Latest Sheep Technology and Innovations: Meat, Wool and Milk

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डॉ सैयद मोहम्मद खुर्शीद नकवी
निदेशक
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Sheep farming is a traditional occupation of shepherds in arid, semiarid, coastal and mountain harsh topographies of the country. In the recent past, sheep farming has been undergoing rapid changes with the growing demand of mutton and remunerative price in the market. To enhance the sheep production, the adoption of newer economic and viable technologies is important. ICAR-CSWRI, Avikanagar is a premier institution engaged in research and development activities of sheep and wool. It has developed a large number of technology and innovations in sheep production and management in the recent past. Many of them are being used by the farmers in their flocks and harvesting the benefit of it in terms of increase in production of wool and mutton and higher return. Still, many of the technologies are not being used by the farmers in-spite of their positive perception for the technology, due to lack of capital, awareness and direction from the government and extension agencies. The aim of this publication is to provide the stakeholders with up-to-date knowledge of sheep production and utilization technologies to enhance per animal productivity and to meet outrising demand of mutton and wool in the country.

It is hoped that this compilation on sheep technology and innovations would be welcome by the farming community, extension workers, scientists, students, veterinarians, woollen industries and teachers, which will result in the increased awareness about these technologies and pave the way for early adoption. I express heartfelt appreciation to all the scientists of Institute for supporting in the development of the present publication. I also acknowledge the contributions made by Drs A. K. Shinde, Y.P. Gadekar, BasantiJyotsana, ArpitaMohapatra in editing and compilation of the publication.

(S.M.K. Naqvi)

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About the University

VISION

Sustainable sheep production to address the issues and to inspire an exchange of ideas among experts, policy makers, stakeholders, industrial leaders and general public

MANDATE

- Basic and applied research on sheep husbandry
- Dissemination of technologies for sheep productivity enhancement and management

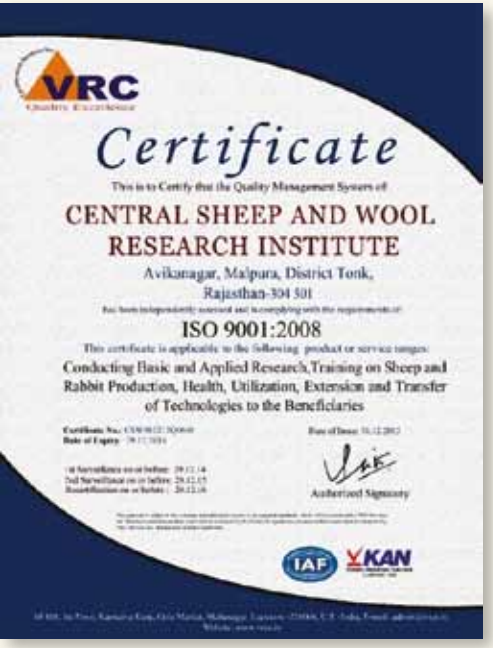
OBJECTIVES

- To undertake basic and applied research on all aspects of sheep production
- To develop, update and standardize meat, and fibre technologies
- To impart trainings on sheep production and utilization
- To transfer improved technologies on sheep production to farmers, rural artisans and development workers
- To provide referral and consultancy services on production and products technology of sheep

INSTITUTE HISTORY

The ICAR-Central Sheep and Wool Research Institute is a premier Institute, of Indian Council of Agricultural Research (ICAR) engaged in research and extension activities primarily on sheep and wool. It was established in 1962 at Malpura in Rajasthan. Now campus is popular by the name of Avikanagar. The campus is spread over an area of 1591.20 hectare.

Name and address of Institute	ICAR – Central Sheep and Wool Research Institute, Avikanagar 304 501 Rajasthan
Head Quarter	Avikanagar, Rajasthan
Regional Stations	Arid Region Campus Beechwal, Bikaner 334 006 Rajasthan
	North Temperate Regional Station, *Garsa* (Kullu) 175 141 Himachal Pradesh
	Southern Regional Research Centre, Mannavanur, Kodaikanal – 624 103 Tamil Nadu



It has three Regional Research Centres in different climatic zones of the country to develop region specific technologies. North Temperate Regional Station (NTRS) was established in 1963 in temperate region at Garsa, Kullu in Himachal Pradesh. The Southern Regional Research Centre (SRRC) was established in 1965 in sub-temperate region at Mannavanur in Tamil Nadu. Arid Region Campus (ARC) was established in 1974 at Bikaner in arid region.

TRAINING AND CAPACITY BUILDING

Institute organizes training programmes for field veterinarians, women and farmers in different areas of sheep production and health, capacity building and skill development in sheep sector, woollen and handicraft products and sheep rearing practices

1. CONSULTANCY AREAS

The Institute through a team of Scientists and Technical Officers provides consultancy services to woolen industries, Central Wool Development Board, Commercial farms, Animal Husbandry Departments etc. on sheep farming and economic, wool grading, processing and products etc.

2. EDUCATION

Institute has linkages and collaborations and also entered into MoU with following Universities and Institutions for post graduate and Ph.D. programmes.

1. RAJUVAS, Bikaner	7. Mewar University, Chittorgarh
2. MAFSU, Nagpur	8. IIS University, Jaipur
3. CGKV, Durg	9. SHIATS, Allahabad
4. NDRI, Karnal	10. UPTTI, Kanpur
5. IVRI, Izatnagar	11. IICT, Bhadohi
6. Banasthali Vidyapeeth, Tonk	

PATENTS FILED

1. Indigenous progesterone impregnated vaginal sponges for estrus synchronization in sheep
2. Method to deliver nematophagous fungus, *Duddingtonia flagrans* to sheep for biological control of Haemonchus *contortus*
3. Area specific mineral-mixture pellets for augmenting reproduction and production in sheep
4. Production of fermented probiotic feed, production protocol, fermentation conditions, drying, storage and uses thereof
5. Fermentation vessel for conducting gas production studies (*in-vitro*): fabrication, protocol and uses
6. Low cost, indigenous cradle for safe restraining of sheep for pregnancy diagnosis

7. Low cost, indigenous vaginal sponges for estrus control in buffaloes
8. Identification of cashmere (Pashmina) fibre from processed textile products by PCR- based technique
9. Table top paddle Charkha for Cashmere (Pashmina) fibre

COPY RIGHTS

1. Computer software work- FROGIN (Forecasting for Rajasthan on ovine gastrointestinal nematodiasis) (SW-8118/2014) by C.P. Swarnkar, D. Singh, F.A. Khan and V.K. Singh
2. Cinematograph film work- semen collection and artificial insemination (AI) in sheep (CF-3786/2014) by S.M.K. Naqvi
3. Cinematograph film work- estrus synchronization in sheep and goats (CF-3785/2014) by S.M.K. Naqvi

MAJOR ACCOLADES

1. ICAR award for the outstanding research contribution in small ruminant production for the biennium 1997-98 to S.M.K. Naqvi, Anil Joshi, Rajeev Gulyani, G.K. Das and J.P. Mittal
2. ICAR award for the outstanding research contribution in genetic improvement of sheep for the biennium 2003-04 to V. K. Singh, A. L. Arora, A. K. Mishra, D. Singh, S. M. K. Naqvi, Anil Joshi, C. P. Swarankar and Satish Kumar
3. Dr Rajendra Prasad Puruskar of ICAR for technical books in Hindi in the field of agriculture and allied sciences for the year 2005-06 to S.C. Dubey, A.K. Shinde and B. N. Singh for their book on Applied Animal Husbandry (Cattle, buffaloes, sheep, goats, pig, horse and camel)
4. Lal Bahadur Shastri young scientist award of ICAR for the biennium 2007-08 to Suresh A. for his research work on production and utilization of wool and woollens in India
5. Lal Bahadur Shastri young scientist award of ICAR for the biennium 2011-12 to V. Sejian for his research work on multiple stresses in sheep

SERVICES

Institute extend following facilities to farmers and stakeholders through transfer of technology and extension activities in adopted villages around Institute

1. Supply of breeding seed stocks
2. Vaccination and drenching
3. Medicine and treatment of sick animals
4. Wool procurement and processing
5. Product manufacturing
6. Feed blocks/supplementary feed

FACILITIES

Institute extend following facilities to farmers/ stakeholders / industries/entrepreneur on payment basis

1. Testing of wool and woolen products
2. Testing of meat and meat products
3. Analysis of feed and fodder
4. Disease diagnosis
5. Semen analysis and pregnancy diagnosis
6. AI in sheep with chilled semen
7. *FecB gene* genotyping of sheep
8. Detection of adulteration in Pashmina fibre products

ACTIVITIES

- Institute is working with farmers in districts of Rajasthan, Tamil Nadu and Himachal Pradesh under Institute programme
- Supplying elite germplasm to farmers through Network and Mega Sheep Seed Projects in the state of Rajasthan, Maharashtra, UP, Andhra Pradesh, Tamil Nadu, Jharkhand and Karnataka
- Institute imparts training and demonstration to farmers, artisans and stakeholders on various aspects of sheep production and utilization
- Strengthening sheep farming in villages under Mera Gaon Mera Gaurav, Sansad Adarsh Gram Yojna, Transfer of technology and farmers participatory programmes
- Institute organizes Farmer's fair to show recent technologies and innovations
- Organizes Field days, Health camps, Kisan goshti in the villages etc.
- Display institute exhibitions in ICAR institutions/ SAUs and SVUs
- Organizes training for farmers of ATMA, Watershed programmes etc.
- MSM alert service: Farmers receive alert message about management and health practices regularly
- Institute link to Kisan Call Centre and address queries of farmers
- Films/videos on important technologies displayed to farmers
- Folders/brochures regularly published and made available to farmers

MAJOR RESEARCH AREAS

- *FecB* gene introgression from Garole in non-prolific sheep for multiple births
- Genetic improvement of sheep for enhancing mutton and wool production
- Breeding of sheep for resistance/resilience to gastrointestinal nematodes
- Intensive feeding of lambs for enhancing mutton production
- Use of prickly pears in sheep feeding
- Ration balancing to reduce methane emission
- Melatonin receptor in sheep in relation to reproductive seasonality
- Genetic variability in immune response of sheep and goat for PPR and ET vaccine

- Indigenous impregnated sponges for estrus synchronization and AI with chilled semen
- Accelerated lambing system (3 lambs in 2 years) to increase life time production
- Single strategic anthelmintic intervention during mid to late monsoon
- Targeted selective treatment (TST) approach to reduce use of anthelmintic
- Neonatal mortality losses and prevention
- Identification of adulteration in Pashmina fibre with other fibres
- Fibre rich and low salt healthier and designer mutton products
- Mozzarella cheese and paneer from sheep milk
- Carcass evaluation and yield
- Training on different aspects of sheep production

IMPORTANT MILESTONES OF THE INSTITUTE

1962 - Established Institute at Avikanagar

1963 - Established NTRS, Garsa, Kullu

1964 - Introduced Romney Marsh, South Down and Rambouillet sheep

1965 - Established SRRC, Mannavanur

1967 - Established Office cum Laboratory building at Avikanagar

1968 - Wet processing and spinning plant at Avikanagar

1969 - Post Graduate Hostel building

Introduced Corriedale sheep at SRRC, Mannavanur

1971 - Introduced Soviet Merino sheep

1974 - Established ARC, Bikaner

Introduced Dorset and Suffolk sheep

1975 - Introduced Karakul sheep at Bikaner

1977 - Developed Avikalin and Avivastra sheep

1978 - Introduced rabbits at NTRS Garsa

1981 - New Administrative Building at Avikanagar

1982 - Introduced rabbits at CSWRI, Avikanagar and SRRC, Mannavanur

1985 - Established Nutrition, Physiology and Biochemistry (NPB) building

1986 - Developed disease data information system for organized sheep farm

Developed Bharat Merino sheep

1988 - Administration cum Laboratory building at ARC, Bikaner

Implemented planned flock health calendar

1990 - First lamb born by pelleted frozen semen

1992 - First lamb born through embryo transfer technology

Established Asian Small Ruminant Information Centre

1995 - Kendriya Vidyalaya School building at Avikanagar

		Office cum Guesthouse at Jaipur
1996	-	Introduced Awassi sheep
1997	-	Introduced Garole sheep
		Merged Goat Unit of WRRC, CIRG in CSWRI, Avikanagar
		Established VSAT facilities at Avikanagar
		Implemented single anthelmintic drench per annum in sheep at Avikanagar
2004	-	Guesthouse at Avikanagar
		Recovered 24 embryos in single flushing from Garole sheep
		Implemented Region specific worm programme for sheep flocks in Rajasthan
2007	-	Animal Biotechnology building
		Auditorium building
2008	-	Introduced Patanwadi sheep at Avikanagar
2010	-	Introduced Kendrapada sheep at Avikanagar
2011	-	ATIC Centre building at Avikanagar
2012	-	Wi-Fi connectivity in the campus
2013	-	Extended NPB building
		Extended LPT building
2014	-	Security, Sale counter, Horticulture building, Community hall, shed at Bikaner
2015	-	Kisan ghar, Sheep washing unit, Machine shearing unit
		Sport complex, Children park, Herbal garden, Shopping complex
		Office boundary wall, PM room and Sheep Health lab, sheep sheds
2016	-	Released Avishaan – a prolific sheep for field testing

Avishaan: A Prolific Sheep

Most of the Indian sheep give single lamb except Garole, Kendrapda and Edka sheep of eastern region. They give twins/triplets, but have a body weight of 15-16 kg at adult age. In the country, demand of meat is growing rapidly, a prolific sheep bearing twin/triplet with higher body weight is required. Improving prolificacy in sheep flock could enhance the profitability of sheep owners as the maximum income comes from lamb. After realizing the importance of *FecB* mutation, a cross breeding scheme was initiated in 1997 to introgress the *FecB* gene from prolific Garole sheep of the Sunderban area of West Bengal into non-prolific large size mutton sheep breed Malpura of Rajasthan to produce Garole x Malpura (GM) crossbred carrying *FecB* gene. Encouraging results were obtained in GM half-bred in terms of increasing twinning 40-45% with overall survivability of 90%. Due to lower body weights of GM lambs as compared to Malpura, a need was felt to improve the prolific GM sheep for relatively better growth by backcrossing with native Malpura. In the backcrossing programme, the *FecB* gene carrier GM rams were used as sires and Malpura ewes as a dam breed to produce the GM x Malpura (GMM) having 25% Garole and 75% Malpura inheritance and reciprocal crosses were also attempted to produce M (GM). The 3/4th crossbreds ewes so produced were able to produce twins (>50%) and also have a higher body weight compared to half-bred, but problem of low milk yield in dam persisted in the 3/4th crosses. The body weights of GMM lambs were also lower compared to Malpura lambs. The survivability of GMM has been more than 90% over the years. To overcome the problem of low milk yield in the dams for feeding twins/triplets and to enhance the live weights of lambs, Patanwadi sheep (a

Avishaan is a prolific sheep for increasing mutton production

heavy breed of Saurashtra region of Gujarat and famous for milk yield) was introduced in the GMM crosses during the year 2008. In this process, three breed crosses are being developed with the genetic constitution of 12.5% Garole, 37.5% Malpura and 50% Patanwadi inheritance in which *FecB* gene has been introgressed successfully.

Birth weight (kg)	3.28±0.03 (752)
3 month weight (kg)	16.76±0.19 (660)
6 month weight (kg)	25.90±0.31 (469)
12 month weight (kg)	34.69±0.46 (231)
Prolificacy (%)	46.42-57.14
Litter size	1.50
Adult survivability (%)	98.00

The results obtained so far are encouraging in terms of higher prolificacy, body weights, survivability and ewe productivity efficiency. Screening of *FecB* carrier lambs at an early age through PCR-RFLP and *inter-se* mating and selection are being followed to improve the prolificacy as well as other desired traits. The new genotype GMM x Patanwadi (Avishaan) sheep is being evaluated at the farm and field level.

Field testing

Two units (each of five females and one breeding ram) are established in villages. The animals possessing the *FecB* gene (B+) are provided. The initial results are encouraging as 50% twin lambing is observed. The pre-weaning survivability of lambs born from prolific ewes is around 95%. A total of ten sheep owners are provided Avishaan breeding rams. The ewe productivity efficiency of this genotype in the field conditions is 18.73 kg and 29.06 kg at 3 and 6 months of age, respectively which excelled the native Malpura sheep. From 100 breeding ewes, a sheep farmer can harvest 40 extra lambs in a year compared to non-prolific ewes with 85% lambing rate and 95% lamb survivability. He can earn extra income of Rs. one lakh (@ Rs. 2500 per lamb) in a year by selling 3-4 months old lambs.

Fat Tail/Rump Sheep (Dumba): Extra Ordinary Growth and Demand

The fat-tail type of sheep comprises about one third of the world's sheep population. The major biological role of fat is to serve as an energy store, providing the survival buffer against periodic feed scarcity such as drought. Fat tail/rump sheep is not a native of India and exact source of origin of fat tail sheep found in the country is not known. Fat tail/rump sheep has a large body size with higher growth rates. Fat tail/rump sheep has huge demand in the country as they have great aesthetic and religious value. The survey, conducted by the institute indicated that entrepreneurs and animal traders raise fat tail sheep and sell them at a higher price. The market price of these animals in the country is very high. Adult males are sold at the rate of Rs. 1.00-1.50 lakh, female Rs. 0.70 lakh and lambs Rs. 0.15-0.30 lakh.

Dumba is a fat-tail type sheep with higher growth rate and better adaptability

Different types of fat tail/rump sheep are found in the country: (1) Fat rump sheep: Fat is deposited on rump and tail is almost absent (2) Fat tail without fat rump sheep: Fat is deposited on tail. This type of animals is produced from the crossbreeding of exotic fat rump sheep with native sheep (Nagori Dumba) (3) Fat tail

and rump sheep: fat is deposited on both tail and rump. Few fat rump sheep were brought in 2014 and maintained under stall feeding in the institute. Pure breeding is being followed to maintain characteristic fat rump in their progenies. The growth, production and reproduction traits of fat rump sheep at the institute is given below:

Growth and reproduction traits of fat tail/rump sheep

Growth traits	Male (kg)	Female (kg)	Reproduction traits	Average (days)
Birth weight	4.5±0.21	4.1±0.28	Age at first service	312.8
3 month weight	32.8±2.43	31.0±1.22	Age at first lambing	465.5
6 month weight	48.2±3.00	45.0±2.02	Inter-lambing period	283.4
9 month weight	68.3±4.05	56.1±2.11	-	
12 month weight	79.3±4.52	66.7±1.67	-	

Malpura: A Promising Mutton Sheep of Semi-arid Region of Rajasthan

Malpura sheep is known for meat, milk and wool. Lambs can achieve body weight of 33-35 kg at 6 months of age under intensive feeding

Malpura, an indigenous mutton type sheep breed with coarse wool, is well adapted to harsh climatic conditions of semiarid region. It is found in Jaipur, Tonk and Sawai Madhopur districts of Rajasthan. Ewes yield 800-1000 ml milk daily in early lactation. In the institute, Malpura flock is maintained under intensive selection and improved management practice. The average 6 month weight, improved from 13.84 kg in the year 1974-77 to 25.74 kg in the year 2010-11 and 29.32 kg in 2015-16. Few extraordinary lambs attain a body weight of >42.00 kg at 6 months of age in semi-intensive management system. Malpura lambs have better growth efficiency under stall feeding and attain 33-35 kg body weight at 6 months of age on complete feed. They produced a dressing yield of 50-55%, lean content of 65-67%, fat 16-18% and bone 15-18%. Wool is coarse with a fibre diameter of 49.9 μ, medullation of 71% and staple length of 6.02 cm. Wool is found suitable for felt and other diverse use such as *dari, namda,* toys, wall hanging etc. Institute under Mega Sheep Seed project extending services to farmers and currently 3318 sheep of 50 farmers are covered. Every year about 50-60 superior Malpura rams from project are being supplied to farmers for improvement in their flocks.

Avikalin: A Dual Type Crossbred Sheep for Carpet Wool and Mutton

A crossbreeding programme for improving wool production and quality was initiated at CSWRI, Avikanagar in 1964-65 involving exotic fine wool breed (Rambouillet) and native extremely coarse wool breed (Malpura). The half-bred have been pooled and interbred and the new strain arising out of this base having 50% Rambouillet and 50 % Malpura inheritance has been named as Avikalin (Avi-Sanskrit word for sheep and Kalin- a Persian word for carpet). Avikalin was evolved in 1977 with the objective to produce an annual greasy fleece yield of 2 kg with fibre diameter around 30 μ and medullation 30%.

Avikalin is a promising dual type sheep for mutton and carpet wool

Since 1993, efforts were made to develop it as promising dual type sheep for mutton and carpet wool. Ram lambs are selected on the basis of an index incorporating six-month body weight and first six monthly GFY. Young rams are ranked and selected on their own performance basis. Information available on the progeny of these rams is utilized to finally select the rams for breeding purpose.

Body weights of 2.82, 17.16, 29.91, 33.31 and 37.15 kg at birth, 3, 6, 9 and and 12 months have been achieved, in semiarid region. Avikalin sheep produce about 80% more wool compared to native Malpura sheep. The overall means for 1st six monthly GFY and Adult annual GFY are 1.035 and 1.408 kg, respectively. The overall fibre diameter, medullation % and staple length in adult sheep are 35.78 μ, 36.19 % and 5.42 cm respectively. A small flock of Avikalin is also maintained at sub temperate climate of SRRC, Mannavanur, Kodai hills of Tamil Nadu. The performance of Avikalin are found much higher at sub temperate than hot semiarid climate. Avikalin has been used as an improved breed and has a great demand, particularly in the southern part of India to crossbred their local non-descript sheep.

Chokla: Best Carpet Wool Breed of Rajasthan

Chokla is best wool producing breed ofIndia, suitable for carpet manufacturing

Chokla sheep is found in the Shekhawati area of Rajasthan viz., Churu, Jhunjhunu, Sikar, Nagaur and border area of Jaipur and Bikaner. A superior flock of Chokla sheep is being maintained at ARC, Bikaner. Chokla is a carpet wool sheep breed. In the institute, male lambs are selected on the basis of index based on body weight and wool yield at 6 months of age. Chokla wool has fibre diameter of 30 m and medullation of 30% with staple length of > 6.0 cm. Since 1992, through an intensive selection and improved management in the institute flock, six month weight of the sheep has increased from 16.51 to 24.80 kg. Chokla lambs attained a body weight of 17.09 kg at 3, 24.80 kg at 6 and 32.22 kg at 12 months of age. A practice of three clips in a year has been adopted in Chokla sheep, they produced 2.36 kg greasy fleece yield annually. Superior rams are provided to farmers for breeding purposes from ARC, Bikaner.

Magra: A Lustrous Carpet Quality Wool Sheep

Magra sheep is found in Bikaner, Nagaur, Churu and Jhunjhunu districts of Rajasthan. A superior flock of Magra sheep is being maintained and improved through selection at ARC, Bikaner. Magra sheep has the unique characteristic of lustrous carpet wool. Magra wool has great demand in the carpet industry because of its lustrous properties. Lambs attained body weight of 24.0 kg at six months and 32.0 kg at twelve months. Three times shearing in a year is being practiced at ARC, Bikaner. Magra sheep produced 2.30 kg annual greasy fleece yield with a fibre diameter (32.0 µ), staple length (6.0 cm) and medullation (40-45%). Around 80-90 rams are being supplied to farmers annually for breeding purposes from ARC, Bikaner.

Chokla is best wool producing breed ofIndia, suitable for carpet manufacturing

Marwari: A Robust Sheep Breed of Arid Zone

Marwari is one of the important carpet wool producing sheep breed of north-western arid and semiarid region of India. The breed is hardy and well adapted to harsh climatic conditions of the hot arid region. This breed is considered to be highest in number and distributed widely in Rajasthan and Gujarat. Earlier good numbers of Marwari sheep were found in Jodhpur, Sirohi, Pali and Barmer district in Rajasthan and adjoining areas of Gujarat state. Now Marwari sheep has declined sizably. A superior flock of Marwari sheep is being maintained at ARC, Bikaner. In the institute flocks, since the year 1993 the body weight has improved by 56.35 % (from 15.9 to 24.86 kg) at 6 months of age. The adult annual GFY has improved from 1209 to 1526 g (26.22 %) by intensive selection and improved management practices. Marwari sheep yields 1.5 kg wool annually in two clips with a fibre diameter of 35-38 μ, staple length of 5.0 cm and medullation of 55 %. Superior Marwari rams are being supplied by the ARC, Bikaner to farmers for bringing genetic improvement in their flock.

Gaddi Synthetic: Fine Wool Sheep for Temperate Region

Gaddi Synthetic is crossbred sheep of temperate region for fine wool production. Gaddi Synthetic lamb attains body weight of 14 kg at 3 months, 19 kg at 6 months and 26 kg at 12 months of age. First six monthly and adult annual GFY are 0.840 and 1.796 kg respectively. The staple length, fibre diameter and medullation are 3.20 cm, 19.36 μ and 0.060 % respectively in six monthly clip. A total of 70-75 Gaddi synthetic sheep are supplied annually to the farmers in the region for genetic improvement in the flocks from NTRS, Gara, Kullu HP.

Gaddi Synthetic is a fine wool producing sheep for temperate region

Bharat Merino: Fine Wool Producing Sheep of India

In 1962, Rambouillet sheep from Texas, USA were introduced in Avikanagar, Rajasthan for evolving fine wool sheep through crossbreeding. Native sheep viz., Chokla, Malpura and Jaisalmeri breed were bred with Rambouillet for producing half bred. Half bred ewes were backcrossed with Rambouillet rams for producing ¾ Rambouillet. Similarly, the crossbreeding of native Chokla and Nali ewes with the Rambouillet and Russian Merino rams from the USSR was done since 1971 in the Institute. The ¾ crosses of both the projects were merged in the year 1982 and named as Bharat Merino. During the year 2008, Bharat Merino sheep were shifted from a hot semiarid climate of ICAR-CSWRI Avikanagar to cold climate of SRRC, Mannavanur and NTRS, Garsa. Presently a superior flock of Bharat Merino is being maintained at SRRC, Mannavanur.

Bharat Merino sheep produce apparel wool and one of the substitutes for exotic fine wool inheritance in the country.

Bharat Merino is fine apparel wool producing sheep for temperate and sub temperate regions

At Mannavanur, Bharat Merino sheep attain body weights of 19 kg at 3 months, 25 kg at 6 months and 35 kg at 12 months of age. The ram and ewe of Bharat Merino produce clean greasy fleece yield of 1.83 and 1.67 kg with a fibre diameter of 20 m,<1% medullation and 8 cm staple length. Elite rams of Bharat Merino sheep are being supplied to farmers from SRRC, Mannavanur. Bharat Merino sheep are in good demand from farmers of Karnataka state. Farmers are using Bharat Merino for upgrading Bannur/Mandya sheep for increasing meat and wool yield.

Sirohi: Dual Purpose, Hardy Goat Breed of Rajasthan

Sirohi is a dual purpose (meat and milk) goat, mostly distributed in semi-arid region of Rajasthan. They are well adapted to a wide range of climates. The Sirohi unit of AICRP on Goat improvement was established at Avikanagar in 1976. In the research project, selective breeding is being practiced to genetically improve the breed. The bucks are selected based on a selection index incorporating 9 month body weight and dam's 1st lactation 90 day milk yield. Intensive selection and improved management are being followed in a Sirohi flock that has improved the nine and twelve month body weights from 16.95 and 21.55 kg in the year 1976 to 29.26 and 34.92 kg in the year 2014. Sirohi kids attain a body weight of 12.13 kg at 3 months, 19.65 kg at 6 months, 27.86 kg at 9 months and 33.27 kg at 12 months of age. A Sirohi goat produces 119.06 kg milk in a lactation period of 194.62 days. The multiple births in a flock of institute vary from 6 to 15%. A total of 747 animals have been supplied to the farmers, Government agencies, NGOs etc. during last five years for breed improvement.

Sirohi is a best meat and milk purpose hardy goat breed of Rajasthan

Sheep genetic resource available in Institute, its Regional Stations, Network Project on Sheep Improvement and Mega Sheep Seed Project centres

Breed/strain/genotype	Purpose	Available at
Malpura	Meat, milk and coarse wool	ICAR - CSWRI, Avikanagar, Rajasthan
Patanwadi	Meat, milk and coarse wool	ICAR - CSWRI, Avikanagar, Rajasthan
Muzaffarnagri	Meat and coarse wool	ICAR - CIRG, Makhdoom, Uttar Pradesh
Deccani	Meat and coarse wool	MPKV, Rahuri, Maharashtra
Sonadi	Meat and coarse wool	Livestock Research Station, Navania, Vallabhnagar, RAJUVAS, Rajasthan
Chokla	Carpet wool	ARC, Bikaner, Rajasthan
Marwari	Carpet wool	ARC, Bikaner, Rajasthan
Magra	Carpet wool	ARC, Bikaner, Rajasthan
Avikalin	Carpet wool	ICAR - CSWRI, Avikanagar and SRRC, Mannavanur, Tamil Nadu
Bharat Merino	Fine wool	SRRC, Mannavanur, Tamil Nadu
Gaddi Synthetic	Fine wool	NTRS, Garsa, Himachal Pradesh
Garole	Meat	ICAR - CSWRI, Avikanagar, Rajasthan
Nellore	Meat	LRS, SVVU, Palamner, Andhra Pradesh
Madras Red	Meat	PGRIAS, TANUVAS, Kattupakkam, Tamil Nadu
Chhotanagpuri	Meat	Birsa Agricultural University, Kanke, Ranchi, Jharkhand
Mandya	Meat	LRIC, Nagamngla Mandya, Karnataka
Mecheri	Meat	Mecheri Sheep Research Station, Pottaneri, Mecheri, Salem, TNUVAS, Tamil Nadu

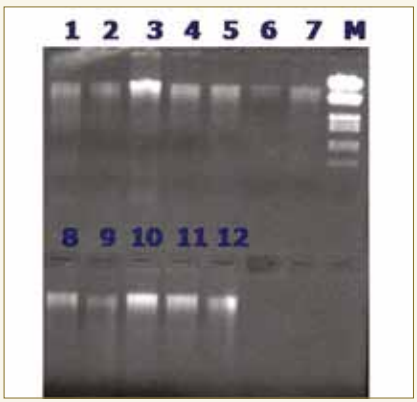
Molecular Technique for Identification of Adulteration of Meat of Sheep and Goats

The false labelling and substitution of apparently similar looking cheaper meat is sometimes practiced by local meat vendors / sellers due to price variation. PCR is commonly used molecular technique because of its sensitivity, specificity and ability to detect minute quantity of nucleic acids. The significant amounts of sequence variation exist in closely related animal species, which is useful for designing species specific primers.

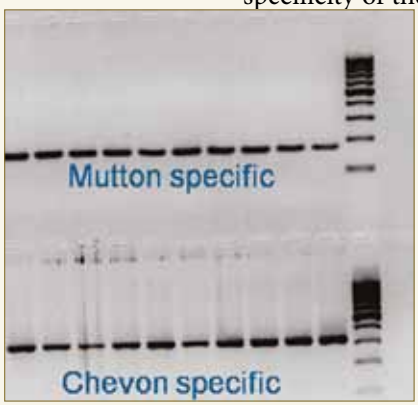
The DNA from the meat samples is extracted using DNeasy blood and tissue kit (Qiagen) following manufacturer instructions. Quality and quantity of DNA are ascertained using agarose gel electrophoresis and spectrophotometric analysis, respectively.

Ovine origin genomic DNA using forward (5'-atatcaaccacacgagaggagac-3') and reverse (5'-taaactggagagtgggagat-3') primers (product size 172 bp) and caprine origin genomic DNA using forward (5'-cgccctccaaatcaataag-3') and reverse (5'-agtgtatcagctgcagtagggtt-3') primers (product size 326 bp) are amplified by PCR.

PCR products are checked for amplification by electrophoresis on 3% agarose gel, in parallel with 100 bp DNA ladder. The PCR products are visualized under UV light after staining with ethidium bromide. To test sensitivity of the PCR assay, serial two fold dilutions of genomic DNA is used for PCR reaction and to ascertain specificity of the PCR assay admixture of genomic DNA are extracted from meat samples. To check sensitivity of the developed PCR serial two fold dilution of genomic DNA are made. PCR amplification is obtained up to 20 ng of genomic DNA in 20 µl PCR reaction. Specificity of sheep and goat primers has been checked by DNA mixture from sheep, goat, cattle and buffalo. Developed tests can be useful to for rapid detection of meat of sheep and goat origin.



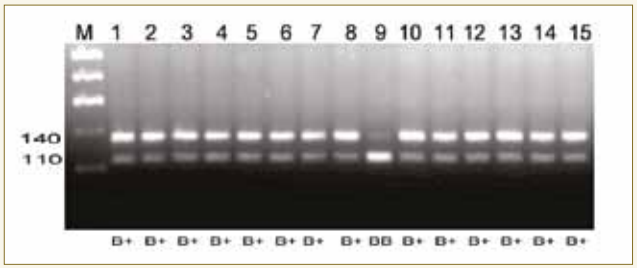
Extraction of genomic DNA from meat samples (lane 1-12); M: Double digest DNA marker



PCR amplification of DNA samples using sheep (Mutton) and goat (Chevon) specific primers

Application of *FecB* Genotyping Test in MAS Programme in Sheep

DNA test for identification of fecundity gene (*FecB*) responsible for multiple births has been developed. This test has been used in screening of the prolific sheep or strains and also in the breeding programme. The DNA test for *FecB* gene has been successfully applied in Marker Assisted Selection (MAS) programme of prolific sheep in the institute.



Forced RFLP-PCR of *FecB* gene. M: molecular weight marker 50 bp ladder, Lane 1-15: Garole x Malpura female produce twin or more lambs.

Booroola fecundity (*FecB*) gene mutation is responsible for high prolificacy of Garole sheep. *FecB* mutation in Garole, Kendrapada, GM, GMM, MGM and GMM x Patanwadi prolific strains have been identified in the institute.

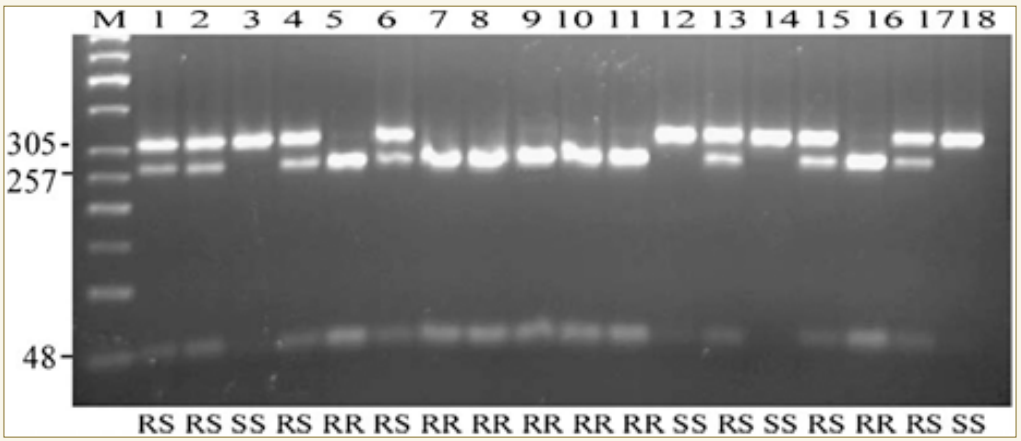
Adoption of Technology

DNA test has been used for *FecB* gene introgression programme in the Institute. It will be useful to other Sheep Farms also.

DNA Test for Identification of the Benzimidazole Drug Resistance in *Haemonchuscontortus* Parasite in Sheep

Benzimidazole resistance in *Haemonchus contortus* parasite is a major problem in worldwide. The benzimidazole resistance is emerging day- by- day in the parasites and drug is no more effective to kill the parasite. A RFLP-PCR technique has been developed for detection of the benzimidazole drug resistance in adult and larvae of *Haemonchus contortus* parasite. This technique detects the mutation conferring benzimidazole resistance in the *H. contortus* parasite and can discriminate the resistant and susceptible individuals of *H. contortus*.

This resistance is primarily linked with the mutation in the β-tubulin isotype-1 gene at 200th codon which substitutes the phenylalanine to tyrosine. This test is useful in establishing the prevalence rate of benzimidazole drug resistance and control of the parasite infection in the sheep in India.



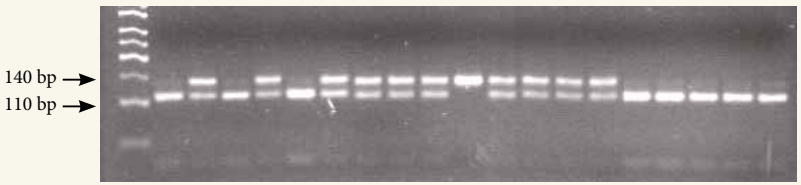
RFLP-PCR profile of β-tubulin isotype -1 gene in adult male *H. contortus*recovered from the Bikaner. SS: homozygous susceptible, RS: heterozygous, RR: homozygous resistant, M: 50 bp ladder

Finding of the Booroola Fecundity (*FecB*) Gene in Kendrapada Sheep

For the first time, Booroola fecundity (*FecB*) geneis found in the Kendrapada sheep of Orissa, which is second prolific sheep of India after Garole. Kendrapada sheep produces twin and triplets lambs due to the mutation of the *FecB* gene. The Kendrapada sheep of Orissa produce 35.1% single, 62.8% twin and 2.3% triplet births.

Future of Technology

The finding of the *FecB*mutation in Kendrapada sheep will facilitate the use of *FecB*allele in improving the prolificacy of non-prolific sheep breeds of India.



Analysis of *FecB* gene in Kendrapara sheep. M: 50bp ladder, Lane 1-19 Kendrapara sheep, BB (homozygous), B+ (heterozygous), ++ (non-carriers)

Artificial Insemination in Sheep with Liquid Chilled Semen

Artificial insemination (AI) technique is used in animal breeding programme for faster multiplying the elite animals in a flock, it reduces the number of rams for breeding and avoids the possibilities of transmitting contagious diseases. Recent advances in semen diluents and insemination procedures have opened a new avenue for achieving higher genetic gain through AI in sheep.

Technology Details

Semen from adult donor ram is collected using artificial vagina. Ejaculates of thick consistency, rapid wave motion, ≥80% motility and intense movement of motile spermatozoa are diluted in 1:2 with EYCG diluents at 30°C in a water bath and kept at refrigeration temperature. Ewes exhibiting estrus in the morning (early estrus) and evening (mid-estrus) of the same day are brought at the common place for AI. A ewe is properly held with its forelegs on the ground and hind legs up at an inclined angle facing the sunlight. The lubricated glass speculum is inserted gently and the cervix is visualised through the sunlight entering the glass speculum. If the sunlight is not adequate to locate the cervix, then a flashlight is used. Diluted semen 0.1 ml is taken in a pipette from the semen shipper and the pipette is held firmly in the right hand. The semen is deposited through pipette at the mouth of the cervix and the pipette and glass speculum are withdrawn gently from the vagina. Heat detection is continued in inseminated ewes for 2 cycles. Ewes not returning to estrus are marked as conceived. The cost comes to Rs. 5 per AI, including the cost of chemicals and glassware.

Adoption by Farmers

The adoption rate of AI by farmers is gradually increasing in the field flocks. The use of a cost-effective estrus synchronization device in the form of vaginal sponges has given the scope for taking up large-scale fixed time AI programme. Around 1962 sheep in farmer's flocks are artificially inseminated by the Institute with an overall success rate of 62.69%.

Semen collection


6. Savlon
Savlon

Indigenous Intra-Vaginal Sponges for Estrus Induction and Synchronization

One of the major applications of oestrus synchronization in sheep is to facilitate artificial insemination (AI). Synchronization of estrus has made the AI much more attractive to commercial sheep farms because majority of sheep can be inseminated within two to three days and lambs can be raised as per demand in the market. It permits the flock management easy and schedule sheep handing and breeding and reduces the time consumed in heat detection. Further, it helps in scheduling the breeding and lambing to overcome the seasonal variation and can be simulated as per the forage availability.

Technology Details

Progesterone impregnated intra-vaginal sponges for oestrus induction and synchronization in sheep and goats have been developed indigenously at ICAR-CSWRI, Avikanagar. One kit containing 25 sponges, 1 speculum and 1 plunger cost Rs. 722. The selected animals are prepared for estrus synchronization as below:

Insertion of sponge: The progesterone-impregnated sponge is loaded in a vaginal speculum (a glass tube with both the ends open). The sponge is loaded in speculum through anterior end and a thread of sponge taken out from distal end. Push the sponge through the speculum by a plunger, a glass rod, until it reaches the cervix.

Sponge removal

Retain the plunger and withdraw the speculum 2 to 3 cm to expel the sponge out of the speculum. Remove the instruments, speculum and plunger.

Management of ewes: After the insertion of vaginal sponge, the ewes are free to move for grazing, feeding and other routine management practices. But special care must be taken until the vaginal sponge is not removed.

Removal of sponge: The sponge is kept *in-situ* for 12 days. After 12 days, the sponges are taken out from the vagina of ewe carefully. While removing the sponge the thread should not break and sponge should come out by pulling the thread.

Development and application of an intra-vaginal sponge: An intramuscular injection of 200 IU of Pregnant Mare Serum Gonadotrophin (PMSG) is administered at the time of sponge removal. In general, PMSG is used when estrus is induced among anestrus ewes and ewe lambs. In cycling ewes PMSG is not required.

Detection of estrus: Detection of estrus is done by aproned ram at an interval of 6 h for 72 h commencing from 24 h of sponge withdrawal. Ram should possess high vigour and libido.

Adoption by Farmers

So far sponges were used in 3056 sheep and out of that 2562 sheep exhibited estrus with an overall success rate of 83.8%. Further, around 38000 sponges have been supplied to different agencies, including ICAR institutes, SAUs, NGOs and progressive farmers.

Embryo Transfer Technique in Sheep

Embryo Transfer Technique (ETT) is useful for i) fast multiplication of superior germplasm, ii) preservation of endangered or diminishing breeds and iii) international exchange of germplasm. A quick and easy method of laparoscope aided embryo transfer is developed at the Institute. A unique protocol of superovulation and embryo collection is developed in native and crossbred sheep. A special designed cradle is fabricated for easy restraining and positioning of a ewe (suspended at 45° angles) during laparoscopy. The recipients having synchrony with donor are fasted for 24-36 hours before laparoscopy. Sedation is induced by intramuscular injection of Xylazine. Xylocaine is administered subcutaneously as local anaesthetic. Abdominal area anterior to udder is shaved and sprayed with 70% alcohol. Uterine horn is gently grasped with the forceps (modified in our laboratory) and lifted through the puncture site to expose a loop of horn. A blunt needle is used to make a small aperture in the loop of horn and tom-cat catheter loaded with the embryo is introduced into the lumen of horn. The embryo is pushed into the lumen and horn is again put into the abdomen. The skin is sutured or sealed with wound clippers.

Success rate

The success rate of embryo transfer in sheep is around 50% in terms of pregnancy. A total of 240 lambs were produced through *in-vivo* derived embryos at the institute. Transferring two embryos gives better results with increased number of twin pregnancies. The success

depends on management of donor and recipient animals, synchronization of estrus in donors and recipients, superovulation of donors, embryo collection and evaluation, transfer of embryos, and factors affecting survival of transferred embryos.

Adoption by commercial farms

Embryo transfer technique is in its infancy in sheep in India. Only few progressive farmers like Asad Farm Pvt. Ltd, Anantpur (AP) adopted this technology.

Laparoscopic examination

Ram Semen Freezing Technique

There are two techniques of AI using frozen semen in sheep, i.e. Laparoscopic AI and Trans-cervical AI. Laparoscopic AI is not feasible and practicable in Indian field conditions as it requires minor surgery. However, in an experiment we have achieved 44% lambing after laparoscopic AI with frozen semen. The world status of laparoscopic AI with frozen semen is 70-80% conception in sheep. The results of trans-cervical AI are not acceptable and ranging from 4 to 40% lambing worldwide including our laboratory. A freezing procedure has been developed for cryopreservation of ram semen of exotic, crossbred or native sheep breeds. Semen is frozen in the medium (0.5 ml) and mini (0.25 ml) size French plastic straws. The protocol developed for freezing of semen is as below:

Variable	**Optimum Conditions**
Extender	Egg yolk tes tris glycerol (Ey-TEST-G)
Extension rate	@ 1 x 10^9 sperms/ml
Packaging Size	0.25 ml mini & 0.5 ml medium size straws
Equilibration time	2 h
Mode of Freezing	Programmable LN2 vapour freezing
Equipment	Cell Freezer
Thawing temperature	50°C for 0.25 ml straw, 60°C for 0.50 ml straw
Thawing time	10 seconds
Assessment	Objective by CASA technique
Mean post-thaw motility	70 %

The freezing procedure is based on controlled cooling and freezing in the programmable cell freezer and involved following steps:

Start temperature: +25°C

Step 1: Hold for 10 minutes (it means that rate is zero and the temperature is maintained at +25°C)

No seeding selected

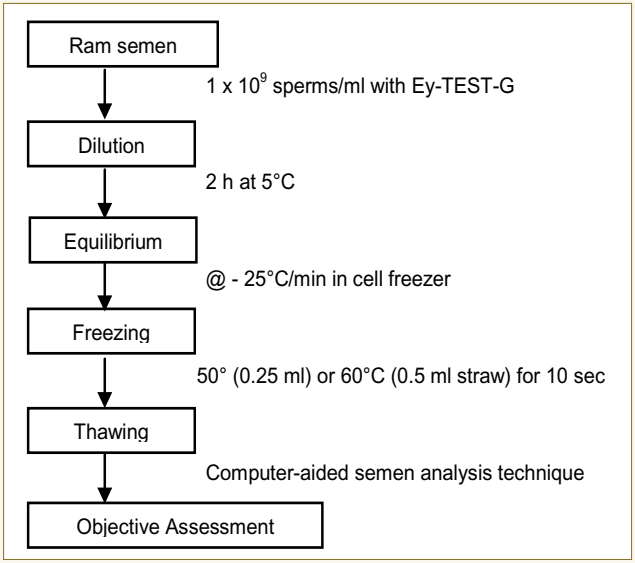
Step 2: -0.15°C/min to +5°C

Step 3: Hold for 10 minutes (it means that rate is zero and the temperature is maintained at +5°C)

Step 4: -25°C/min to -125°C

Step 5: Hold for 10 minutes (it means that the rate is zero and the temperature is maintained at -125°C)

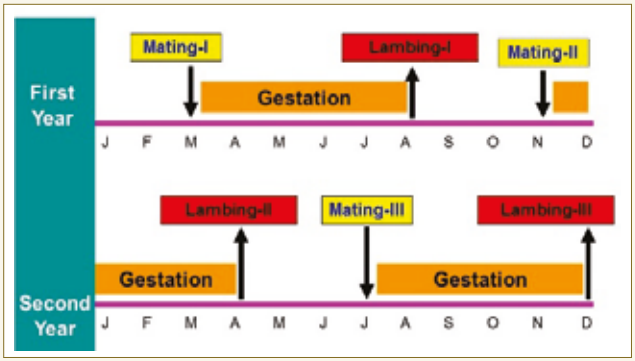
Step 6: Plunge straws in liquid N_2



The semen freezing in different breeds by this technique gives 70 % average mean post-thaw motility of spermatozoa. The higher post-thaw recovery depends on thick consistency, rapid wave motion, 90% initial motility and ≥3000 x 10^6 spermatozoa per ml.

Accelerated lambing system: Three lambs in two years

In the country, conventionally sheep gives one lamb in a year under extensive system. The accelerated lambing system for producing three lambs in two years per ewe is developed to increase mutton production. Accelerated lambing systems require optimum feeding and management and are hardly applicable under low input system.



Technology Details

The production of 3 lambs in 2 years is characterized by a mating and lambing at fixed schedule period. In this system, the periods between lambing are shortened and the lamb crops are produced every 8 months instead of every 12 months. Ewes are bred strictly within 90 days post lambing naturally or by inducing estrus. The estrus is induced by progesterone impregnated intra-vaginal sponges and PMSG.

This accelerated lambing system produced 50% more lambs in Malpura sheep in comparison to conventional one lamb per year.

Three lambs in two years in sheep is feasible with support of Avikasil® progesterone sponge intervened oestrus induction in ewes.

Lamb Feeding for Mutton Production

The demand of mutton is increasing rapidly due to increase in economic status, demand for quality meat products, floating population of mega and metropolis and growing trend of eating in restaurants and hotels. Balanced nutrition and feeding of lambs can bring out sizable improvement in weight gain and feed efficiency. In the field condition, lambs attain body weights of 8-10 kg at 3 month and 16-18 kg at 6 months of age whereas same lambs under intensive feeding can achieve 30-32 kg body weight at 6 month of age. In lamb production, major objective is to harness maximum growth with better feed efficiency and desirable meat yield and quality by applying improved feeding practices.

Pre-weaning growth

Attainment of early weaning weight gives an impetus to next phase (post-weaning) growth. Early weaning of lambs enable early marketing, out-of-season lambing and multiple lamb crops per year.

Newly born lambs should be allowed to feed/suckle their mothers within 4 hours of birth. Colostrum should be given at the rate of 50 ml/ kg body weight right at birth and every 6 hours for the first 24 hours. In addition to immunoglobulins, colostrum consists of nutrients which fuel heat production and prevent hypothermia in newly born lambs. Lamb growth and development depends upon the ewe's milk yield during early lactation. Lambs start nibbling on feeds within a few days after birth, but nibbling alone will not sufficient for higher growth. Lambs should be offered free choice feeding of concentrate and good quality roughage. The creep ration should be fed to lambs, it should not be complex or expensive. At a young age lambs prefer feeds that are finely ground and have a small particle size. Feeds that have high palatability for lambs include soybean meal, ground corn, cowpea hay, guar hay, tree leaves etc. Crumbled or textured rations are consumed better than pelleted creep feeds. The feed should be fresh and dry. To achieve higher growth in lambs, milk replacer (contain 24-28% crude protein, 10-12% fat and 15-17% total solid) should be fed at the rate of 100-250 ml from 12-90 days of age, 100 ml during 10-15 days and thereafter 250 ml up to 90 days. It increases 4-5 kg more weight and also reduce raising cost.

Post-weaning growth

Post-weaning growth in lambs is considered as active phase of growth and important for achieving finishing weights at an early age. In developed countries, the post-weaning growth is primarily used for fattening purpose for ensuring an average daily gain of 250-300 g whereas under Indian condition an average daily gain of 150-180 g can be achieved. The post weaning diet should be rich in energy and should contain 18-20% protein (as fed basis) for the first three weeks and then 14 to 17%

protein thereafter. The concentrate supplementation in addition to grazing is cost effective and economical, should be adopted. The weaner lambs maintained on Cenchrus pasture with concentrate supplementation @ 1.5% of body weight attain 27-30 kg at 6 months of age. Intensive feeding of lambs from 3-6 months of age on complete feed consisting of roughage and concentrate in 50:50 attain body weight of 32-34 kg at finishing age of 6 month. Economics of lamb rearing system on stall feeding is worked out and presented in table.

Parameters	Intensive system (Per lamb)	
	Quantity	Cost (Rs.)
Pre-weaning (1-3 month)		
Body weight (1 month) (kg)	7.00	-
Body weight (3 month) (kg)	15.00	-
Cost of 1 month old lamb (Rs.)	-	950.00
Total conc. feed consumed (kg) @ Rs. 20.00/kg	12.00	240.00
Total hay consumed (kg) @ Rs. 5.00/kg	35.00	175.00
Total green fodder consumed (kg) @ Rs. 5.50/kg	9.00	49.00
Cost of medicine (Rs.)	-	10.00
Labour cost for 2 months @ Rs. 9000/month/100 lambs	-	200.00
Total cost pre-weaning (Rs.)	-	1624.00
Post weaning (3-6 month)	-	
Body weight (3 month) (kg)	15.00	-
Six month slaughter wt. (kg)	30.00	-
Total conc. feed consumed (kg) @ Rs. 20.00/kg	40.00	800.00
Total hay consumed (kg) @ Rs. 5.00/kg	13.50	68.00
Total green fodder consumed (g) @ Rs. 5.50/kg	18.00	99.00
Total body weight gain (kg) in 3 month	15.00	-
Cost of medicine (Rs.)		30.00
Labour cost for 3 months @ Rs. 9000/month/100 lambs	-	300.00
Total expenditure for post weaning (Rs.)	-	1147.00
Slaughter charges Rs. per animal	-	350.00
Total expenditure (Rs.)		3171.00
Meat @ Rs 280/kg		4452.00
Head and hooves (kg)		250.00
Skin with wool (kg)		200.00
Edible offal's		700.00
Intestines and rumen		100.00
Manure		320.00
Gross Income (Rs)		6022.00
Net income(Rs)		2851.00

Milk Replacer Supplements in Lambs

Majority of Indian sheep breeds did not produce enough milk to support higher growth rate of pre-weaner lambs. Institute has developed milk replacer for lambs for higher body weight gains and survivability.

Milk replacer feeding in lambs

Ingredients of milk replacer	Skim milk powder, soya powder, peanut meal, different types of flour, variety of edible oils, citric and butyric acids, minerals and vitamins
Nutrients composition (% on dry matter basis)	Crude protein - 24-28 Ether Extract - 10-12 DM - 15-17
Fed at the rate Cost of milk replacer powder Liquid milk	100-250 ml from 12-90 days of age. 100ml during 10-15 days and thereafter 250ml up to 90 days. Rs 115/kg Rs 19.50/lt.
Feed efficiency ratio Free milk suckling + creep ration Free milk suckling + creep ration + milk replacer	 2.48 2.44

Feeding procedure

1. All the utensils of milk feeding like bottle and nipple should be cleaned and sterilized regularly.
2. Clean water should be boiled up to 42^{0}C for preparation of liquid milk.
3. The liquid milk should be stirred with blender for 2-3 minute for proper mixing.
4. The temperature of milk should not be less than 35^{0}C.
5. Lambs start drinking milk within 2-3 days. It should be fed @ 100 ml initially and later on gradually increased to 250 ml in 60-70 day old lambs.

Economics of milk replacer feeding

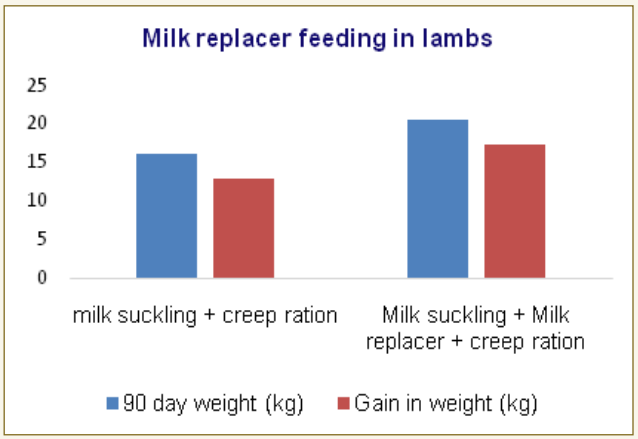
In milk replacer feeding system, lambs attained 20-22kg body weights with feed efficiency of 2.46-2.48. Milk replacer feeding per lamb for 75 days requires additional expenditure of Rs 200. Lambs gain additional body

weights of 4-5kg at 3 month of age which pay Rs 800-1000 more in the market. Net return to farmers comes around Rs 600-800 per lamb.

Cost of milk replacer (Rs./kg dry powder)	82.00
Consumption of milk replacer (ml/day/lamb)	150
Consumption in 75 days (kg/lamb)	1.8 kg = 11.5litre
Cost of milk replacer (Rs.)	150
Extra gain from milk replacer in 90 days	4.3 kg
Extra cost of lambs (@Rs. 150/kg live weight)	645
Net profit (Rs.)	645-150 = 495
Profit from milk replacer in 90 days (Rs.)	495

Adoption of Technology in Field

The milk replacer is well accepted /adopted by the farmers. They prepare six litre of milk from 1 kg of milk powder and fed to lambs, individually by a bottle. The feeding of milk replacer increased body weights to 24.4 kg at 105-110 days of age. Lambs reared on milk replacer are sold at Rs. 3200 per lambs. Farmers earn Rs. 800 per lamb more by milk replacer feeding.



Area-Specific Mineral Mixture for Sheep and Goats

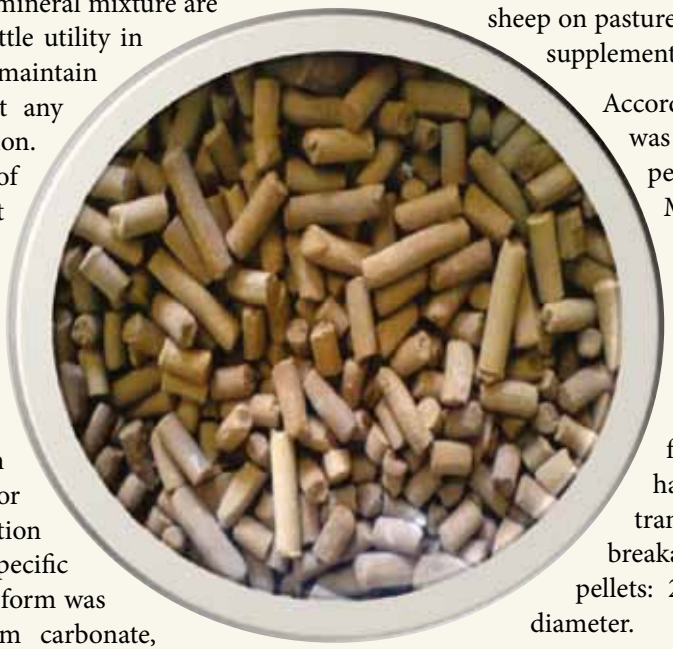
Mineral deficiency or excess in animals is an area specific problems and influenced to a great extent by mineral content and its bioavailability from feeds and fodders in the tropics. Sheep and goats are maintained in rangeland system that does not meet the exact requirement of minerals in the tropical regions. Supplementation of area specific mineral mixture to animals, meet the exact requirement of minerals and avoids excess or deficiency of minerals. In the market, mineral mixture are sold in powder form has little utility in sheep flocks. Since farmers maintain sheep on pastures without any kind of grain supplementation. Thus alternate mode of mineral mixture in pellet form was developed for easy delivery.

Technology Details

Area specific mineral mixtures for sheep and goats of semi-arid Rajasthan have been developed for improving health, reproduction and production. The area specific mineral mixture in powder form was prepared from the calcium carbonate, di-calcium phosphate, cobalt sulphate, zinc sulphate, copper sulphate and common salt. The concentrations of calcium, phosphorus, copper, zinc and cobalt in 100g of mineral mixture are: 35.31 g, 13.64 g, 318 mg, 324 mg and 76 mg, respectively.

Initially, mineral mixture was developed in powder form and tried in sheep flocks. But it was observed that it was difficult to use it in sheep feeding since farmers maintain sheep on pastures without any kind of grain supplementation.

Accordingly mineral mixture was changed from powder to pellet form for easy delivery. Mineral mixture pellets of 5g incorporating the required minerals concentration were prepared with molasses (1%) as binder. It was dried at room temperature for establishing desirable hardness for easing the transportation and preventing breakage losses. Average size of pellets: 2.5 cm length and 6 mm diameter.



Area specific mineral pellets

Salient Findings

The supplementation of pellet mineral mixture to sheep (@5 g /day for 5 months) increased wool yield by 8-9%, during 3 month of early lactation increased milk yield by 10-15% and supplementation of mineral mixture to anoestrus sheep brought 60% of sheep into oestrus within 15-21 days and remaining 40% after 42 days of supplementation. The supplementation of area specific mineral mixture recovered sheep from keratinization of skin and improve wool growth. In organised farm, supplementation of area specific mineral mixture in concentrate mixture at the rate of 2% of feed in feeding of sheep flocks reduce the case of urinary calculi, stomatitis and wool shedding.

Adoption by Farmers

Since cost of mineral mixture is very low and it comes to Rs. 12-15 / sheep / month. It can be easily adopted by even the poor farmers. Farmers are ready to take the technology since it has many benefits. The accessibility of mineral mixture to farmers can be enhanced by making it available to farmers at their doorsteps through dairy cooperative society in the villages, State extension departments, NGOs, State Agricultural Universities, Indian Council of Agricultural Research institutions and Agriculture extension centres may be involved for better dissemination of technology.

Multi-Nutrient MIX (MNM)

The unique ability of the sheep to synthesize enough protein for maintenance through microbial action which permits the use of urea as a NPN source provided ready source of energy is available. Thus, it is now well established that urea molasses mix can provide additional nutrition and enhance the utilization of roughages. The primary objective of these MNM licks is to provide supplementary nutrition to the sheep on grazing resources. These MNM should serve as licks. It should release the urea nitrogen more slowly and frequently so as to minimize the chances of ammonia toxicity. In addition, such a MNM can also facilitate the supply of other nutrients such as minerals and vitamins. MNM also helps in overcoming the malnutrition/under nutrition of sheep and increase production at farm level and generate better returns for a farmer.

Multi-nutrient mix are developed at ARC, Bikaner centre of CSWRI and made available to farmers for feeding to animals after grazing during scarcity period. Multi-nutrient mixture are prepared by uniform mixing of molasses 45.40, wheat bran 37.50, urea 1.00, guar churi 6.00, salt 5.00, vitamins and mineral mixture 5.00 percent. The block is able to meet requirements of digestible carbohydrate, protein, minerals and vitamins of grazing sheep. For preparation of multi-nutrient block (MNB) mixed material is put with guar dust into iron mould for making block. The formulation is cost effective and feeding of 200 g of MNM in lamb improved 15 to 20 % body weight. The daily cost of feeding mix come to Rs. 3.35 per sheep. The technology is successfully demonstrated at field level for sustainable sheep production.

Complete Feed Blocks for Animals

Livestock in general and ruminants in particular, are the most vulnerable animal species during famine. Livestock feeding during disaster is yet to be established to save

Multi-nutrient blocks preparation

livestock wealth. Every year one or the other parts of the country face famine like situations. Moreover, in some states like Uttar Pradesh, Uttaranchal, Haryana, Punjab etc. valuable feed resources (rice and paddy straw, mustard straw, sugarcane leaves, tops and bagasse) are burned adding to environmental pollutions while animal casualty due to inanition is recorded in other parts of the country. Thus,

- Most of the poor quality roughages have low bulk density, which create problem during storage and transportation
- These problems are overcome by converting them into complete feed blocks (CFB)
- CFB have many advantages like ease in transportation, palatable in nature, require less space for storage and reduced losses and risk during transportation

Details of the Technology: The complete feed block of roughage and concentrate mixture is prepared in 70:30 ratios with 5.0% molasses for easy binding. The suitable combinations of low cost agro-industrial by-products and waste material based CFB could be prepared by applying a pressure of 4000-5000 psi.

Complete feed blocks

Ingredient	Parts
Cenchrus straw	38.60
Dried ardu leaves	37.00
Wheat bran	14.00
Mustard cake	7.40
Common salt	1.00
Mineral mixture	2.00

Use of feed block feeding in sheep and goat reduces the cost per kg gain by 38% as compared to feeding of grass hay and concentrate separately. CFB reduces bulk density by 33% and can be stored up to 2 years. in dry weather without deterioration in nutrients.

Blocks made of 50:50 parts concentrate: roughage are found satisfactory in sheep feeding. High energy feed blocks could be prepared for higher growth with 60:40 or 75:25 concentrate: roughage. Lambs on these blocks attained 12-20% feed efficiency. The low-grade roughages have poor nutrient density and cannot maintain animals. The CFB can be prepared meeting the maintenance as well as production requirements of livestock by enrichment hence will sustain the precious stock during famine.

The cost of making feed blocks comes to Rs.0.40/ kg, which is commercially viable in view, its importance in sustaining precious livestock species in critical zone.

Prickly Pear Cactus: A Promising Feed Resource during Scarcity

Prickly pear cactus [Opuntia ficus-indica (L.) Mill.] an excellent natural biomass, is a fast growing draught resistant xerophytes, well adopted to arid and hot environment. Opuntia yield 2000 kg DM /hectare on uncultivated wastelands. Opuntia has been used as a drought feed worldwide. However, the genus appears in great genetic diversity, as it is widely used in human (fruits and green vegetables) and animal diets (fodder) in Mexico and Latin America.

Cactus feeding

Components	% DM basis
Dry matter	12.0
Crude protein	10.5
Neutral detergent fibre	57.2
Acid detergent fibre	25.9
Acid detergent lignin	2.4
Gross energy (Mcal/kg)	3.9

Chemical composition of Opuntia species

A Prickly pear cactus along with *Cenchrus* grasses could not meet the crude protein requirements of sheep. The protein deficit could be meet out through supplementation of 50 g groundnut cake or 200 g concentrate (18% CP). The Opuntia supplemented diets could be advantageous, when appropriate N supply is ensured, as sheep have similar digestion than those on common diets and may reduce considerably drinking water consumption. One kg fresh opuntia feeding to a sheep provides 0.88 litre of water thus it can compensate mild water restriction by 1.00 litre without effecting feed intake during summer.

During summer, cactus could be an important source of water to sheep besides nutrient supply in hot arid regions. The feeding of 8.80kg cactus provides about 7.50 litre water to 10 sheep or 75 litre of water from 880kg cactus to 100 sheep.

Prickly Pear cactus

Cactus silage in drums

Thorny cactus is usually used as fencing material by the farmers to prevent entry of wild as well as domestic animals to their cultivated field/crop area. The thorn can be burned by fire and then chopped for feeding to sheep.

Burning of cactus reduce moisture (75-82%) and increase DM content, thus providing more gut fill. Both the type of cactus (thorn and less thorn) have similar nutrient contents and palatability during summer in sheep.

Cactus thorn burning

Cactus silage

The cactus can be harvested and preserved as silage for feeding to sheep during scarcity periods. The cactus (contain > 85% moisture) should be mixed with dry roughages/tree leaves for silage making. To make protein rich silage from cactus, ardu leaves, green gram/cowpea/ cluster bean straws etc. can be mixed in desirable ratio. This will also help to maintain 35-40% moisture content in the silage. About 3.0 - 4.0 kg (900-1200 g DM) cactus mixed silage can be fed to adult sheep as maintenance ration.

Herbal Feed Supplements: Nutritional and Therapeutic Intervention to Ameliorate Stress

Institute has developed herbal garden comprising of 30 different medicinal plants. These plants are used in traditional medicine for treating ailments.

											
Tulsi *Ocimum tenuiflorum*	*Hadjod* *Cissus quadrangularis*	*Dama bel* *Tylophora indica*	*Jyotish Malkangani* *Celastrus paniculatus*	*Giloy* *Tinospora cordifolia*	*Gurmar* *Gymnema sylvestre*	*Amaltas* *Cassia fistula*	*Aritha* *Sapindus laurifolia*	*Baheda* *Terminalia bellirica*	*Jamun* *Syzygium cumini*	*Thai Apple* *Syzygium samaran gense*	*Curry Patta* *Murraya koenigii*
											
Bael *Aegle marmelos*	*Arjun* *Terminalia arjuna*	*Adusa* *Adhatoda vasica*	*Palash* *Butea monosperma*	*Night Jasmine* *Nyctanthes arbor-tristis*	*Negar* *Vitex Negundo*	*Guggul* *Commip hora wightii*	*Shikakai* *Acacia concinna*	*Gwarpatha* *Aloe vera*	*Ashwagandha* *Withania somnifera*	*Vajradanti* *Barleria prionitis*	*Satawari* *Asparagus racemosus*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Pasture Establishment

Ever increasing human and livestock population as well as diversion of land for other purposes has left the livestock and their grazing land in a pathetic condition. The environment changes and poor management of grazing lands have caused severe degradation. There is huge gap between demand and supply of green as well as dry fodder in India. By proper management and use of latest technology forage production can be increased 8-20 times.

Ardu (*Ailanthus excels*) based three-tier agro-forestry system

Three-tier agro-forestry system: Ardu (*Ailanthus excelsa*) as fodder tree on top tier– 100 trees/ha in a configuration of 10 x 10 m^2, Dichro (*Dichrostachys nutans*) as fodder bush at middle tier– 100 bush/ha, one bush in between two ardu trees and ground tier of arable crops along with 4 m wide cenchrus grass strip (2 m both side of tree row) provide insurance to animals in drought prone area,

Three-tier agro-forestry system

Grass pasture

which not only reduces climatic risk but also maximizes food and fodder per unit area per unit time in semi-arid regions.

Average yield (green and dry fodder and grain) of various crops in three-tier agro-forestry system increased by 4.71 and 12.95% in dry fodder yield, 5.43 and 22.57% in grain yield and 4.85 and 14.34% in biomass yields in comparison to two-tier agro-forestry system and open field conditions, respectively.

Grass pasture establishment and management for semi-arid regions

Anjan (*Cenchrus ciliaris*) and Dhaman (*Cenchrus setigerous*) are prominent grasses of semi-arid regions. Pasture grasses are established by opening the furrows (45 cm apart) after a good rainfall. Prepared grass seed (well mixed with moist soil and sheep manure in equal quantity) is dropped in bunches into furrows and is pressed by foot. Fertilizer is applied on pasture @ 60 kg N, 40 kg P_2O_5 and 40 kg K_2O per hectare. Weeding is done at 30-35 days after planting. Dry fodder of grass at maturity is harvested 5 cm above the ground. Animal should not be allowed for grazing during first year of establishment of pasture. Next year, grass may be harvested 40 days after first rain and then animals may be introduced for grazing.

Establishing pasture and silvi-pasture at sloppy degraded lands for soil and water conservation

V-ditch contour bund along with panipula (*Saccharum munja*) act as a vegetative barrier, it play important role in soil and water conservation on sandy loam sloppy degraded lands in semi-arid regions. It helps in extinguishing unpalatable and poor grasses like *Aristida* spp. and regenerates the nutritious and quality grasses.

Grass pasture at sloppy land

This practice also helps in establishment of *Cenchrus* pasture on sloppy degraded lands. Fodder trees are planted inside V-ditch contour bund along with pond mud + sheep manure which ensure higher moisture retention and plant survivability.

Mixed cropping and improvement in forage quality

In order to increase the quality and quantity of pasture, legumes species are introduced, since legumes are rich

Horti-pasture system

source of proteins and are palatable to most of the livestock species. Perennial legumes like *Dolichos, Clitoria, Siratro, Stylosanthes* and *Atylosia* spp. can be incorporated as a mixed crop in pasture to improve pasture quality as well as quantity. Dry fodder yield of 28.80 q in cenchrus alone, 37.50 q in Cenchrus + Siratro (*Macroptilius atropurpureum*), 45.00 q in Cenchrus + Clitoria (*Clitoria ternatea*) and 59.00 q/ ha in Cenchrus + Dolichos (*Dolichos lablab*) has been obtained.

Annual legume like Cowpea, Guar and Moth can also be grown as nurse crops in Cenchrus pasture during first year of establishment. This not only increases total biomass but also provide quality forage. Cenchrus alone yield 8.90, Cenchrus + Moth 13.00, Cenchrus + Guar *(Cymopsis tetragonoloba)* 14.90 *and* Cenchrus + Cowpea (*Vigna sinsensis)* 19.20 q/ ha.

Horti-pasture system

Horti-pasture system is highly remunerative in semi-arid region. Ber and aonla trees are prominent fruit crops of dry areas. In mixed pasture of grass *Cenchrus setigerous* and legume *Dolichos lablab* (1:2 row ratio), incorporation of ber and aonla as fruit tree in the configuration of 8x8 m^2 resulted in higher returns than sole pasture.

Tree lopping

Cenchrus setigerus and *Dolichos lablab* under ber-based horti-pasture system found more remunerative than aonla based hoti-pasture system.

Lopping management of fodder trees

Trees and shrubs in the silvi-pastoral system and road side often contribute substantial amount of leaf fodder in arid and semi-arid regions during lean period. The leaf fodder yield per tree varies considerably and it depends on species, initial age, lopping intensity and interval as well as agro-climatic conditions.

Ardu (*Ailanthus excelsa*) can be lopped fully twice a year in the month of December and May-June at any age while, fully-grown Neem can be lopped fully once in a year in the month of December-January. However, young tree of Neem can be lopped fully twice a year in December-January and May-June. Reverse is true for Khejri, young Khejri plant can be lopped fully once in a year, however, full-grown tree/age old tree can be lopped two-third twice a year in May-June and November-December.

Organic Sheep Manure from Wool Waste

In India around 46 million kg wool is produced and around 100 million kg wool is imported. Around 10 % of wool produced during shearing is kept/set aside as a waste from woollen industries and wool Mandies, which is thrown away considering it useless. At many places these are burned or piled up.

Parameter	Quantity
Moisture	11.56%
Gross density	0.92 g/sq cm
Total organic carbon	14.72%
C:N ratio	18.87
Total nitrogen	0.78%

Sheep wool waste

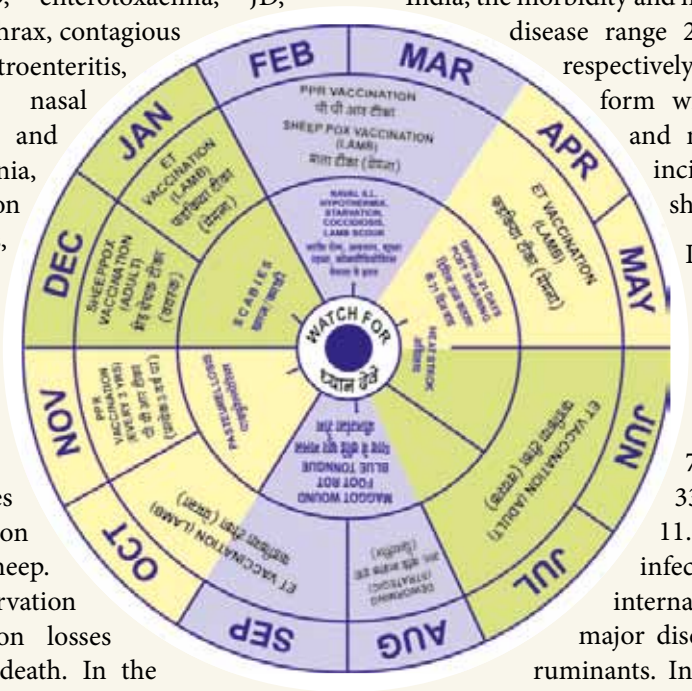
Parameter	Quantity
Phosphorous	0.69%
Total potash	3.40%
pH	7.20

The advantages of wool waste based manure: 1. Hold water for longer duration 2. Contains higher amount of natural potash 3. Improves the soil fertility 4. Increases the irrigation interval of the crops 5. Control environmental pollution 6. Decreases the dependency on chemical fertilizers 7. Increases the productivity of crops 8. Decreases the water evaporation from soil 9. Reduces the pollution in the soil, food material and land 10. Highly useful for the ornamental flower plants 12. Useful for the preparation of plants bed in the nursery.

Manure from sheep wool waste

Sheep Flock Health Technology

Sheep diseases are major constraint on the production efficiency of sheep and have obvious and profound effects or remain sub-clinical without obvious effect. The common diseases in sheep are: Sheep pox, PPR, bluetongue, FMD, enterotoxaemia, JD, pasteurellosis, foot rot, anthrax, contagious ecthyma, parasitic gastroenteritis, scabies, coccidiosis, nasal myiasis, ectoparasitism and non-infectious: pneumonia, exposure and inanition syndrome, enteritis, tympany, anaemia, vitamin and mineral deficiencies, hyperthermia, debility, toxaemia, septicaemia, hepatitis, toxic and metabolic diseases.



The incidence of diseases has negative impact on production of the sheep. According to field observation about 20% of production losses are due to diseases and death. In the country, the cases of morbidity and mortality in sheep flocks range 35-50 and 10-15%, respectively. The losses will be more if cases of abortion and still birth and reduction in milk, meat and fibre yield and expenses incurred on treatment are included. In sheep pox, although the mortality rate is often negligible but causes fatality rates of nearly 100% in young animals. In India, the morbidity and mortality due to Bluetongue disease range 29.4-77.0 and 25.0-45.5%, respectively. PPR occurs in epizootic form with morbidity of 27-84% and mortality of 18-60%. The incidence of JD is >15.0% in sheep, mainly in farm flocks.

In small ruminant the incidence of abortion due to Chlamydiosis, Brucellosis, Listeriosis, Leptospirosis and Toxoplasmosis range 7.7-27.3, 2.2-7.9, 3.33-33.0, 14.3-15.2 and 6.6-11.5%, respectively. Parasitic infections, particularly, internal parasitism is one of the major disease/syndrome of pastoral ruminants. In Rajasthan, under natural condition the gastrointestinal nematodes found to cause decreased mutton production (59.56%), increased susceptibility for mortality (16.57%),

premature culling (11.25%), reduced fertility (7.97%) and decreased wool yield (4.65%) along with predisposes other diseases and hamper the efforts for genetic selection. Among non-specific entities, different kinds of pneumonia cause maximum morbidity and mortality losses in flocks. Moderate to severe pneumonia reduces carcass weight on an average by 0.45 kg/lamb. In general, during the prenatal period animals die from adaptation failure, hypothermia, exposure- inanition syndrome and septicaemia consequent upon inadequate colostrum intake. To reduce the losses caused by diseases in sheep flocks, an annual health calendar developed through planned flock health approach for farm and field.

Details of Technology

Based on epidemiology of sheep diseases, a calendar of prophylaxis has been developed which includes timely vaccination, drenching, dipping and tactical health care. The commonly used prophylactic measures are as under:

Event	Frequency and time for adult	Frequency and time for newborn
ET vaccination	Twice a year (June and December)	Lambs (2.5 month of age with booster) Followed by every six month with adult
Sheep pox vaccination	Once a year (December)	Lambs at 3 month of age, Followed by annual vaccination with adult
PPR vaccination	Once in 3 years (December- January)	Lambs at 3.5 month of age
FMD vaccination	Need based in the month of February	
Deworming	Strategic drench during mid-monsoon (Late Aug – early Sep) with rotation use of anthelmintic type Targeted selective approach (Use of anthelmintic is reduced by 70-80%) Breeding for resistance is another promising alternative and in practice at farm (No use of anthelmintic in resistant line)	
Dipping	Once a year, 15-21 days after March shearing	
Foot bath	During monsoon, 3-4 times at weekly interval with copper sulphate	

The application of above mentioned practices cost around Rs. 60-70/ sheep/ year.

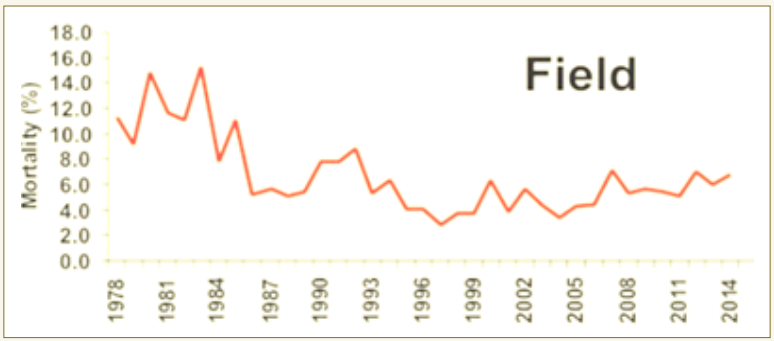
Salient Findings

Prior to adoption of prophylactic health calendar, the average mortality in farmer's flocks of Rajasthan was 20.4% (1975-76). However, regular health inputs from 1977 to 1985 resulted in reduction of mortality to 10.88%. Based on study, planned flock health programme was developed and implemented from 1986 resulted in decline of mortality to around 6.0%.

The reductions of mortality from 1975-76 to 2015-16 showed clear impact of flock health approach. A sheep cost Rs. 4000-6000 and if a farmer is maintaining 100 sheep then losses due to annual mortality at initial stages (without adopting the prophylactic measures) comes to 20 sheep i.e. Rs. 100000 per year. After initial health inputs the losses came down to 11 sheep i.e. Rs.55000 per year and further reduced after the application of flock health programme to 6% i.e. Rs. 30000 per year. Hence, with an investment of Rs. 60-70 per sheep per year, farmer can save Rs.18500 per year/100 sheep in addition to simultaneous improvement in body weights wool yield and lambing.

Adoption by Farmers

The technology is implemented in farmer's flocks through TOT programme. Each year > 100 farmers having > 8000 sheep adopted the health calendar and save the mortality losses due to diseases and benefited from improvement in body weights, wool yield, lambing and survival of animals etc. Now farmers are following the health calendar at their own and making periodical consultation in the institute or TOT outlets itself indicates faith in prophylactic and curative animal health technologies.



Annual mortality rate in field flocks of semi-arid Rajasthan

Worm Management Programme for Sheep Flocks of Rajasthan

Helminthic infections are considered as an important cause of reduced productivity in sheep world-wide. The control of gastrointestinal nematodes (GIN) of grazing sheep is necessary to prevent ill health and improve productivity. The majority of farmers are reliant solely on benzimidazole and levamisole. The sheep breeders of Rajasthan drench their animals usually 2-3 times in a year mostly coinciding with wool shearing. This practice of worm control is not based on sound epidemiological knowledge and often resulted in failure of worm control programme, emergence of anthelmintic resistant strains of parasites and increased cost of worm control.

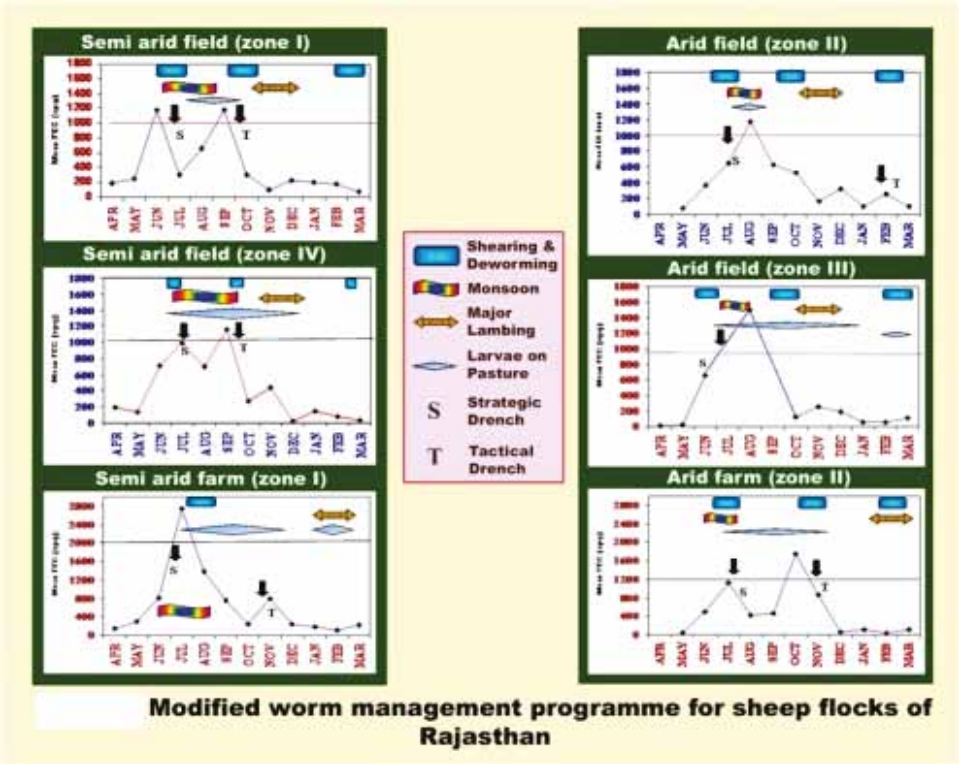
Technology Details

Before 1984, 6 drenches / year were practiced in sheep flocks maintained by farmers in Rajasthan. The cost of drench per sheep per year was approximately Rs. 24.00 with mortality rate of 0.40% in flock due to GIN. Later, in 1984 the programme was rationalized and the drenching schedule was reduced to 4 drenches / annum. The cost of drenching per sheep / year came down to Rs. 16.00 with mortality rate of 0.45% due to worms. After that detailed studies were conducted at the institute on epidemiology and anthelmintic resistance in gastrointestinal nematodes of sheep to formulate a worm control strategy for sheep flocks of Rajasthan. The study revealed that:

- *Haemonchus contortus* is mainly responsible for production and mortality losses
- Peak intensity of infection is in the month of September
- Favourable period for larval translation on pasture is from late June to November
- There is no typical peri-parturient rise in faecal egg count
- Hypobiosis in worms occur from November to April
- There is wide prevalence of benzimidazole and levamisole resistant strains of *Haemonchus contortus* in Rajasthan

Based on above findings, a regional worm management programme was devised. It consisted of single strategic drench (preferably with narrow spectrum long acting anthelmintic) during mid to late monsoon and one tactical drench in October if required (based on faecal examination).

Month of drenching	Type of anthelmintics	Remark
Late August / Early September	Narrow spectrum anthelmintic (closantel, rafoxanide) / Levamisole group	Strategic drench
Late October/ Early November	Narrow spectrum anthelmintic (closantel, rafoxanide) / Levamisole group	Tactical drench based on faecal examination



Modified worm management programme for sheep flocks of Rajasthan

The type of anthelmintic was rotated between narrow spectrum salicylanilide and levamisole group. The main features of technology includes epidemiology based strategic deworming programme, reduced frequency of anthelmintic drench, less chances for emergence of anthelmintic resistant worms and economized worm management.

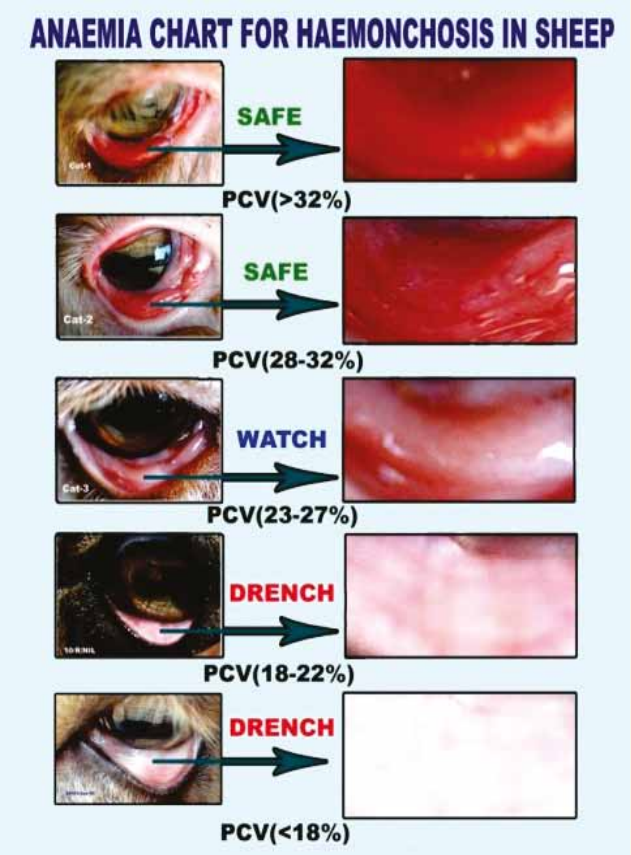
Salient Findings

The technology was implemented in both farm and field flocks of arid and semi-arid climatic conditions of Rajasthan. Flocks were monitored at monthly interval over the years. The monthly incidence and intensity of strongyle nematodes remained almost similar among flocks given either strategic (one drench / annum) or conventional (3 drenches / annum) anthelmintic treatment. The epidemiological profile exhibited higher magnitude of infection only during mid-monsoon. The data on flock performance exhibited that reduction in anthelmintic frequency in strategic scheme as against conventional scheme had no adverse effect on flock performance and yields better financial return to farmers. The result reflected the value and success of single drench schedule (strategic scheme) for the effective management of predominant gastrointestinal nematodes in field flocks of arid Rajasthan.

The programme saved Rs. 12/ sheep/ annum compared to conventional drench schedule without compromising the flock productivity. Comparative evaluation of conventional (2-3 drench/ annum) and modified technology (one drench/ annum) in sheep naturally infected with GIN at farmer level yielded a net gain of Rs. 100.57/ sheep/ year as direct benefit on application of modified technology. Further, indirect benefits of technology are reduction in selection pressure on parasites, delaying the emergence of anthelmintic resistance and extending the life of existing anthelmintics.

Adoption by Farmers

The technology is implemented in field through field Veterinarians and Livestock Assistants. Regular consultancy to farmers increased awareness among farmers for faecal examination in order to decide anthelmintic treatment and training to farmers through ATMA widen its adaptation. Since long the one drench per annum schedule has been found effective not only in farm flocks but also in field flocks of TOT areas and other flocks covered under All India Network Programme on Gastrointestinal Parasitism. The full acceptance of technology will pave the path for implementation of TST approach in field flocks.



Targeted Selective Treatment (TST) Approach for Management of Haemonchosis in Sheep

Gastrointestinal parasitism is the major disease responsible for economic losses in sheep. Among gastrointestinal nematodes (GIN) *Haemonchus contortus* is predominant and economically important nematode causing anaemia and death in heavy infection and substantial production losses at low infection levels. Traditionally control of parasites in livestock has been based on chemotherapy. The sustainability of anthelmintic treatment is threatened by the emergence of drug resistance in parasite populations. The rising incidence of resistance by the parasites to available anthelmintics is challenging the ability of farmers to maintain high level of productivity in the sheep throughout the world. The rampant emergence of anthelmintic resistance in parasites with resultant inability to rely upon chemotherapeutic measures poses a significant threat to the sustainability of sheep production. For control of gastrointestinal parasitism, the anthelmintics were used in different ways viz., whole flock treatment at frequent intervals (metaphylactic/ suppressive treatment) and strategic treatments based on epidemiology (targeted treatment) along with other non-chemotherapeutic measures. The need to conserve the efficacy of currently available drugs and any novel drug to be discovered in future must be balanced with the ability to maintain high levels of animal production and welfare. One approach which has been the focus based on recent research and debate is to maintain a parasite population in *refugia* (unexposed to drug), in order to maintain both phenotypic and genotypic susceptibility. The occurrence of over-dispersion phenomenon in faecal egg counts, within flock variation and rising importance of *refugia* in management of anthelmintic resistance led to evolution of techniques of targeted selective treatment (TST) of the most affected and / or the most anaemic animals to prevent / delay the development of drug resistance.

Technology Details

It is a simple system to categorize the anaemic status of sheep based on the conjunctiva mucosa colours on a scale from 1 (red) to 5 (white). Sheep were categorized into five scales as 1: red (non-anaemic), 2: red-pink (non-anaemic), 3: pink (mild anaemic), 4: pink-white (anaemic) and 5: white (severe anaemic) at monthly interval. The animals falling in category 1 to 3 were considered as normal while those falling in category 4 and 5 were considered as anaemic. Only those sheep categorized in group 4 / 5 were recommended for anthelmintic treatment particularly in wormy season. An average of 17% sheep in a flock was given anthelmintic drench / annum through TST as against 100% in modified or 200-300% in convention approach.

Salient Findings

The relatively increase in proportion of visually anaemic sheep was started after mid monsoon and reached to

peak level at the end of monsoon. The difference among two evaluators in detecting the anaemic animals in sheep flocks (based on eye colour chart) was higher at initial (July) phase which became marginalized in succeeding months. The study demonstrated application feasibility of eye colour chart by different evaluator. Over the years of application of TST approach in sheep flocks exhibited that 72.33% decisions were correct (infected and drenched) for detection of anaemia as well as infection. Incorrect decisions like uninfected but drenched (sheep side) and infected but not drenched (worm side) were made on 21.00% and 6.67% occasions, respectively. The analysis of pooled data (over the period of 8 years) for different treatment schemes exhibited higher lambing, low morbidity and mortality in modified worm management programme (MWMP) and TST flocks compared to conventional worm management programme (CWMP) flocks.

Comparative performance of flocks under different schemes of worm control in organized farm

	CWMP	MWMP	TST
Av. Strength	1271	1274	634
Lambing (%)	61.72	56.10	73.19
Mortality (%)	12.41	10.04	10.70
Morbidity (%)	103.28	61.87	48.67
Sale (%)	13.77	13.84	6.81
Annual wool yield head (kg)	1.547	1.387	1.361

The technology found to reduce expenditure on anthelmintics from Rs. 9.00 (conventional) and Rs. 5.85 (strategic) to Rs. 1.02/head/ yr (TST). Economic evaluation of different worm management schemes at farm level indicated that in sheep naturally infected with targeted treatment approach (1 drench / yr), there was a net gain of Rs. 176.07 /sheep/yr as compared to conventional treatment approach (>3 drench / yr). Compared to targeted treatment approach, a net gain of Rs. 155.76 / sheep/yr was realized with TST.

Adoption by Organized Farms

The technology is successfully implemented in sheep flocks managed at organized sheep farms (Sheep Breeding Farm, Fatehpur and Arid Region Campus, Bikaner of CSWRI) in Rajasthan. Though, farmers and veterinarians are naturally more concerned with the short-term economic, production and parasitological benefits accruing from prophylactic anthelmintic treatments, it is important that attention has to be given on the sustainability of anthelmintic treatment regimes. The acceptance of TST strategies by producers and their implementation may require a high level of input and education to the farming community. It is crucial that practitioners/farmers and advisors are made aware not only of the cost benefits, and potential disadvantages, accruing from a TST approach but also those associated with extreme multi-drug resistance. The use of TST thus requires some time investment for selecting the animals for treatment and the acceptance that a reduction in the number of treatments is necessary, based either on the fact that levels of resistance in gastrointestinal nematodes will decrease due to reduced selective pressure or that limited use of anthelmintics is more environment friendly and accords with organic production regulations.

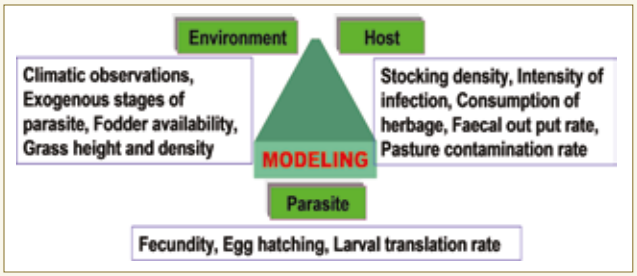
FROGIN: Software for Forecasting Gastrointestinal Nemetodiasis in Sheep of Rajasthan

It has been observed that use of anthelmintics in sheep was in jeopardized manner and did not based on sound epidemiological evidences. In order to tackle the rising problem of anthelmintic resistance in parasites, it was felt to develop a mechanism by which use of anthelmintics in sheep could be rationalised. A computer based programme was developed that simulates life cycle of *Haemonchus contortus* in sheep and on pasture for different agro-climatic conditions of Rajasthan. The life cycle of *H. contortus* starts with production and laying of eggs by adult worms and their shedding on pasture with faeces followed by development of eggs to infective larvae and their dissemination on herbage, ingestion of L_3 by grazing animals, establishment of infection in host and finally ends with recontamination of pasture was taken into consideration for formulating the prototype of modelling for *H. contortus* forecasting in sheep. The model was developed to predict the intensity of *H. contortus* in sheep.

Technology Details

Mathematical model (regression analysis) based on development and mortality rate / establishment rate, climatic data, development and survival of larvae on pasture, fecundity of parasite, stocking rate on pasture and migratory behaviour of larvae was used to predict the level of pasture contamination and subsequent possible intensity of infection in sheep. Monthly total rainfall, average maximum and minimum temperature and relative humidity were used to determine the period in which worm eggs from faeces reach the infective larval stage and migrate on to the herbage. The magnitude of infective larval population on the pasture was assessed by considering the mortality rate during the development of eggs to infective larvae, the mortality rate of infective larvae which have migrated on grass blades, the infection rate in animal in which adult worms have established after ingestion of L_3, the mortality rate of adult worms and the egg production rate of adult female worms. The steps involved in developing model are as follows:

- Interaction between faecal egg count and climate
- Development rates
- Larval survival rate
- Larval migration (vertical) rate on grass blade
- Stocking rate / density
- Seasonal herbage availability
- DM consumption rate
- Faecal output rate
- Establishment of adult worms in sheep
- Fecundity rate of adult worm
- Development of prototype of forecasting for *H. contortus* in sheep



Salient Findings

For this purpose farm and field flocks in different zones were taken and monitored for entire year with anthelmintic intervention as per modified worm management programme (once a year during mid-late monsoon). The comparative trends in FEC as predicted by FROGIN and observed on real time basis are as under:

On comparison, it was observed that while considering a variation of 500 epg in FEC as non-significant, the FROGIN based forecast about intensity of infection was > 80% in agreement in all the location and management system except in arid farm where agreement was 66%. The low agreement in arid farm could be due to creation of artificial environment suitable for worm propagation by practicing the irrigation means to cultivate the fodder. Variation in predicted and observed FEC to the tune of > 500 was noticed mainly during monsoon season and this could be due to variation in quantity of herbage and dilution of infection on pasture.

Adoption by Research Organization/Organized Farms

FROGIN will help to choose the number and time of drug treatments to get good worm control and to reduce the use of chemicals. This programme is capable of precisely forecasting the magnitude of parasitism for 60 days in advance and is extremely useful in decision making to organize deworming for sheep. Further, the programme is capable of shifting the scheduled drench in face of changing weather pattern and management modifications made by farmer.

Diagnosis of Paratuberculosis (Johne's disease)

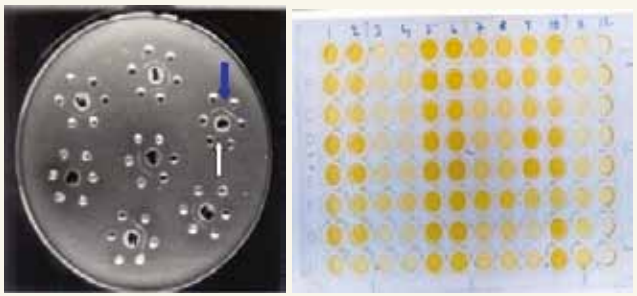
Paratuberculosis, popularly called Johne's disease, is a chronic, incurable bacterial infection of cattle and small ruminants primarily affecting gastrointestinal tract and the associated lymph nodes.

ELISA: An ELISA for diagnosis of Johne's disease has been developed and tested on natural sera of over 3000 small and large ruminant population in the country. The test has better sensitivity and over 95% specificity and has compared well with a most commonly used commercial ELISA. The assay is rapid and easy to perform and can be used as screening test at organized farms as well as in field conditions. The detection of animals even several months before they die is a significant advantage for early removal of animals from the flock/herd to reduce further load of infection at the farm premises.

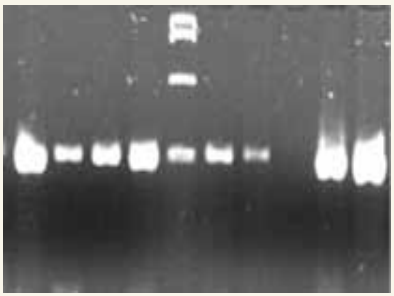
AGID: Agar-gel immunodiffusion (AGID) test is used for the specific detection of antibody to MAP for the diagnosis of clinical cases of paratuberculosis in ruminants.

The test is considered most specific and reliable especially in small ruminants. It is rapid and easy to perform and does not require any specific equipment and can be done in field conditions even by less skilled personnel. The detection of animals even several months before they die is a significant advantage for early removal of animals from the flock/herd to reduce further load of infection at the farm premises.

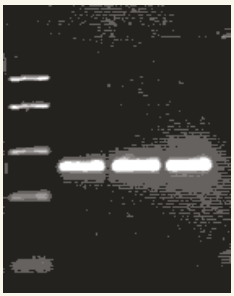
Polymerase Chain Reaction (PCR): PCR based assays targeting IS900, 251 locus and ISMav2 genes have been developed for diagnosis of paratuberculosis on a variety of clinical samples of animals' origin. These assays are sensitive and specific and being used regularly for confirmation of clinical and post-mortem diagnosis and isolated bacterial culture.



Screening test for Paratuberculosis



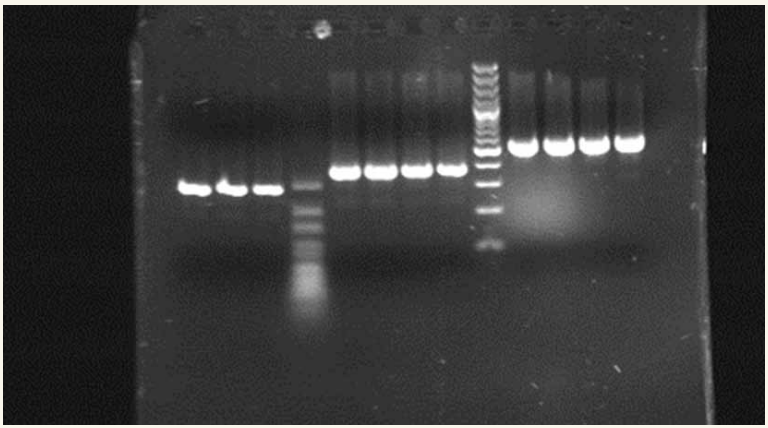
ISMav2 gene PCR



251 gene locus PCR

Diagnosis of Caseous Lymphadenitis

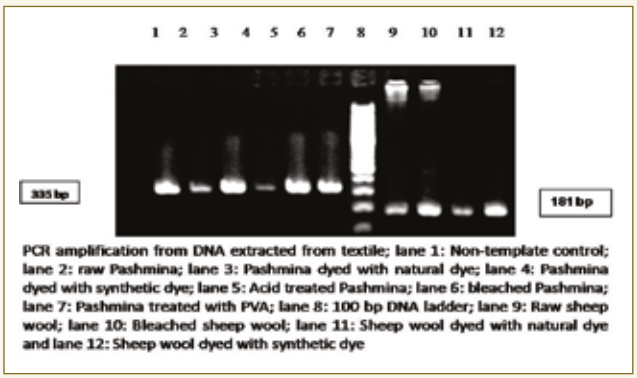
Caseous lymphadenitis (CL) is a chronic bacterial disease of sheep and goats caused by *Corynebacterium pseudotuberculosis*. The isolation of this bacterium and conventional characterization is cumbersome and time consuming. A PCR based assay employing primers from three specific genes of *C. pseudotuberculosis* viz., ABC, NADP and PIP genes is developed for rapid identification and characterization. This assay is used on the clinical samples of sheep and goats for diagnosis of caseous lymphadenitis.



Molecular Technique for Identification of Wool and Specialty Hairs

The production of Pashmina fibre in India is limited. Adulteration of Pashmina with other fibres is a common practice due to limited production and higher prices. Sheep wool is one of the cheaper fibre for adulterating Pashmina fiber primarily because of similar appearance. The ultrafine Merino wool (14-16 μ diameter) is quite similar to Pashmina (Cashmere) and can be easily adulterated for production of high quality value added Pashmina products. The conventional physical and chemical tests are unable to identify adulteration of Pashmina with fine wool due to similarity in their quality attributes. The cost effective and readily available Polymerase chain reaction (PCR) based molecular technique has been developed to identify and differentiate Pashmina from the adulterated products.

In this process, DNA is extracted and amplified using PCR from the processed fabrics containing Pashmina/ adulterated products of wool. This process can be used to identify even up to 10% Pashmina in the adulterated products.



PCR amplification from DNA extracted from textile; lane 1: Non-template control; lane 2: raw Pashmina; lane 3: Pashmina dyed with natural dye; lane 4: Pashmina dyed with synthetic dye; lane 5: Acid treated Pashmina; lane 6: bleached Pashmina; lane 7: Pashmina treated with PVA; lane 8: 100 bp DNA ladder; lane 9: Raw sheep wool; lane 10: Bleached sheep wool; lane 11: Sheep wool dyed with natural dye and lane 12: Sheep wool dyed with synthetic dye

Adoption of Technology

Technique is promising one and utilised by number of Government organization and Export houses viz., Office of the Commissioner of Customs (Import & Gen.), New Delhi, Office of the Joint Commissioner of Customs, Export (Shed), New Delhi, Sodhani Biotique, Jaipur; M/s Absolute Pashmina Designs Pvt. Ltd., New Delhi; Bhudha Eximp & HR Pvt. Ltd, New Delhi and JKM Overseas Pvt. Ltd., Gurgaon. This technique can help exporter/Importer for quality assurance of Pashmina or its blended product.

Carpet

Aesthetic and Durable Carpet from Indigenous Wool and Its Blends

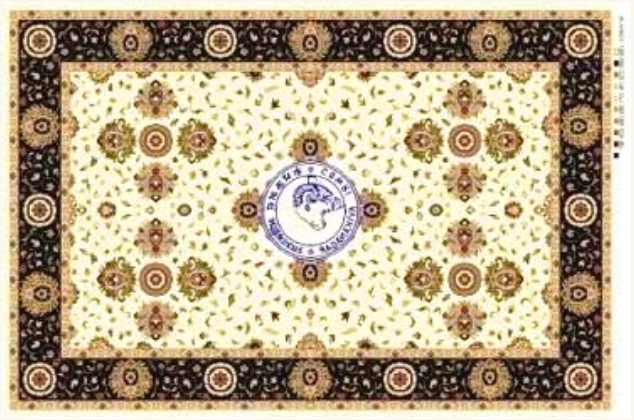
Indian wool is graded as best carpet type wool, as it provides excellent resilience, lustre and performance. Sheep breeds producing carpet wool in Rajasthan are Magra, Chokla and Marwari. Among them, Magra sheep produces excellent quality carpet wool. Magra wool gives excellent resiliency and lustre property to the carpet, however, the carpet has low abrasion resistance. It can be improved by blending with 10% nylon fibre.

Technology Details

The carpet wool of Magra is blended with nylon (10%) and converted into 4 Nm carpet yarn. The yarns are dyed with metal complex dyes into different shades having good colour fastness. The yarns are converted into hand knotted carpet with intricate design having quality 100 knots/inch^2 (10 X 10) and 12 mm pile height. In second lot, the yarns are woven into handloom carpet with single colour having 1200-1500g/meter^2 and 10 mm pile height. Carpet is chemically washed along with anti-moth treatment. The technique has been standardized for important construction parameters viz., pile height, pile density and ply of yarn.

Parameters	Hand knotted	Hand loom
Price of raw wool (Rs./kg)	100.00	
Spinning cost (Rs./kg)	60.00	
Yarn realization (%)	70.00	

Parameters	Hand knotted	Hand loom
Cost of yarn (Rs./kg)	272.0	
Dyeing cost (Rs./kg)	40.00	
Cost of dyed yarn (Rs./kg)	312.00	
Yarn required (kg/ sq. ft of carpet)	0.400	0.112
Yarn cost per carpet (Rs./ sq.ft)	125.00	35.00
Weaving charge (Rs./sq.ft)	375.00	25.00
Finishing charges (Rs./sq.ft)	30.00	30.00
Cost of carpet (Rs./sq.ft)	530.00	90.00
Sale price (Rs./sq.ft)	600.00	100.00



The higher cost and low production of hand-knotted carpets make them exorbitant to middle income group. They are well in demand, especially in cold region of Jammu and Kashmir, Himachal Pradesh and Uttarakhand.

The low cost and higher production of handloom carpet has great demand for wall to wall covering. These carpets provide equivalent comfort and interior in houses and offices.

Adoption of Technology

The technology has been adopted by the Chetna Carpets, Jaipur and Ganga Carpets, Jaipur. They are preparing the carpet and selling at their sale outlet. The antiquity of designs and carpet durability attract Indian and foreign tourists.

Angora Rabbit Hair-Bharat Merino Wool Blended Shawls

Angora rabbit hair-Bharat Merino wool blended shawl

The woollen products prepared from Angora rabbit hair are always in demand due to their special attributes like higher thermal insulation and softness with light weight. Conventionally, Angora rabbit hair is blended with imported Australian Merino wool in different proportions to spin into yarn for making good quality shawls. Indigenous fine cross-bred wool can be used for blending in place of imported Merino wool for quality shawls.

Technology Details

The blend level of Angora hair and Bharat Merino wool has been optimized in the ratio of 60:40. Angora hair is blended with Bharat Merino wool using modified cotton card at slow speed to avoid breakage and

processed into yarn using semi worsted system using gill box, roving frame and worsted ring frame.

The blended yarn is then used to weave shawl in 2/2 twill weave pattern on handloom. Conventionally, the shawls are not given any treatment. However, the quality of the shawls can be improved through chemical treatments.

A chemical finishing process has been optimized in order to improve the whiteness, softness and pilling resistance of developed shawl. In this process, the shawl is bleached using 4gpl hydrogen peroxide (H_2O_2) followed by treatment with 0.25% optical brightening agent. The bleached shawl is then treated with 2gpl cationic silicone softener in the same bath.

Salient Findings

The produced Angora and BM blended shawls show 30% higher whiteness and 20% higher softness compared to the conventionally shawl. The Bharat Merino wool can be used in place of imported Merino wool to produce Angora hair blended shawls.

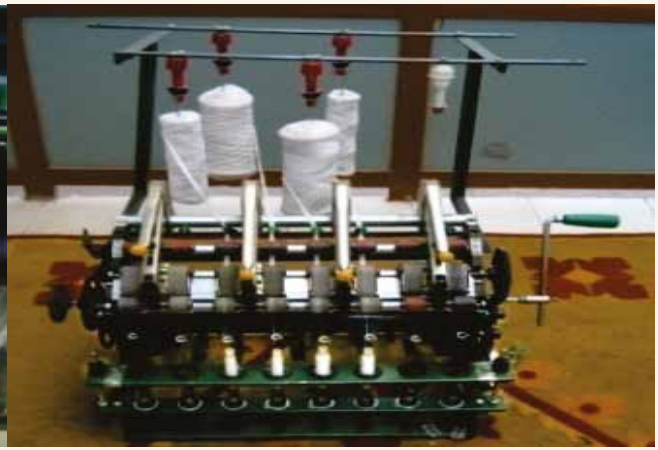
Adoption by the Artisans/Industries and Handloom Sector

The shawl manufacturing industries of Himachal Pradesh, have well adopted this technique of Angora hair blending and producing off-white and bright shade shawls. M/s Mahadev Woollen Mills, Sundernagar, Mandi has established semi-worsted spinning unit and successfully adopted the Angora hair blending up to 60% at commercial level. They are supplying yarn to local artisan/ weaver for shawl weaving. Another entrepreneur Mr. Rajeev Sharma, Chairman, Shikar Handloom Co-operative Society, Rampur Buhsir, Shimla adopted the improved process for shawl bleaching and softening. The treatment not only enhance the appeal and value of shawl but also significantly reduces the pilling property associated with angora blended shawls. The process got wide acceptance among the stakeholders due to enhanced quality of shawls.

Development of Pure Pashmina Yarn using PVA as a Carrier Fibre

Pashmina, popularly known as 'Cashmere' is well known for its fineness, warmth, softness, desirable aesthetic value, elegance and timelessness in fashion. It is most luxurious fibre which is much softer than superfine Merino of the same diameter therefore it commands much higher price. On account of small production of this specialty fibre, most of it is utilized in products locally with the help of manually operated traditional charkha. The hand spinning of Pashmina yarn requires unique dexterity and highly laborious also. Some of industries have developed a process of spuning 100% Pashmina yarn by mixing with nylon as carrier fibre. However, the nylon is removed by conc. hydrochloric acid which is a hazardous and also not eco-friendly process. Institute used PVA (polyvinyl alcohol) as a carrier fibre which can be easily removed by hot water.

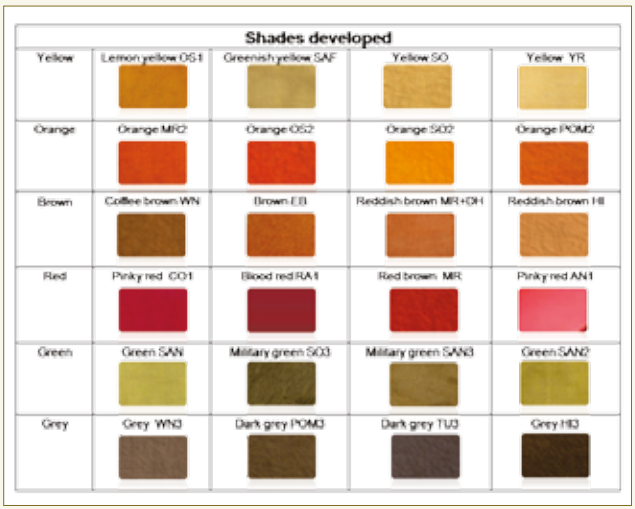
In this process, the dehaired and carded sliver of Pashmina fibre is passed through gill box 3-4 times to remove the short fibres and parallelize them. At this stage, the PVA fibre (in sliver form) is blended with the Pashmina fibre in (30:70) and allowed to undergo 5-6 passages in gill box for proper blending. The resultant sliver is then converted into roving on bobbiner. The roving is taken to modified Amber Charka /ring frame for spinning. The produced yarn is doubled to yarn linear density of 2/80 Nm and get the required strength for handloom weaving.



The PVA from the fabric is removed by treatment with hot water at 80°C for 15 minutes in three baths with intermittent washing. An addition of 0.5 % sulphuric acid in the dissolution bath can completely remove PVA in single bath. Fabrics produced from Pashmina-PVA blended yarn are as good as traditional hand spun yarn in terms of their strength, handle and other properties.

Adoption by the Artisans/Industries and Handloom Sector

The developed process for Pashmina yarn is more productive and cost effective. The shawl manufacturing industries of Himachal Pradesh has adopted this technique. M/s Kailash Udyog, Sundernagar and Shikar handloom Co-operative Society, Rampur Buhsir, District Shimla are producing 100% Pashmina shawls by this technique. The yarn spun by this process is more uniform which enhance the production and reduces the cost of production by 50%. Pure pashmina shawls produced by this process got wide acceptance among the customers due to better softness and quality.



Natural Colours for Wool and Specialty Hair Fibre

In recent years, the concern for clean environment has created a deep interest in natural dyes. India has a rich tradition of utilization of natural dyes in textiles. The animal fibre like wool and specialty hair fibre are used to produce unique products. The value of such products can be improved if they are dyed with natural colour. Keeping above facts in view, several sources of natural dyes are screened for dyeing wool and specialty hair fibre.

Technology Details

The extractions of colourant and application process on the fabric are optimized. A comprehensive natural dyeing process has been developed for dyeing woollen products in all range of colours with good light and wash fastness properties. The natural sources used and the colours produced are:

Colour	Source	Mordant	Shades produced
Yellow	Onion skin	Without mordant	Yellow
		Aluminum sulphate	Lemon yellow
	Saffron	Without mordant	Greenish yellow
	Silver oak		Yellow
	Onion skin	Stannous chloride	Orange
	Silver oak		Orange
	Madder		Orange
	Yellow root	Without mordant	Bright lemon yellow
Brown	Madder+ Dholkanali		Reddish brown
	Henna		Reddish brown
	Eucalyptus bark		Brown
	Wattle		Brown
	Wall nut		Coffee brown
Red	Madder		
	Annota	Aluminum sulphate	Pinky red
	Ratanjot		Blood red
	Cochineal		Pinky red
Blue	Indigo	Without mordant	Indigo blue

Colour	Source	Mordant	Shades produced
Green	Fresh flowers of saffron	Without mordant/ Alum	Green
	Onion skin	Ferrous sulphate	Military green
	Pomegranate rind		Military green
Grey/ Black	Silver oak		Dark grey
	Henna		Black
	Shisham		Grey
	Wall nut		Black

Salient Findings

Shawls made of wool and speciality hair fibres,especially, Pashmina can be dyed comprehensively with natural dyes in all colours with good fastness properties. Some of the natural dyed materials are found to have functional properties like anti-microbial, anti-moth etc.

Adoption by the Industries/ Artisans/Handloom Sector

The technology has been demonstrated to dyeing industries, Pashmina processing artisans/dyers of Srinagar, Kullu, Jaipur etc. Pant woollen mills, Hurla, Bhuntar, Kullu; Artisan of Nagger village, Patlikul, Manali, M/s colours of Kashmir, Srinagar; Faculty members of Indian Institute of Craft and Design, Jaipur; Artisan of Ghothoo village, Kullu and Badshah Studio, Jaipur have adopted the technology. The process is eco-friendly and the shades are obtained with acceptable fastness properties. The colour obtained from new sources like saffron, silver oak, onion skins, dhol kanali, Indian barberry have greater acceptability among the customers.

High Quality Blankets from Indigenous Wool

Good quality and cost effective woollen blankets are prepared from indigenous wool. The blankets are woven on handloom with appropriate picks per inch. The chemical processing of indigenous blankets improves the functional properties and makes the blanket more attractive.

Technology Details

High quality check blankets of different colour patterns are developed by optimising different wool mix. Indian wool of different fineness mixed in different proportion and spun into 3-4 Nm yarn on woollen spinning system. Fine cross-bred wool: Indigenous Chokla wool: Nylon in the proportion of 45:50:5 was found optimum blend for good quality blanket. The blanket is woven on handloom as per the BIS specifications. The chemical finishing treatments viz., milling, scouring, drying (stenter), raising and decatizing are given to enhance softness and dimensional stability of blanket.

Salient Findings

- The blanket possesses soft feel and excellent thermal insulation properties
- Good handle and durable
- The shrinkage is within tolerance limit
- The blanket has adequate strength and consumer acceptance

Adoption by Handloom Sector

The technology and designs of blanket developed by the institute is well accepted by the Khadi and Village Industries Commission (KVIC) and Jammu and Kashmir Small Scale and Rural Industries and M/s Vishudh Khadi Samiti, Bikaner.

Development of Woolen Handicrafts from Coarse Wool

The handmade felt viz., Namda is one of the handicraft product which is made of non-apparel or coarse grade wool with traditional design. Felt are prepared in various thickness, colour, size and in traditional and geometric patterns. Innovative and durable handicrafts and wall hangings are developed from handmade felts.

Technology Details

The handicraft designing and painting have been introduced in traditional felt. Anti-moth treatment is introduced during dyeing of handmade felt. The stages like pattern making, designing, cutting, pasting, stitching and decoration are added to improve its attractiveness and demand. These features adds to value of the product. Different home furnishing articles like handmade painting, soft toys, wall hangings and useable households are developed with novel designs. Different geometric figures and artistic designs have been created by different colour combination and stitching of felts.

Salient Findings

Value addition of traditional namda could increase income of artisans. Farmers will get better price for coarse grade wool. Namda making has potential to provide sustainable livelihood opportunities and employment in rural areas. It would also provide platform for artisans to show their creativity and nurture the rural talent.

Economic analysis of handicraft making

Expenditure particulars	Cost (Rs.)
Cost of wool/kg (Including losses up to Lefa making)	50.00
Cost of wool consume in handicraft making (500g)	25.00
Handmade felt making charges	40.00
Designing, pattern making and cutting charges	10.00
Cut piece gluing their stitching, glitters, stone, glass etc. decoration charges	60.00
Total cost of handicraft	135.00
Sale price of handicraft item	175 – 200

Adoption by artisans

The economic analysis shows that good profit of margin to all value chain partners. A self-help group under the leadership of Mrs. Sabnam from Tonk city adopted the technology and is earning good remuneration. The technology is also adopted by rural artisans of Tonk, Malpura, Bhaghera, Chandsen of Tonk district of Rajasthan.


CSWRI

Anti-microbial and Anti-moth Properties of Natural Dyes for Wool and Speciality Hairs

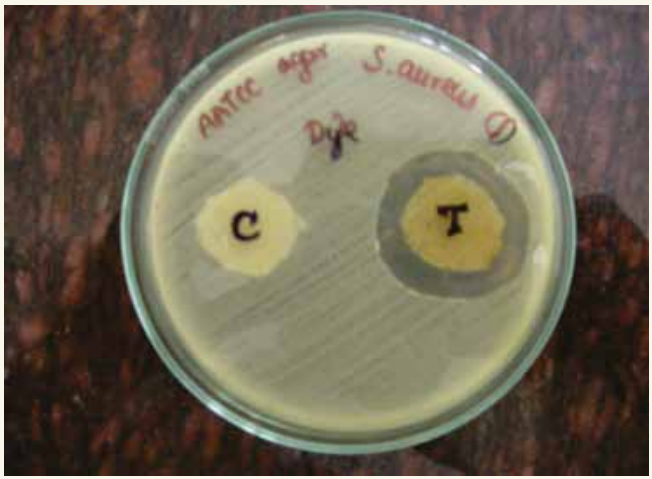
The natural dyes apart from giving colour to the textiles also have anti-microbial and anti-moth properties. Several natural dyes are screened for anti-microbial and anti-moth properties. The silver oak and myrobalan dyed wool fabrics exhibit antimicrobial efficacy against *S. aureus* and *E.coli* bacteria. The shisham, silver oak, henna leaves and walnut and pomegranate husk/rind and dhol kanali and madder root extract dyed wool fabrics have shown anti-moth properties against the carpet beetle larvae.

Salient Findings

The phytochemical analysis of the above natural dye sources revealed that the presence of higher tannin (> 40%) and quinone has effective antimicrobial and anti-moth properties.

Adoption by the Industries/Artisans/Handloom Sector

The technology has been demonstrated to dyeing industries, Pashmina processing artisans/dyers of Srinagar, Kullu, etc. M/s colours of Kashmir, Shrinagar, Shikar Handloom Co-operative Society, Rampur Buhsir, Shimla and M/s Mahadev Woollen Mills Sundernagar, Mandi.



Anti-moth and anti-microbial properties of natural dyes

Hand Made Felts and its Products

Inferior grade rabbit hair and camel hair, which has little textile application, can be used for manufacturing quality products. It can be blended with short length fine wool in various proportions. The felt can be used for value added products like felt jackets, floor coverings, women ruffles etc. Little embroidery work can further enhance its value.

Salient Findings

The blending of inferior rabbit wool (up to 40%) with short staple length fine wool is used for manufacturing felts of superior quality, low weight and extra white handmade (density of 1500 g/m^2 with 3 mm thickness), which can be used for better quality jackets. Camel hair blend can be used up to 40% for felts (density1800g/ m^2 and thickness of 6 mm) and found suitable for floor coverings and interlining of winter jackets or all felt jackets with embroidery.

Adoption by the Industries/Artisans/Handloom Sector

Adoption of the specialty fibre blending to wool, can increase the remunerations to artisans and income and generate enhance employment in the rural / cottage industries.

Felt products

Development of Fabric from Fine Wool of Dumba Sheep

Wool from Dumba sheep is generally coarse and hairy type with a mixture of medium fine (21%) and coarser wool (79%) fibre. The process for harvesting of fine wool fibres has been developed. The increase in proportion of fine fibre improves the spin ability of wool thus, spun into yarn of higher linear density. Fabric is woven on handloom with appropriate specification viz., 2/2 twill structure, EPI-43 and PPI-35 with areal density of 165g/m^2.

Salient Findings

Dumba wool contains fine fibre of diameter < 10-12 μ and coarse fibre of >150-246 μ with mean fibre diameter of 37.69 μ%. The process of coarser fibre removal improved mean fibre length fibre and diameter of fine and coarse wool by 50% and 23% and 24.03 μ and 47.2 mm respectively which is suitable to fabric making. Nylon blending further enhanced the spin ability and weaving efficiency. The slightly rough feeling of fabric due to presence of medullated fibres (5-6%) can be improved through enzyme and softener treatment during finishing process.

Fabric from fine wool of Dumba sheep

Adoption by the farmers/ Industries/Artisans/Handloom Sector

Dumba sheep is mainly reared for mutton and recovery of fine wool from Dumba fleece can increase remuneration to the farmer. Dumba have great aesthetic and religious value and apparels from its wool could provide better opportunity to artisans and handloom weaver and retailers.

Development of Lustre Wash Process for Carpet Yarn

Lustre in wool and woollen products impart an aesthetic appeal to the eye. Canary colouration causes yellowness to wool and poor appearance. It is difficult to dye yarns into bright and pastel shades. To overcome the risk of commercial mild alkali wash to carpet for improving lustre, a yarn scouring process has been developed to improve lustre of carpet wool yarn. There is clear difference in whiteness index (L*) and a value of 5.0 % higher absolute value for high to low lustrous wool has been recorded in subjective evaluation. Carpet yarns treatment is optimized to 1% solution of sulfuric acid or caustic soda for 10 minutes at 35 °C followed by 4 to 5 rinsing.Yarns can be treated with 10% protease enzyme with same conditions.

Comparative profile of carpet yarn (Rs./kg)

Particulars	White wool mix	Yellow wool mix	Yellow wool mix yarn with treatment
Cost of spun yarn	120	100	100
Cost of Scouring	10	10	10
Cost of treatment	-	-	10
Cost of finished / scoured yarn	130	110	120
Expected price realization	160	140	160
Net profit (Rs.)	30	30	40

Salient Findings

The highest whiteness (L*) value of 80.54% has been found for treatment of H_2So_4 solution at 1.0 % conc. for 10 min duration, which is 6.0 % absolute higher value. For NaOH treatment at 1.0 % conc. for 10 min duration though similar whiteness (L*) value observed but hue of the treated yarn is changed to reddish and bluish i.e. toward dullness.The improvement in yarn whiteness (L*) value on enzyme treatment is not significant. Treatment of wool with caustic affect its durability and also have risk of carpet discolouration after weaving thus not suggested. The treatment of wool with H_2SO_4 4.5-7.5 % (w/v) for 10 minute duration improves lustre. The treatment cost comes to Rs. 8-10 per kg and Rs. 20 per kg in case of yellow wool mix yarn.

Adoption by Industries

The technology is well adopted by carpet yarn industries viz. Mundra Woollen mills, Kakri, Chitra Carpets, Bikaner, Shyam Textiles, Bikaner, Chetna Carpets, Jaipur, Bikanew Vishudh Khadi gram Udhyog Samiti, Bikaner etc.

Lustre wash process for carpet yarn

Value Added Sheep Meat Products

Meat and meat products are rich in proteins, health promoting elements like conjugated linoleic acid (CLA), minerals such as iron, zinc and selenium, L-carnitine, histidyl dipeptides (carnosine and anserine), creatine, taurine, vitamins (B, E), glutathione, ubiquinone, lipoic acid, etc. Rising awareness about role of meat and meat products in human nutrition is driving force for increasing meat consumption. Nuclear families, ever-increasing number of women entering in workforce has increased demand for ready to eat as well as heat and serve type convenience meat products. The meat processing into various value added meat products has been linked with many advantages like creation of variety products, convenience, enhanced shelf life and creation of healthier meat products with low fat, low salt and fibre enriched meat products. Meat processors and consumers could be benefited from the development of value-added products with high acceptability at reasonable cost. With changing consumer preferences, traditional meat processing which was aiming addition of non-meat ingredients for the purpose of altering the colour, flavour, safety, and shelf-life characteristics has been changed and nowadays meat products prepared to have unique sensory characteristics, health benefits and convenience.

Technology Details

Meat Sausages: Sausages have acquired universal popularity. Preparation of sausages involves deboning, freezing, thawing for 12 h and cutting of the meat into cubes/chunks followed by mincing. The minced meat is processed for preparation of meat batter/ emulsion. Meat emuslion is stuffed into natural or synthetic casings followed by linking at specific length. Cooking is carried out in water bath. The sausages are cooled and packed in LDPE bags. The artificial or synthetic casings are peeled off before the product is packed, small sized natural casings need not be removed. The product is generally unit packed for retail outlets.

Nuggets (Ready-to-eat, partially or completely emulsion based product): Nuggets are popular convenience products and is generally used as a snack food or mixed

with gravy. The product is packed in unit pouches. It is usually shallow fat fried before serving for breakfast or refreshment. Healthy nuggets containing less salt, fat and more fibre have been developed.

Enrobed Mutton Nuggets (Meat based fast food): These are popular by virtue of their versatility and superior sensory properties. Enrobing contributes multiple benefits like value addition, improvement of nutritive value and texture profiles. Application of edible coatings has been reported to extend shelf life and improve the quality of fresh frozen and fabricated foods. The mutton nuggets are coated with egg white, bread crumbs and other ingredients and then deep fat fried. This gives attractive golden brown colour and enhances palatability of the product.

Patties: Meat patties are one of the most popular products among the ground meat items and are generally used as filling for burger roll or sandwich. Patties are partially or completely emulsion based product and are molded manually or mechanically. Lean meat is minced twice through 6 mm plate and fat through 4 mm plate of a meat grinder. These are mixed thoroughly with other ingredients for preparation of meat batter/ emulsion. The meat emulsion/batter weighing 60-80 g is molded into 70-80 mm diameter and 15-20 mm thick patties. Raw patties may be frozen for future use or broiled in a pre-heated oven at 180^{0}C for 20 min. The internal temperature of the patties must not be less than 72^{0}C. The patties are cooled and consumer packed.

Meat Pickle: Meat is perishable item. Meat pickles are shelf stable, traditional and ready to eat products. Pickling of perishable foods in vinegar or edible oil with added salt, spices and condiments provide ready to eat products with good shelf stability at ambient temperature. The meat pickles can be stored at ambient temperature for 2-3 months. For preparation of pickle, meat is cut into chunks of 3-4 cm size and turmeric and half of the quantity of the vinegar is added then marinate is kept in the refrigerator for 2-3 h. Excess of fluid is drained out and meat chunks are cooked in the pressure cooker. Spices and condiments are fried in oil and cooked meat pieces are fried till brown coloration. Then meat chunks are allowed to cool on and remaining half of the vinegar is added. The chunks are then filled in sterilized pet bottles/glass jar and heated and cooled refined oil layered on the top. Keep it at room temperature till seven days for maturation.

Mutton Soup: Even after careful manual separation of meat from bones, 10-15% meat is left over bones. These bones could be used to extract juice for preparation of mutton soup. The bones are pressure cooked and broth obtained is separated and filtered through sieve.

The broth is kept at refrigerated storage for overnight and solidified fat layer is separated. Equal quantity of water and broth are boiled separately. Spices and condiments are fried in oil and salt, flavoring and other ingredients are mixed and simmered for 5 min. The contents are filtered through a sieve and served hot.

Enrobed Eggs: Preparation of enrobed eggs involves hard boiling of eggs, separation of egg shell and coating of around 50-60 g of mutton emulsion over the egg. Coated eggs are cooked in water for 10-15 min. Then enrobed eggs are cooled and packaged.

Meat Loaf: The meat mix or batter is tightly filled in aluminium or steel loaf pans. The pan-in mix is steam cooked or broiled in hot air oven at 165^{0}C for 2.5 to 3.0 h. The internal temperature of 72^{0}C must be achieved. It is then cooled in water and chilled at 4^{0}C. The chilled loaves are either packed as such or cut into slices of desired thickness and packed. These slices can be used for making meat sandwich.

Meat Kofta (Meat Ball): It offers a great convenience to restaurants, hotels and housewives who can just put few balls in the gravy and serve the food within 10 min. The product is prepared from ground meat. The meat emulsion of 15-20 g is rolled into balls manually or mechanically. These are either stored raw or deep fat fried in refined vegetable oil at 135^{0}C for 3 min to get brown colour and fried flavour. Alternatively, these are cooked in hot water maintained at 80^{0}C. Water cooked balls may be subjected to light frying to get golden brown colour. These are packed in polyethylene pouches. Whenever required, the cooked balls could be simmered in gravy for a few minutes and enjoyed with rice or bread.

Mutton Kabab: *Kababs* are a dish of oriental origin, prepared by charbroiling. Variety of *kababs* can be made either from mince or chunks of meat and other ingredients. Two variety of kabab are popular i.e. seekh and shami kabab. The flavour of charbroiled *kabobs* is unique due to combustion of fat that drips on the red hot charcoal. Oven roasting is generally used for commercial scale cooking.

Restructured Meat Products: Restructuring is the technique in which meat is partially or completely disassembled and then reformed into the same or different. Reformed meat products are well-known and consist of meat pieces (usually minced meat or loose meat) which are bound together using a binder. In reformed meat products underutilized cuts and quality

trimmings can be used. These restructured meats can be used for new product development. A major benefit of restructured meat products is that they can be adapted to consumer needs for convenience, portion size, composition, and ease of preparation.

Mutton Croquettes: Preparation of croquettes involves, mixing of batter with chaffed onion, curry leaves and coriander leaves. Then small lumps are deep fat fried in the oil at a temperature of 180-200°C until golden brown colour appears. The croquettes have unique flavour and other sensory attributes.

Salient Findings

Value added meat products

1. Various value added convenience mutton products like sausages, patties, nuggets, loaves, enrobed products, croquettes, kabab, kofta, pickle and mutton soup have been developed.
2. The functional, inulin fortified, low fat mutton nuggets have been developed. The inulin has number of advantages of low calorie, fat replacer and is also used as prebiotic. It is not digested by humans thus makes it suitable as a dietary fibre.
3. To improve the fibre content of mutton nuggets, 5% seedless date paste is found optimum.
4. The enrobing of mutton nuggets significantly improved sensory attributes.
5. To improve conjugated linoleic acid content of mutton nuggets combination of 3% mutton fat & 7% vegetable oil is found optimum.
6. The low fat mutton nuggets can be stored for 18 days at refrigeration (4±1°C) storage.
7. Meat from cull sheep is very tough. To decrease its toughness locally available *Cucumis trigonus Roxb* (Kachri) powder and papain is used. For tenderization of tough meat from cull/spent sheep 2.5% Kachri powder can be used.
8. Common salt/sodium chloride is the main source of sodium in diet. The processed meat products contains significant amount of salts Salt content in the nuggets could be reduced up to 42.5% level with blend consisting of salt, KCl, $CaCl_2$, monosodium glutamate, Citric acid.
9. The mutton based snacks developed could be stored up to 45 days. The vacuum packaging is useful in enhancing the keeping quality of the mutton snacks at ambient storage.

Value Added Sheep Milk Products

The sheep milk is rich in many of the components. The value addition to sheep milk can create variety of milk products. The sheep milk is utilized for development value added milk products.

Flavoured Milk

The sheep milk is filtered and is heated to boil and 10% carrot pulp and 7% sugar, few pieces of cardamom are added and milk is cooled and filtered again. The flavoured sheep milk is highly acceptable.

Mozzarella Cheese

The processing technique is optimized for mozzarella cheese preparation from sheep milk. The processing steps involved filtration of milk to remove extraneous matter, followed by pasteurization. Then cooling and acidification of milk, addition of rennet. After setting the curd is cut and again cooked. The whey is drained and curd is immersed in hot water and kneaded and stretched for proper body and texture. The resultant mass is then moulded into shape and immersed in 20% brine solution at refrigerated storage. The cheese is rich (33%) in proteins and also relished by consumers.

Sheep Milk Paneer

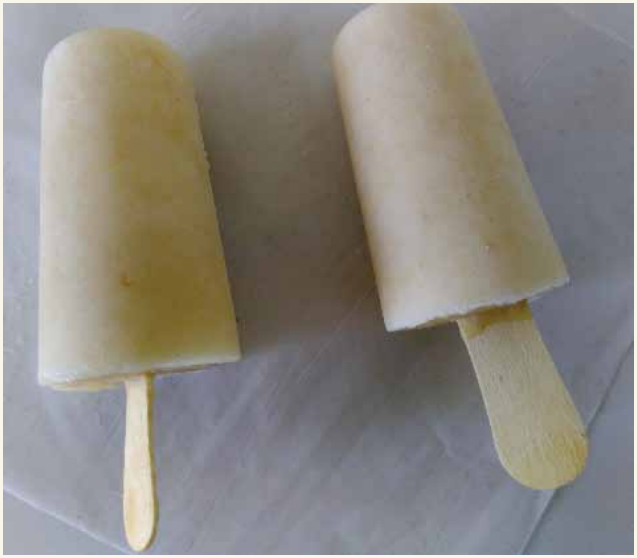
The sheep milk is heated and then acidified with 1% citric acid. The resultant coagulum is filtered through muslin cloth and then pressed. Paneer obtained from sheep milk contain 26% protein and 11% fat with 18% cook yield. The sheep milk paneer has desirable texture and is highly acceptable.

Gulabjamun:

The sheep milk is heated in karahi with continuous stirring to obtain the khoa. The yield of khoa is 22.4%. The khoa is used for preparation of gulabjamun. For making Gulab-Jamun, khoa and maida are taken in 3:1 proportion. The gulabjamun are highly acceptable.

Sheep Milk Kulfees

The processing technique and formulation is optimised for processing of sheep milk into Kulfi. The milk is boiled and concentrated to 2:1 ratio. Then sugar and stabilizer are added and mixture is cooled. Then flavours are added and the mix is filled in the moulds and filled moulds are kept in deep freezer. The sheep kulfi is relished by all the consumers.



Adoption of Technology

The sheep milk contains higher proportion of fat and solid not fat content. The milk could be processed into different milk products and highly nutritious and healthier milk products could be made available for the consumers. This would also provide be additional source of income to sheep rearers.

Success Story

Avishaan Sheep to Double the Income of Farmers…..

A new Avishaan sheep with multiple birth, more body weight and milk yield has been developed at ICAR-CSWRI, Avikanagar. New genotype developed by introgression of *FecB* gene and has genetic constitution of 12.5% Garole, 37.5% Malpura and 50% Patanwadi. Mr. Gopal Jat of Rindliya village (Tonk district) in September 2013 established a unit of five adult ewes and one ram. Till date 25 lambs born (litter size of 1.56) from 16 lambing of 5 ewes provided by ICAR – CSWRI in his house. Avishaan lambs attained live weight of 3.01, 13.73 and 22.95 kg at birth, three and six month, respectively. The ewe productivity efficiency (EPE) of 18.73 kg and 29.06 kg at 3 and 6 month of age, respectively achieved by the farmers in his field flock which excelled the local Malpura sheep. The pre-weaning survivability of around 95% achieved in lambs born from prolific ewes. Farmers received 9 lambs more from five Avishaan than Malpura sheep in 3 years. He earn Rs 22500 more from sale of lambs (9 lambs at the rate of Rs. 2500). Farmer is building the Avishaan sheep flock and would get more income in future with increase flock size. Thus, Avishaan sheep enhancing the economic returns of farmers.

Milk Replacer Supplements to Lambs Raise Income of Farmers

Majority of Indian sheep breeds did not produce enough milk to support higher growth rate of pre-weaner lambs. Institute has developed milk formulae (MF) for lambs for higher gains and survivability. It consists of skim milk powder, soya powder, peanut meal, different types of flour, variety of edible oils, citric and butyric acids, minerals and vitamins. It contained 24-28% crude protein, 10-12% fat and 15-17% total solid (dry matter). It should be fed to lambs at the rate of 100-250 ml from 12-90 days of age, 100 ml during 10-15 days and thereafter 250ml up to 90 days. The MF powder costs @ Rs. 115 per kg and the reconstituted liquid milk (RLM) @ Rs. 20.00 per litre.

Shri Rodu Gujjar of village, Tantya, Malpura, Rajasthan has adopted RLM feeding to lambs in April 2015. He made 6 litre of RLM from 1 kg of MF powder, which was fed individually in a bottle. In successive year of adoption of this technology, he achieved an average body weight of 24.4 kg in lambs at 105-110 days of age. He sold the lambs at an average price of Rs. 3200 per lambs and recorded a net profit of Rs. 800 per lamb more. Shri Gopal Jat of Rindlia village and Shri Mahaveer Jat of Tantya village also adopted the RML feeding in lambs in May 2015. Shri Gopal Jat achieved average body weight of 21.95 kg (10 lambs) and sold at the rate of Rs. 3000 at the age of 95-100 days and the Shri Mahaveer Jat achieved an average body weight of 25.95 kg (10 lambs) and sold at the rate of Rs. 3500 at the age of 110-120 days of age. Farmers are adopting the MF powder feeding in lambs and getting more body weight (4-5kg) at an early age (3-4 month) and earning more money (Rs. 800-1000) from their lambs in the market.

Lambs raised on milk replacer

Improved Sheep Farming Boosted the Income of Farmer Manifold…

Satyanarayan Gurjar, a sheep farmer of village Amli, Tehsil Malpura, Dist Tonk Rajasthan, has become a burning example for sheep farmers and youth. Sheep rearing was a traditional ancestral occupation in his family. Earlier he lost most of his animals due to disease out breaks. Moreover, body weights and reproduction of animals was poor and also did not get better price in market. He met extension scientists of ICAR-CSWRI, Avikanagar in January 2014. On their recommendations, he started adopting regular and timely vaccination, deworming, use elite Malpura ram in flock, flushing of ewes before breeding, concentrate supplementation during late gestation and early lactation, feeding of weaner lambs and estrus synchronization and artificial insemination.

After one year sizable improvement was witnessed in his flock: mortality has been come down to 7% against 15-20%, more lambs (30-35%) per year, higher body weight (15-20%) and price in market (25-30%). He started earning 1.50-2.00 lakh rupees per year from sale of animals from his flock of 100 sheep besides wool and manure. Additional income from sheep rearing was used for education of his children, purchase of house hold items, agriculture implements etc. In recognition of his achievements, he was awarded prestigious Breed Saviour Awards, 2013 by SEVA, Madurai, and NBAGR, Karnal for conserving native Malpura sheep breed. He is now a role model not only in his village but also for the entire sheep farming community of region. Farmers from other villages are motivated by the success of this farmer and headmen of neighbouring villages are encouraging farmers to implement similar model in their villages.