced is mixed with 70 parts of chopped straw or milled stovers, in feed mixer. This crop residue-concentrate mixture is then compressed in fodder block making machine to produce the complete block. Such blocks can be stored for a long period without spoilage when wrapped in paper. The complete fodder block on fresh weight basis, contained 1.3% moisture and on dry weight basis, contained 83.7% organic matter, 11.8% crude protein, 4.5% ether extract, 16.3% minerals, 67.0% total carbohydrates and 389 kcal% gross energy. These blocks can be used as complete ration for productive animals. Formulations of complete- and supplemental-folder blocks for different categories of livestock have been presented in Table 12.

Table 12. Composition of Some Complete- and Supplemental-fodder Blocks

S. No.	Ingredient	Quantity, kg		
		Complete fodder block for weaned kids (2.0 kg^{-1} block)	Complete fodder block for growing heifers (1.5 kg^{-1} block)	Supplemental fodder block for lactating does (2.0 kg^{-1} block)
1.	Pearl millet, ground	20.4	10.0	10.0
2.	Wheat bran	17.0	7.5	7.5
3.	Maize ground	17.0	10.5	-
4.	*Tumba* seed cake	-	-	10.5
5.	Rape-seed oil cake	-	7.5	7.5
6.	Sesamum seed cake	4.7	-	-
7.	Guar meal	4.7	7.5	7.5
8.	Molasses	4.1	5.0	5.0
9.	Urea	-	1.0	1.0
10.	Common salt	0.68	0.5	0.5
11.	Vitamin-mineral mixture	1.36	0.5	0.5
12.	Total concentrates	30.9	30.0	50
13.	*Khejri* leaves	6.6	-	-
14.	Lentil straw	6.6	-	-
15.	*Cenchrus ciliaris* straw	-	70.	50.0
16.	Total	44.1	100	100

Lucerne Leaf Meal Block

Lucerne is a high input intensive but valuable fodder crop. It is a rich source of protein, minerals and other critical nutrients including beta-carotene, which is a known precursor of vitamin A. But due to high moisture contents, its shelf life is very short. It is estimated that 20-25% of field harvested Lucerne is spoiled and can not be used. The harvested Lucerne is chopped, loosely spread over wire-mesh and dried in the sun. This is then milled in hammer mill and compressed in fodder block making machine to produce 1 kg block (Plate 8). Such dried blocks are rich source of protein, beta-carotene, calcium and other critical nutrients. As such basis, the Lucerne meal block contained, 91.8% dry matter, and on dry matter basis, it contained, 84.4 organic matter, 23.5% crude protein, 3.2% ether extract, 15.6% minerals, 57.7% total carbohydrates, and 402 kcal% gross energy. These blocks can be used as a supplement to desert livestock maintained on dry roughage diet.

Plate. 8. Production of Lucerne Meal Block

Macro- and micro-mineral analysis of Lucerne meal block revealed that it on dry matter basis contained 2.74% calcium and 0.11% phosphorus (Ca: P and P: Ca ratios were 2: 0.08 and 1: 24.9, respectively), 0.43% magnesium, 1.78% potassium and 1.14% sodium. Calcium (critical value, CV, 0.21-0.52%), magnesium (CV, 0.04-0.08), potassium (CV, 0.5) and sodium (CV, 0.04-0.10) levels were higher but phosphorus (CV, 0.16-0.37) level was lower than its critical values reported in the literature. The essential micro-mineral viz., cobalt, chromium, copper, iron, manganese, molybdenum and zinc contents of the meal were 11.4 ppm 11.3 ppm 4.3 ppm, 92.3 ppm, 19.6 ppm, 582.5 ppm and 36.9 ppm, respectively. It indicated that the cobalt (CV, 0.1), iron (CV, 0.01-0.30), molybdenum (CV, 0.50) and zinc (CV, 35-50) levels were higher, and copper (CV, 5.0) and manganese (CV, 20-40) levels in the block were lower than its critical values reported in the literature; non-essential elements, viz., aluminium, boron, cadmium, nickel, and lead contents in the block were 672.7 ppm, 39.95 ppm, 58.75 ppm, 245 ppm and 4.8 ppm, respectively. The results indicated that though Lucerne meal block contains appreciable quantities of essential minerals but in relation to calcium, phosphorus is low (calcium-phosphorus ratio need to be corrected to 2:1); copper and manganese contents are also lower than its critical values recorded in the literature. Therefore, further fortification of the block with these minerals is suggested. The Lucerne block can be used as a supplemental feed for the desert livestock maintained on dry roughage diet.

Value Added Feed Products from *Prosopis juliflora* pods

Recently, technologies for processing of *Prosopis juliflora* pods have been developed at CAZRI using modified Multi-purpose Plot Thresher (MPPT) and Full Circle Hammer Mill (FCHM) by which different value added pod fractions can be obtained (Plate 9). These milling products can be used for production of various animal feed products (Bohra *et al*, 2010). The milling process involves collection of mature pods

Plate. 9. Milling of *Prosopis juliflora* Pods for Production of Supplemental- and Complete-block

from the field, which after drying in the sun are milled either by MPPT or by using FCHM. Out of 25 different fractions separated by MPPT milling the 3-products (fibrous epicarp, amorphous mesocarp and fibrous endocarp) were used for production of value added multi-nutrient feed-blocks and multi-nutrient feed mixture.

For obtaining different fractions of *P. juliflora* pods through Full Circle Hammer Milling, first freshly collected pods were sun dried and hammer milled to pass through coarse sieve (A). This product was further hammer milled and passed through medium sieve (B), which was subsequently sieved through traditional sieves to obtain 4 fractions, viz., B_1, B_2, B_3 and B_4. First, fraction B was sieved through wheat-grain (GS) sieve. The un-sieved material obtained on sieving of this fraction was termed as B_1, and the sieved material was further sieved through wheat-flour sieve (FS). The un-sieved material obtained on sieving of B_1 was termed as B_2, and material passed through the sieve was further sieved through *Maida* sieve (MS). The material could not passed through MS sieve was termed as B_3, and which passed through the sieve was termed as B_4. All these milling products were analysed for various proximate components (Table 13).

Table 13. Proximate Principles and Gross Energy Content (100 g^{-1}) of *Prosopis juliflora* Pods and its Milling Products

Feed ingredient	Preformed water	Ash content	Organic matter	Crude protein	Ether extract	Total CHO	Gross energy, kcal
A	4.02	5.75	94.25	14.44	2.90	76.91	428.03
B	3.89	4.75	95.25	11.75	2.20	81.30	424.46
B_1	3.70	3.25	96.75	7.35	1.40	88.00	419.88
B_2	4.38	3.75	96.25	8.46	1.50	86.29	420.00
B_3	3.72	8.00	92.00	13.40	3.10	75.50	418.18
B_4	3.43	11.75	88.25	17.39	1.00	69.86	397.57
Mean ±S. E.	3.86 ±0.13	6.21 ±1.30	93.79 ±1.30	12.13 ±1.54	2.02 ±0.35	79.64 ±2.81	418.02 ±4.35

A: PJ pods hammer milled, passed through coarse sieve, **B**: A, further hammer milled and passed through medium sieve, **B_1**: Residue, when B sieved through wheat grain-sieve, **B_2**: Residue, when B_1 sieved through wheat-flour sieve, **B_3:** Residue, when B_2 sieved through *Maida* sieve, **B_4**: B_2 (fine powder), passed through Maida sieve.

Out of A and B products obtained by FCHM milling, only fine portion (B) was used for production of complete and supplemental fodder blocks using hydraulic fodder block making machine. Adoption of such products help in generating employment in the rural sector and at the same time also help to augment livestock productivity in the drought prone areas. These products are not only cheaper but also nutritionally superior over the standard formulations.

Macro- and micro-mineral contents of *P. juliflora* (PJ) pods milling products obtained by hammer milling of sun dried freshly harvested pods, and subsequent sieving with conventional sieves, were determined with AAS and ICPESM. Similarly, complete- (CPJ) and supplemental-blocks (SPJ), lentil straw block (LS), and 10% urea containing multi-nutrient block (MNB) were also analysed for the mineral contents. The calcium contents (0.51±0.028%) of PJ pods and its milling products (PJMP) were comparable with its critical values (0.21-0.52%) reported in the literature. Calcium contents of CPJ, SPJ, LS and MN blocks were 0.60%, 1.32%, 2.19% and 3.83%, respectively (Table 14); phosphorus level (0.15±0.020%) in PJMP was lower than its critical values (CV, 0.16-0.37%) reported in the literature.

Table 14. Macro-mineral Contents (100 g^{-1}) of *Prosopis juliflora* Pods, its Milling Products and Fodder Blocks Produced from the Milling Products

Commodity	Calcium	Phosphorus	Ca: P	P: Ca	Magne-sium	Potass-ium	Sodium
PJ pods, summer	0.54	0.15	2: 0.57	1: 3.48	0.14	1.11	0.07
PJ pods, winter	0.40	0.14	2: 0.72	1:2.77	0.09	1.20	0.10
PJ pod fraction **A**	0.50	0.20	2: 0.79	1: 2.52	0.17	1.09	0.09
PJ pod fraction **B**	0.44	0.24	2: 1.07	1: 1.87	0.12	1.28	0.08
PJ pod fraction $\mathbf{B_1}$	0.58	0.07	2: 0.25	1: 7.94	0.05	0.66	0.05
PJ pod fraction $\mathbf{B_2}$	0.63	0.07	2: 0.23	1: 8.55	0.10	0.70	0.09
PJ pod fraction $\mathbf{B_3}$	0.53	0.13	2: 0.50	1: 3.97	0.16	1.50	0.13
PJ pod fraction $\mathbf{B_4}$	0.42	0.16	2: 0.77	1: 2.59	0.24	1.68	0.11
Mean ± S. E.	0.51 ±0.028	0.15 ±0.020	2: 0.62 ±0.100	1: 4.21 ±0.910	0.14 ±0.020	1.15 ±0.125	0.09 ±0.008
PJC	0.60	0.11	2: 0.36	1:5.53	0.23	1.37	0.16
PJS	1.32	0.23	2: 0.35	1:5.77	0.42	1.18	0.25
LSB	2.19	0.15	2: 0.14	1:14.15	0.38	0.83	0.34
MNB	3.83	0.31	2: 0.16	1:12.57	0.54	0.83	1.69
Critical value of mineral	0.21-0.52	0.16- 0.37	2: 1	1: 2	0.04-0.08	0.5	0.04-0.10

PJC: PJ, complete fodder block, 1% molasses; **PJS**, PJ supplemental fodder block; **LSB:** Lentil straw block; **MNB**: Multi-nutrient Block, 10% urea

A, B and B_4 contained 0.20%, 0.24% and 0.16% phosphorus, respectively, and PJC, PJS, LS and MNB possessed 0.11%, 0.23%, 0.15% and 0.31%, phosphorus, respectively. The data further indicated that magnesium, potassium and sodium levels in the PJMP were higher than its critical values, i.e., 0.04-0.08%, 0.5% and 0.04-0.10%, respectively. The essential micro-mineral analysis of *P. juliflora* pods and its milling products revealed that cobalt, iron and molybdenum level of these feeds were higher than its critical values, viz., 0.1 ppm, 0.10-0.30 ppm and 0.5 ppm, respectively. Copper contents of most of these feeds were higher that its critical value (5 ppm) but A and B_2 possessed only 1.5 ppm and 4.2 ppm copper, respectively (Table 15). Manganese and zinc contents of all most all samples of the pods and milling products were lower than its respective critical values, viz., 20-40 ppm and 35-50 ppm. Non-essential micro-elements, viz., aluminium, boron, cadmium, nickel and lead levels in the pods and milling products were 839.44±189.34 ppm, 36.67±2.68 ppm, 48.29±9.02 ppm, 282.94±40.92 ppm and 17.34±5.10 ppm, respectively (Table 15). The result of the macro- and micro-mineral analysis of *P. juliflora* pods and hammer milling products indicated that these products are rich in most of the nutrients but deficit in phosphorus, copper, molybdenum and zinc, therefore fortification of PJMPs with these minerals is suggested.

Table 15. Micro-mineral Contents (ppm) of *Prosopis juliflora* Pods, its Milling Products and Fodder Blocks Produced from the Milling Products

Commodity	Essential micro-minerals							Non-essential micro-elements				
	Cobalt	Chro-mium	Copper	Iron	Manga-nese	Molyb-denum	Zinc	Alumi-nium	Boron	Cadmi-um	Nickel	Lead
PJ pods, summer	9.4	8.3	15.5	84.2	10.5	582	16.2	742	36.08	41.63	238	40.4
PJ pods, winter	8.7	8.43	39.7	3.7	0.2	683	12.4	142.8	34.55	41.09	258	39
PJ pod fraction **A**	8.9	7.9	1.5	266	9.9	480	27.1	805.2	36.08	77.79	401.9	14.1
PJ pod fraction **B**	11	10.3	7.2	28.5	2.1	619	17.6	738.9	45.27	95.77	504.5	16.8
PJ pod fraction $\mathbf{B_1}$	8	13.6	2.8	4.4	1.9	617	9.6	609	46.08	23.89	196.7	10.1
PJ pod fraction $\mathbf{B_2}$	14	13.3	4.2	46.1	4.1	592	16.3	766.2	21.48	45.68	245	7.3
PJ pod fraction $\mathbf{B_3}$	7.6	16.4	12.9	548	26.3	687	25.8	871.4	37.97	23.85	145.4	3.2
PJ pod fraction $\mathbf{B_4}$	9	10.4	11.3	245	17.4	603	23.4	2040	35.87	36.62	274	7.8
Mean ± S. E.	9.46 ±0.67	11.08 ±1.08	11.89 ±4.35	153.29 ±67.27	9.05 ±3.20	607.88± 22.99	18.55 ±2.23	839.44 ±189.34	36.67 ±2.68	48.29 ±9.02	282.94 ±40.92	17.34 ±5.10
PJC	8	13.7	32.7	944	19.9	553	23	606.4	35.27	41.83	248	40.6
PJS	8.4	22.7	25.4	183	37.1	496	95.1	851.4	40.67	25.57	196.7	13.3
LSB	12	17.6	18.1	1015	121	783	62.5	3880	41.67	44.83	196.7	14.4
MNB	17	9.52	46.2	627	140	595	222	672.7	50.48	31.86	299.3	32
Critical value of mineral	0.1		5	0.10-0.30	20-40	0.5	35-50	-	-	-	-	-

PJC: PJ, complete fodder block, 1% molasses; **PJS**, PJ supplemental fodder block; **LSB:** Lentil straw block; **MNB**: Multi-nutrient Block, 10% urea

Feed-block and Nutrient-mixture Supplementation in Farmers' Livestock: On-farm trials were conducted to assess the acceptability and effect of feed block supplementation in farmers' cattle and buffaloes maintained on rangeland pasture. On the basis of their acceptability by the livestock, the farmers' liked feed blocks, formulated and produced at CAZRI. The feed block supplementation, increased feed and water intake, corrected pica, characterized by the animals craving for unwanted feed materials (including geophagia). Farmers' noticed that the block feeding also regulated rumination. On an average, there was an increase in the daily milk yield by 18% in cows (5.01±0.39 to 5.91±0.42, l animal^{-1}day^{-1}), and 18.7% (6.59±0.31 to 7.82±0.38, l animal^{-1}day^{-1}) in buffaloes; an increase of 1.5, l milk animal^{-1}day^{-1} was recorded in some of the buffaloes, (Patel *et al*, 2003). It became visible from 5th to 10th day of introduction of the block. A 2 kg block lasted for 7 days in cattle and 5 days in buffalo. The farmers of Kalyanpur village reported that block introduction increased daily milk yield by one litre over its initial production of 3.5 to 4.0, l cow^{-1}day^{-1}. The blocks were also supplied to the farmers of Kutchch region. Recently, CAZRI's multi-nutrient feed blocks (MNB) have been evaluated on the farmers' cows by KVK, Kalukheda in Ratlam district of Madhya Pradesh. The MNB supplementation lasted for 100 days period. The block supplementation resulted into increase in daily milk yield by 19.5% and milk fat by 0.7% (Shrivastava, 2010, personal communication). CAZRI's blocks have also been evaluated on Deoni cattle maintained at cattle breeding farm, College of Veterinary & Animal Sciences, Udgir (Dist. Latur, Maharastra), and were found advantageous at both the sites. On-farm study conducted at CRIDA, Hyderabad, on supplementation of UMMB licks to crossbred cows maintained under a smallholder mixed farming system, revealed that block supplementation considerably increased feed intake, milk yield and maintained live weight and body condition score (Misra *et al*, 2006). Farmers reported that supplementation of UMMB considerably improved straw consumption, milk yield and general health of the animals with enhanced cash benefit of over Rs. 10 day^{-1}cow^{-1} under smallholder mixed farming system. The supplementation technology was thus found to be a cost-effective approach for maximizing the utilization of locally available feed resources for better animal productivity during the dry season in a rainfed agro-eco-system of India.

Extensive study was conducted on evaluation of multi-nutrient mixture in multiparous lactating *Parbatsari* goats, maintained by landless goat owners of *Raika* community of village Bassi in Nagaur district. All the animals were let out for grazing and browsing to meet out their nutritional requirement on village common grazing lands. The treatment group of animals was offered daily 100 g animal^{-1} day^{-1} of nutrient-mixture after grazing for a period of 60 days. The peak yield of *Parbatsari* goats is normally attained in 90 to 120 days, which was further extended for next 50 days in supplemented group, and total lactation yield was also significantly increased by 38 l (Table 16). The cost of 60 days supplementary feeding of nutrient-mixture was estimated to be Rs. 48/- and by sale of additional milk produced by supplemented group of animals, the farmer could earn Rs. 342/-. Nutrient-mixture has been found economical as returns were to the tune of about 6 times of the cost of the nutrient-mixture (Patel and Bohra, 2006).

Table16. Milk Yield Performance of *Parbatsari* Goats offered Multi-nutrient Feed Mixture

S. No.	Trait	Control animals	Experimental animals
1.	Lactation yield at 90th day, l animal^{-1}day^{-1}	82.9±1.46	84.0±1.86
2.	Lactation yield at 150th day, l animal^{-1}day^{-1}	138.8±2.36	153.6±1.45
3.	Total lactation yield, l animal^{-1}	174.6±4.28	212.2±4.36
4.	Peak yield, l animal^{-1}day^{-1}	1.20±0.01	1.40±0.03
5.	Lactation length, days	227.9±4.2	235.5±3.01

Recently, under National Rainfed Area Authority (Planning Commission), Government of India funded project, entitled, "Livestock centric intervention for livelihood improvement in Nagaur district of Rajasthan", a feeding trial of multi-nutrient feed block (MNB) as a supplement to the lactating cows and buffaloes was conducted at 57 farmers' field spread over in 12 villages of Nagaur district. This trial was selected for a particular micro-situation where farmers were unable to provide balanced ration to their animal due to unawareness and lack of essential nutrients. Animals in this situation met out their nutrient requirement mainly through grazing and stall feeding of dry fodder of crops residues. The concentrate feed, which was prepared by locally available feed ingredients, was also supplemented to the lactating animals as per the milk production level. The concentrate feeds are not often in balance form, but deficient in some minerals and vitamins. Therefore, the feeding of MNB and multi-nutrient mixture (MNM) to the large ruminants and goats, respectively, was found suitable under this micro-situation.

10-12 blocks (2-kg each) were provided to each animal (cows/buffalo) for a period of 3 months to overcome the deficiency of nutrients. The block was kept near the feed manger for the free access during the stall feeding. One block was generally consumed by the animal within 7 to 10 days depending upon the need of the animal (Plate 1). The effect of block licking was observed on milk yield of the animal. The average daily milk yield of cow and buffalo was 4.32 and 5.26, l animal^{-1}day^{-1} (Table 17), respectively, before the feeding of MNB, however, after the feeding it, the trend of increasing in daily milk yield was observed just after 3-4 days. The peak daily milk yield was observed in both cows (6.67, l cow^{-1} day^{-1}) and buffaloes (8.28, l buffalo^{-1} day^{-1}).

Table 17. Effect of Supplementation of Multi-nutrient Feed Block on Milk Yield in Farmers' Cows and Buffaloes

Village	Cow		Buffalo	
	Initial milk yield, l animal^{-1}day^{-1}	Peak milk yield, l animal^{-1}day^{-1}	Initial milk yield, l animal^{-1}day^{-1}	Peak milk yield, l animal^{-1}day^{-1}
Khanwar	3	4	6	6.25
Ratanga	4.25	4.50	4.0	6.5
Somana	2	3	6.8	8.65
Tarnau	-	-	6.5	8.25
Dheri	9.0	9.1	6.5	8.5
Rohina	4.0	4.5	8.2	8.8
Harsolaw	4.5	6.75	7.1	10.35
Karwasro-ki-dhani	3.5	5.0	6.7	7.2
Bhatiyon-ki-Dhani	-	-	6.4	8.4
Lamba Jatan	-	-	7.5	8.3
Betan	-	-	8.0	10
Pundlu	-	-	6.4	8.2
Average	4.32	5.26	6.67	8.28
% Increase		21.7		24.1

In case of goat husbandry the animals met out their feed requirement mainly by grazing except during post-parturient period of 15 days, when these goats were supplemented with concentrate feed. In this micro situation the goats get quality forage during monsoon and post monsoon period (July to November) and for rest of the period animal depend on the poor quality forage during lean period (December to June). The supplementation of either concentrate or roughage to the small ruminants is not practiced in this region due to more numbers of animals per flock, socio-economic conditions of the farmers, etc. This deficiency of nutrients can be rectified through supplementation with vitamin-mineral mixture to the animals but the acceptability of vitamin-mineral mixture was poor in the animals due to the bad odour of organic compounds present in the minerals mixture. Therefore, the vitamin-minerals mixture powder was supplemented to the animals through nutrient-mixture @ 100 g goat^{-1}day^{-1} after grazing hours (Plate 4). This was formulated in the feed technology unit of CAZRI, which comprised of molasses, urea, common salt, vitamin-mineral mixture, dolomite, wheat bran and guar meal. The effect of nutrient mixture supplementation on milk yield of lactating goats was found significant. The average daily milk yield of selected goats was 1.37, l goat^{-1}day^{-1}, which increased maximum up to 1.94, l goat^{-1}day^{-1} (41.8 %) during the feeding trial (Table 18). The farmers reported increased intake of forage and water in treated group.

Table 18. Effect of Supplementation of Multi-nutrient Mixture on Milk Yield of Farmers' Goats

Name of village	Initial milk yield, l animal^{-1}day^{-1}	Peak milk yield, l animal^{-1}day^{-1}
Khanwar	2.0	2.25
Ratanga	1.0	1.35
Somana	2.5	3.0
Tarnau	1.25	2.25
Deheri	1.3	2.5
Rohina	1.0	1.3
Harsolao	2.0	3.0
Karwasro-ki-dhani	0.70	1.2
Bhatiyon-ki-dhani	1.25	1.7
Lamba Jatan	1.3	1.6
Betan	1.2	1.8
Pundlu	0.90	1.3
Average	1.37	1.94
% Increase	-	41.8

Technology Adoption

The supplement feed and its production technologies developed at CAZRI have been evaluated under Institute Village Linkage Programme (IVLP) of National Agricultural Technology Projects (NATP). Farmers, unemployed rural youths and school drop-outs have successfully adopted the technology for commercial production of feed-blocks and nutrient-mixture in villages. The feed block production technology has been disseminated among the farmers and entrepreneurs through organizing 'on-campus' and 'on-farm' trainings (Plate 10), farmers' fairs, field days, exhibitions and arranging exposure visits of the livestock owners and unemployed rural youths.

Plate. 10. On- and Off-farm Trainings for Farmers' and Entrepreneurs

It has been perceived from the feedback that the feed block production technology developed at the CAZRI can easily be adopted by the rural entrepreneur because of its simplicity, using locally fabricated gadgets, and the feed ingredients, which can be obtained from the local market. As far as the adoption of this technology is concerned, the technology of multi-nutrient-feed-block/-mixture production developed by CAZRI has successfully been adopted by 3 farmers (viz., Sarva Shri Deda Ram Patel, Village: Ghajangarh, Tehsil: Rohit, Pema Ram Patel, Village: Aratia, Tehsil: Rohit and Gheesu Lal Chaudhary, Village: Sonaimaji, Tehsil Pali Marwar) of Pali district and 2 farmers (S. Shri Chena Ram, Berdon-ka-bas, Tehsil Osian and Gordhan Ram Patel, Dalibai ka Temple, Jodhpur) of Jodhpur district for commercial production in the region. Recently. under social welfare programme, Ambuja Resource centre, Marwar Mundwa, produced 226 q CAZRI's multi-nutrient mixture and distributed to 195 livestock owners of 10 villages of Nagaur district.

Recently under National Rainfed Area Authority (NRAA) funded Project entitled "Piolet Study on Livestock Centric Intervention for Livelihood Improvement in Nagaur District of Rajasthan" the Complete feed block Machine (Plate 11) with Feed-fodder Mixer and feed Grinder have been installed at *Sant Bhuria Baba Gaushala*, Harsolav village. The main aim of this feed technology is to demonstrate the significance of feeding of complete feed blocks under scarcity and drought period of arid region of the country. Since the poor quality of forage and crop residues are only available during such situation, which are often low in protein, energy, minerals and vitamins. However, these fodder blocks will not only maintain the animal body but sustain the milk production in bovine under scarcity and drought conditions. This kind of field trial of complete feed block has been initiated first time at farmers door in arid area of Rajasthan with people participation mode. Scientists of CAZRI will give technologies to develop low cost nutritionally balance ration through these feed blocks involving local feed resources. The total expenditure of Rs 10 lakhs was involved in establishing this Feed Block Unit at gaushala and farmers of 12 villages of Merta and Jayal Tehsils of Nagaur District will be benefitted with this unit. This machine produces 25 blocks of 4 kg of weight in one hour time (100 kg/hr).

Plate. 11. Complete Feed Block Machine at *Gaushala*, Harsolav Village (Nagaur)

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