Processing and Quality Evaluation of Postharvest products of Sheep and Rabbits

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MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

In terms of livestock wealth, India is the richest nation in the world. However, the production of meat is mostly a by-product of the system used to raise animals. Sheep are typically raised for their wool and killed at the end of their useful lives. By providing milk, wool, meat, eggs, draught power, and flexible reserves during times of economic crisis, livestock and poultry in India's tropical and subtropical regions play a crucial role in the agricultural economy and act as a buffer against crop failure. Since they are raised above the ground and are one of the cleanest animals used to make meat, rabbits don't even require worming.

It is a pleasure to note that, ICAR-CSWRI, Avikanagar, Rajasthan and MANAGE, Hyderabad, Telangana is organizing a collaborative training program on "Processing and Quality Evaluation of Postharvest products of Sheep and Rabbits" from 05-07th July, 2022 and coming up with a joint publication as e-book on "Processing and Quality Evaluation of Postharvest products of Sheep and Rabbits" as immediate outcome of the training program.

I wish the program be very purposeful and meaningful to the participants and also the e-book will be useful for stakeholders across the country. I extend my best wishes for success of the program and also I wish ICAR-CSWRI, Avikanagar, Rajasthan, many more glorious years in service of Indian agriculture and allied sector ultimately benefitting the farmers. I would like to compliment the efforts of Dr. Shahaji Phand, Center Head-EAAS, MANAGE, Hyderabad and the Director ICAR-CSWRI, Avikanagar, Rajasthan for this valuable publication.

Dr. P. Chandra Shekara
Director General, MANAGE

FOREWORD

A nation that has more livestock resources remains more prosperous even in this technological world. India being an agrarian state, 25% of the agriculture GDP is being contributed by the livestock sector. Amongst various livestock species, small ruminants (sheep/goat) are usually reared to provide meat, skins, wool, milk and manure with very little inputs. Sheep rearing is known to us since early civilization and this animal considered as a future animal for rural prosperity especially for low or landless farmers under present climatic conditions. Sheep can acclimatize to a broad array of climate from temperate to tropical conditions and requires nearly zero input system. Along with the sheep rabbit is also popularized in the society due to its more fecundity. Rabbit is the source of low fat meat and good quality fur. Now a day rabbit considered as alternative food animal. Post-harvest products of sheep such as wool and mutton play an important role in the socio-economic life of India. They are an industrial article of trade. There are ample opportunities for value addition to wool, mutton, rabbit meat and fur. ICAR-CSWRI has developed various diversified value added products.

In this context, ICAR-CSWRI is conducting a free online training program on "Processing and Quality Evaluation of Postharvest products of Sheep and Rabbits" sponsored by the National Institute of Agricultural Extension Management (MANAGE), Hyderabad for the Extension officials of state/central animal husbandry departments, veterinarians, faculty of SAUs/KVKs/ICAR institutes, etc. during 5-7th July 2022 through Cisco Webex Online Platform. The lectures of this online course are exactly designed to educate the participants on various aspects of wool, mutton, rabbit meat and fur production, quality evaluation, and value addition. I hope that the participants from different parts of the country would be immensely benefitted from this online course by interactions with expert resource persons selected for the training. I do not doubt that the course will be intellectually rewarding to the participants.

I would like to take this opportunity to congratulate MANAGE and ICAR-CSWRI for their fruitful collaboration towards benefits to the farmer community. I also congratulate course directors and course coordinators of this training programme for their untiring work and high level of enthusiasm.

(Arun Kumar Tomar)
Director, ICAR-CSWRI

PREFACE

ICAR-CSWRI conducted a free online training program on "Processing and Quality Evaluation of Postharvest products of Sheep and Rabbits" sponsored by the National Institute of Agricultural Extension Management (MANAGE), Hyderabad for the Extension officials of state/central animal husbandry departments, veterinarians, faculty of SAUs/KVKs/ICAR institutes, etc. during 5-7th July 2022.

This e-book is a collaborative outcome of said online training program. The editors' main endeavor is to provide insights to all extension workers, faculties, veterinarians, researchers and students about whole value added chain of mutton, rabbit meat, fur and wool products science right from production to consumption. The trainee can be surely benefitted from getting knowledge of various mutton, rabbit meat, fur and wool products. The current information in these products development and value addition will help them to do well in the extension field and create entrepreneurship opportunities among various stakeholders.

The editors felt that all the experience of resource persons of this training should be clubbed together to form a unique proposition on mutton, rabbit meat, fur and wool products. Coordinating the two species i.e. sheep and rabbit in terms of their post harvest products from a widespread angle was definitely a not easy job. The experts and resource persons in this collaborative training programme contributed enormously and tirelessly to develop various chapters of this e-book. The editors extend their sincere thanks to all the experts who have contributed valuable time. The editors also thank MANAGE, Hyderabad for the financial support to the training program. The editors express gratitude towards the Director, ICAR-CSWRI for the constant encouragement for this training and e-book creation for the participants. The editors hope that this e-book will help participants as well as other extension people across the country to gain valuable information on mutton, rabbit meat, fur and wool products.

July, 2022

Dr. Arvind Soni
Dr. Shahaji Phand
Dr. Sushrirekha Das
Dr. Vinod Kadam
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Contents

Chapter-1

STAUS OF SHEEP PRODUCTION IN INDIA

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Introduction:

Livestock sector contributed (at current prices) 28.3% to Agriculture and allied sector GVA which was equivalent to 5.21% of total GVA during 2019-20 (BAHS, 2020). Over the years, the share of livestock sector to agriculture and total GVA is showing an increasing trend despite declining contribution of agriculture and allied sector to total GVA. It indicates the increasing importance of livestock sector in national economy.

Sheep is mostly reared by a large resource-poor section of the human population of India belonging to the marginal, small farmers and landless labourers for their food and nutritional security. Sheep farming is preferred over other livestock as it needs less initial investment, suitable for a low input system and adapted to adverse climatic conditions which make it an important tool of poverty alleviation. Sheep produces mutton, wool, milk, skin, manure etc. Besides domestic consumption mutton is being exported to foreign countries, mostly to Middle Eastern ones.

Sheep Population:

As per 20th livestock census (2019), India is home to a sheep population of 74.26 million, thus ranking 2nd in the World after China and ahead of Australia. The indigenous and exotic/crossbred sheep population in major sheep producing states in India were as follows:

Table 1: Composition of sheep population (2019; million) in major states

Rank	State/UTs	Exotic/Crossbred	Indigenous	Total sheep
1	Telangana	0.49	18.58	19.06
2	Andhra Pradesh	1.18	16.45	17.63
3	Karnataka	0.10	10.95	11.05
4	Rajasthan	0.05	7.86	7.90

5	Tamil Nadu	0.28	4.22	4.50
6	Jammu & Kashmir	1.58	1.66	3.25
7	Maharashtra	0.12	2.56	2.68
8	Gujarat	0.00	1.78	1.79
9	Odisha	0.01	1.27	1.28
10	Uttar Pradesh	0.05	0.93	0.98
11	Other states/UTs	0.22	3.91	4.14
	India Total	**4.09**	**70.17**	**74.26**

Mutton production:

Sheep contributed 8.94% of India's overall meat production of 8.60 million tonnes in 2019-20 (BAHFS, 2020). Telangana, Andhra Pradesh and Karnataka were the top three mutton-producing states, with 37.49, 25.06, and 9.31% share, respectively. In 2019-20, an estimated 56.52 million sheep were slaughtered, yielding an average of 13.61 kg of mutton per animal. The slaughter rate was 76.11% of 2019 population of 74.26 million sheep. The share of mutton to total meat production in the country is remained around 7.5-8.0% for last several years.

Table 2: Mutton production (2018-19) in different states (BAHS, 2020)

Rank	States/ UTs	Mutton (‘000 tonnes)	% share
1	Telangana	288.38	37.49
2	Andhra Pradesh	192.79	25.06
3	Karnataka	71.60	9.31
4	Tamil Nadu	63.98	8.32
5	Rajasthan	39.62	5.15
6	West Bengal	22.00	2.86
7	Karnataka	20.65	2.68
8	Odisha	17.92	2.33
9	Haryana	11.84	1.54
10	Maharashtra	11.65	1.51

11	Uttar Pradesh	11.44	1.49
12	Other states/UTs	17.34	2.25
	India total	**769.21**	**100.00**

Export of sheep/goat meat: During 2021-22, India exported 8695.97 MT of sheep/goat meat earning US$ 60.04 million from different countries. More than 97% of this export was to Middle Eastern countries like UAE, Qatar, Kuwait, Oman, Saudi Arabia and Baharain. The total export quantity of sheep/goat meat by India is again showing an increasing trend after the decline in 2020-21may be due to COVID19 restrictions.

Table 3: Export of Indian sheep/goat meat to different countries (DGCIS, 2022)

S. No.	Country	2019-20		2020-21		2021-22	
		Qty (MT)	Value (US$ Million)	Qty (MT)	Value (US$ Million)	Qty (MT)	Value (US$ Million)
1	United Arab Emirates (UAE)	9,884.44	63.78	5,226.62	33.49	6,401.40	45.22
2	Qatar	1,308.36	8.7	717.95	4.74	825.69	6.04
3	Kuwait	1,303.50	8.66	385.35	2.47	573.84	4.01
4	Maldives	343.93	1.58	180.35	0.76	385.48	1.64
5	Oman	443.17	2.58	230.61	1.2	180.89	1.19
6	Saudi Arabia	596.66	3.87	206.21	1.29	194.64	1.02
7	Baharain	227.15	1.51	92.47	0.57	118.79	0.83
8	Seychelles	14.72	0.07	8.22	0.04	13.59	0.08
9	Gambia	1.00	0.00	1.00	0.00	1.00	0.01
10	Others	5.91	0.02	1.77	0.00	0.65	00
	Total	**14,128.84**	**90.77**	**7,050.55**	**44.56**	**8,695.97**	**60.04**

Wool production:

India's wool production has steadily increased from 1950-51 to 1986-87. After that it declined till

1992-93, again improved consistently upto 2002-03. It again declined till 2010-11. The latest wool production data (2019-20) recorded further decline to 36.76 million kg wool. The wool production decreased from 48.1 to 36.76 million kg during 2014-15 to 2019-20. In 2019-20, Rajasthan (34.59%) was the leading wool producer followed by Jammu & Kashmir (20.34%) and Telangana (10.77%). In spite of varying trend in wool production across different states during 2014-15 to 2019-20, Rajasthan remained as the top wool producing state throughout the period.

Table 4: Wool production ('000 kg) in different states (BAHS, 2020)

S. No.	States/ UTs	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
1	Andhra Pradesh	778.23	788.63	791.62	794.39	797.12	801.14
2	Arunachal	24.23	35.70	58.25	60.40	42.63	43.00
3	Bihar	278.42	240.16	280.87	298.10	312.38	310.78
4	Chhattisgarh	115.53	90.15	87.29	81.77	81.95	82.99
5	Gujarat	2577.41	2282.65	2267.32	2294.96	2270.51	2232.72
6	Haryana	1428.69	702.17	691.22	693.39	718.50	729.52
7	Himachal Pradesh	1663.07	1408.87	1475.00	1481.87	1503.14	1516.44
8	Jammu &	8371.01	6865.65	7265.51	7489.43	7629.28	7477.12
9	Jharkhand	160.76	165.82	177.65	186.59	198.59	209.97
10	Karnataka	8821.44	8191.42	6588.25	4305.00	3057.92	1742.14
11	Madhya Pradesh	483.83	442.39	406.22	408.16	410.17	411.85
12	Maharashtra	1385.78	1389.89	1406.65	1436.77	1456.93	1412.27
13	Punjab	460.89	472.69	489.64	514.70	524.85	525.36
14	Rajasthan	14463.36	13414.6	14321.27	14287.42	14521.84	12716.83
15	Sikkim	0.00	0.00	0.00	0.00	0.00	0.00
16	Tamil Nadu	1.20	1.36	2.08	1.96	2.28	0.00
17	Telangana	4422.97	4562.41	4658.11	4506.02	4263.51	3960.14
18	Uttar Pradesh	1493.71	1264.98	1286.10	1299.62	1315.97	1328.64
19	Uttarakhand	468.93	513.33	538.24	564.07	551.98	496.69
20	West Bengal	740.40	748.47	753.07	758.10	760.43	762.96
All India		**48139.88**	**43581.34**	**43544.37**	**41462.71**	**40420.00**	**36760.57**

Prolificacy:

Few sheep breeds in India can produce more than one lamb per lambing due to their unique genetic constitution. They possess some specific Single Nucleotide Polymorphisms (SNPs) in their major prolific gene(s) which enable them to increase ovulation rate leading to production of multiple births. The indigenous sheep breeds like Garole, Kendrapada, Bonpala and Nilgiri were found to possess the

SNP, popularly known as FecB mutation, in the major prolific gene BMPR1B responsible for prolificacy in these breeds.

ICAR-Central Sheep and Wool Research Institute (CSWRI), Avikanagar has developed a three breed prolific sheep 'Avishaan' through introgression of *FecB* mutation from Garole sheep of Sunderban (West Bengal) into the non-carrier non-prolific mutton sheep Malpura of semi- arid region of Rajasthan, then backcrossing of carrier halfbred (GM) males with Malpura females and subsequently crossing the carrier backcross (GMM) males with dairy type Patanwadi females from Gujarat. The genetic constitution of Avishaan is having 12.5% Garole, 37.5% Malpura and 50% Patanwadi inheritance. Avishaan's average growth performance under farm condition at the time of its release was 3.30 kg at birth, 16.80 kg at 3 months, 25.90 kg at 6 months, and 34.70 kg at 12 months of age. In terms of Ewe Productivity Efficiency (EPE), Avishaan outperformed native Malpura sheep by around 30% at six months of age. Avishaan, the product of a '***Make in India***' initiative is capable of achieving the dream goal of '***Doubling the farmers' income***' by producing more lambs, more mutton, more milk in ewes to sustain the multiple lambs, more wool and increased survivability.

Others produces:

Sheep also produces skin, manure, and a small amount of milk in addition to mutton and wool. Sheep skin is exported in the form of leather and leather products, in addition to its domestic use. Agricultural activities use sheep manure. Some sheep breeds that produce higher amount of milk are milked and sold as whole milk or milk products. Production data of Indian sheep for these traits are not available.

Major challenges in sheep production:

- Rapid shrinkage of natural pasture/grazing land
- Stoppage or reduced scope of migratory sheep rearing over the years
- Climate change effect- shortage in availability of quality feed and fodder
- Insufficient availability of required nutritional inputs and incomplete exploitation of genetic potential of indigenous breeds
- Diminishing interest of youth from farming families for sheep farming
- Low reproductive efficiency of most indigenous breeds

- Loosing value of wool – there is no sensitivity and no hue and cry among livestock farmers for MSP for animal products like that of other agricultural products, consequently no national policy for the same
- Over-emphasis on a single trait instead of overall multiple trait value of sheep
- Large proportion (~40%) of non-descript sheep population
- Lack of awareness about good germplasm (breed) among farmers
- Unrestricted migration of well known breeds far away from their original breeding tract
- Incoordinated efforts from different players - multiple players from different Govt. agencies, domestic and foreign NGOs working for short term gain without any coordination among them
- Very high proportion (76.11%) of early age slaughter of sheep leading to loss of prospective breeding animals
- Insufficient and inaccessible veterinary health care for sheep and goats – very low vaccination and therapeutic coverage leading to high mortality and morbidity in farmers flocks
- Non-availability of proper organized marketing facilities and unstoppable middleman menace in marketing of live sheep
- Rapid conversion of new sheep breeders into traders for risk free instant profit
- Insufficient organized financial support for entrepreneurship in improved sheep farming

Strategies for enhancing productivity of sheep:

Adoption of the following strategies can increase productivity and income from sheep.

- **Ensuring availability of good germplasm:** Though India possesses 2nd highest number of sheep in the world, per animal productivity is low and meat production didn't increase much over the years. Also, farmers are not properly aware about the importance of rearing and availability of good germplasm (breed). It is a huge challenge and at the same time a very good opportunity to upgrade the non-descript sheep population with the locally available high performing breeding rams of recognized breeds in their respective breeding tracts.
- **Adoption of scientific rearing practices:** Adoption of scientific breeding, feeding, and management practices including timely health care by farmers will ensure better production from sheep. There is a need to demonstrate the advantages of streamlining these practices to get good returns from sheep farming.

- **Preference for prolific sheep germplasm:** Some sheep breeds are prolific in nature and can produce more than one lamb per lambing. With little more care provided to these lambs in the initial stages of their life, the per ewe productivity in terms of the litter weight harvested at marketable age will be increased to a large extent if not doubled. It will enable the sheep farmers to produce more lambs from rearing of less number of females resulting in higher and faster economic returns to them.
- **Accelerated lambing:** Round the year breeding and lambing practised by the general farmers causes difficulties in adoption of different health care and other managemental practices leading to increased mortality in the flock. It can be streamlined by adoption of systematic breeding practices to produce three lamb crops in two years, thus, providing overall more economic returns to the farmers.
- **Use of reproductive tools**: Use of reproductive tools like oestrous synchronization coupled with artificial insemination will lead to production of extra lambs and additional income to the farmers.
- **Shifting of production system:** Farmers traditionally manage their sheep through zero input extensive system. Some sheep farmers follow migratory sheep farming. Gradual shrinkage of pasture due to several reasons is forcing the farmers to leave sheep husbandry. There is an urgent need to address this issue crippling the life of poor sheep farmers. Shifting from extensive to semi-intensive or intensive system of management is imminent. Scope of self-sustaining farming systems needs to be explored and demonstrated to the farmers. It can be part of an integrated farming system for production of feed and fodder resources for sheep so that the use of available resources can be optimized. The sheep production in an intensively reared completely controlled managemental condition will be easy to plan according to the specific seasonal availability of resources and market demand. Further, it can guarantee the sustainability of production and thus farmers' income from sheep husbandry.

Other strategies:

- Implementation of **National level Animal Identification System (NAIS)** by tagging/tattooing/RFID of all sheep in all states/UTs for real time traceability, data recording and increase accuracy in policy planning
- Integrated, non-conflicting and coordinated approach to improve sheep production by all players from Govt., NGO etc.

- Expanding the breed coverage of existing indigenous breed improvement programmes, integration of genomic selection into the traditional breed improvement programmes after converting them into community based breeding programmes.
- Ensuring proper and consistent nutritional inputs to the animals covered under genetic improvement programmes
- Emphasis on dedicated new pasture development and maintenance on regular basis– also replenishing the nutrient-deficient pastures
- Climate resilient sheep production
- Encouraging involvement of private sector for input sharing, implementation of schemes etc.
- Entrepreneurship development/Start ups in sheep farming
- Insurance for social security of sheep farmers
- Demonstration and large scale implementation of a profit oriented tested model for commercial sheep production under intensive and accelerated lambing system
- Free, adequate and accessible veterinary healthcare coverage for all sheep in the country
- Processing and value addition of sheep products
- Market chain development for live animal and animal produces
- Minimum Support Price (MSP) for wool in line with crops and other agri products
- Exploring alternative uses of wool; development of associated technologies for this purpose for a turnaround in making wool a blessing from burden for the sheep farmer.

Chapter-2

SHEEP MILK: PRODUCTION TO PRODUCT

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Introduction:

The changes in human lifestyle and the modern diet are emerging challenges in developing countries resulting to endless ailments and so as natural functional foods with health benefits are gaining importance instead of medications which have numerous side effects. In the strengthening of food and nutrition security, milk is emerging as efficient functional food and it is a nutrient rich, inexpensive and easily available food for human population. Its nutrients richness and uniqueness confer the value of milk as ideal food. It is the best natural diet containing diverse essential minerals and vitamins including vitamin A, vitamin E, vitamin B12, riboflavin, calcium, capper, magnesium, iron and zinc that are for proper physiological functions, growth and development to have overall good health. Milk for human consumption is obtained from cow, buffalo, sheep, goat and in certain areas from yak and camel. Milk and milk products from non-bovine are having unique functional and therapeutic properties of human health benefits to treat different body ailments. Among the non-bovine milk, camel and sheep milk has been used medicinally by nomadic people. In arid regions and dry lands camel and sheep are the major dependent milch animals.

Sheep Milk Production Potential:

Cattle produce 81 percent of world milk production, followed by buffaloes with 15 percent, goats with 2 percent and sheep with 1 percent; camels provide 0.5 percent. The remaining share is produced by other dairy species equines and yaks. About one-third of milk production in developing countries comes from buffaloes, goats, camels and sheep. More than half of the world's sheep population is in developing countries. Though sheep production has many potential outputs i.e., milk, meat, skin, fiber and manure but most small-scale producers in developing countries raise sheep for meat or sale as livestock at local markets. Most sheep milk

is produced in the Mediterranean region, and most dairy sheep breeds are found in this region and the Near East. Dairy sheep breeds include Awassi, East Friesian and Lacaune (Table -1). Major sheep milk producers are China followed by Turkey and Greece. The important dairy sheep breeds and Indian sheep milk yield and performance given in Table – 1 & 2 (FAO, 2021). The total milk yield some the popular Indian sheep breeds Malpura, Patanwadi, Muzaffarnagri, Jalouni and Dumba are 366-531,700-800, 100-500, 300-500 and 400-1200 kg/day (Sindhe and Naqvi, 2015).

Table 1. Milk Yield of different important dairy breeds

Breed	Total Milk Yield/Lactation (kg)	Lactation (Day)	Average Milk Yield per Day (kg)
East Friesian	700	300	2.29
Lacanue	454	200	2.50
Sarda	376	150	2.50
Latxa	446	147	3.03
Awassi	460	214	3.71
Assaf	506	173	2.90

FAO, 2021

In world, China is highest producer of sheep milk over 1.5 million tons annually and having highest number of sheep in the world. In Turkey, the production of over one million tons sheep milk annually by over four million sheep farmers reared the most popular breed white Karaman is the ranked second in the world . The Turks love sheep milk products like cheese and yogurt. Sheep rearing for milk is one of the most viable economic activities practiced in the rural regions of Greece and produces 705,000 tons sheep milk annually having Chios most popular dairy breed. Syria produces approximately 648,578 tons of sheep milk annually from Awassi ewes is of high quality with a significant amount of butterfat. Sheep rearing is one of the major contributors to Syria's economy (Economics, 2020).

Uniqueness of Sheep Milk:

Sheep milk has higher specific gravity (1.0347-1.0384), viscosity (2.86-3.93), Freezing point (0.22-0.25) than goat (1.029-1.039, 2.12 and 0.54-0.57) and cow milk (1.0231-1.0398, 2.00 and 0.15-0.18). Sheep milk is considered as nutritional powerhouse. Sheep milk is characterized by

high energy value of 5932 kJ/kg (preferred by athletes), richest source in whey proteins (1.02 g/100 g) and casein (4.18 g/100 g), adequate fat content (5-7%), ample of calcium, phosphorous, iron and magnesium (193, 158, 0.08 and 18 mg/100 g). Sheep milk is an excellent source of protein and calcium. Sheep milk, demonstrated the high content in B vitamins especially niacin. Milk is a valuable source of vitamins, both water soluble and fat-soluble ones. Goat and sheep milk are characterized by higher vitamin A concentration in comparison with cow milk (Park, 2007). All of the β-carotene in milk from goats and sheep is converted into retinol, resulting inthe white color of that milk.

Sheep milk has not only nutritional benefit due to its higher fat and protein content but it also boosts host's natural immune defense system. These beneficial roles are resulted from milk immunoglobulins and protective proteins which in human gut turn in to excellent source of bioactive peptides with antioxidative, antimicrobial, antihypertensive, immunomodulatory and antithrombotic roles. The αS1 and αS2 protein sequence of sheep milk is different from cow milk and make it lower allergic.

Due to high content of beneficial fatty acids in sheep milk, it is now a day's used in anti-ageing formulations and cosmetic soap preparations which can soothe psoriasis and skin eczema like chronic diseases (Mohapatra et al., 2019). It is a better alternative for these countries. Specialty of sheep milk is due to higher concentration of butyric acid (C4:0), conjugated linoleic acid (CLA) and omega 3 fatty acid content than other ruminant milk. Total conjugated linoleic acid (CLA) content in ewe, cow and doe milk fat were found 1.08, 1.01 and 0.65% respectively (Sindhe and Naqvi, 2015). Fat globules are smaller in size that makes it easier for digestion. Five fatty acids ($C_{10.0}$, $C_{14.0}$, $C_{16.0}$, $C_{18.0}$ and $C_{18.1}$) account for > 75% of total fatty acids in sheep milk. Coproic ($C_{6.0}$), Caprylic, ($C_{8.0}$), Capric ($C_{10.0}$), and Lauric ($C_{12.0}$), are significantly higher in sheep milk than cow milk and associated with characteristic flavor of cheese.

The medical importance of sheep milk has been supported by lot many anecdotal evidences, very little research have been carried out in this regard. Sheep milk is a rich source of calcium; almost double of cow milk. Sheep milk is essential for bone growth and development in newborns who have no access to their mother's milk. Researchers claim that it has positive effect on structural integrity and bone health. A recent study showed that sheep milk consumption resulted to higher trabecular bone surface density and trabecular bone surface to volume ratio in growing rats compared to cow milk having equal total solid (Burrow et al., 2018). Sheep milk

has been proved to be suitable raw material for prebiotic and probiotic formulations. It is presently used in anti-ageing formulations and cosmetic soap preparations which have soothing action on psoriasis and skin eczema like chronic diseases due to high fat and mineral content (Belanger, 2018).

Sheep Milk Products:

Milk is a fundamental product and essentially requirement of neonatal baby of all mammal species as a first food. The milk of many of domesticated animal is generally suitable for human consumption. In many nomadic societies and in many small mixed crop livestock systems, sheep is the one of the major source of milk for the family. The main dairy products from sheep in the Middle East are yogurt and cheese. In general, traditional methods are used to prepare these products by households and small scale local processors. In addition to most common used product Yoghurt, the main cheese produced from sheep milk is fresh cheese (Bayda) with a high fat content. There are also low-fat cheeses such as mushallaleh and halloumi to meet the demand of urban and human health conscious consumers. Since sheep milk production is seasonal, use of frozen milk may be necessary to produce yogurt throughout the year. Good quality yogurt can be produced from frozen sheep milk if the milk was frozen and stored at −27 ◦C or less for less than 12 months (Wendorff, 2001). The addition of prebiotic ingredients as inulin in the manufacture of sheep milk dairy products is suggesting that there is great potential to be investigated and explored commercially.

The traditional sheep milk cheeses made with lamb rennet contains lipases including gastric esterase and pregastric enzymes, responsible for the release of small- and medium-chain fatty acids in the food matrix (Jacob et al., 2011). Most of the sheep whey from small cheese makers is either fed to animals as source of nutrients or spread on agricultural land as a source of plant nutrients. Whey from sheep milk cheese contains more beta-lactoglobulin, about the same proportion of alpha- lactalbumin, and lower proportions of serum albumin and immunoglobulins. Studies evaluating the applicability of probiotic cultures in sheep milk products are available in Table 2.

Table 2–Sheep milk in the manufacturing of probiotic products.

Sl. No.	Products	Probiotic strain	Conclusion	Reference
1	Scamorza cheese	*B. longum*, *B. lactis*,and *L. acidophilus*	B. longum and B. lactis strains sustained greater proteolysis in cheese. L. acidophilus strain ruled lipolysis and was able to significantly increase vaccenic andoleic acids and CLA content in cheese.	Albenzio etal. (2013a)
2	Canestrato Pugliese hard cheese	*B. bifidum Bb02* and/or *B. longumBb46*	Cheeses with bifidobacteria added contained significantly higher α- and β-galactosidase activities and nodifferences were found in quality and acceptance.	Corbo et al. (2001)
3	Argentinean cheese	*L. acidophilus* (LA-5), *B. lactis* (BB-12)	The added probiotic cultures did notmodify the different parameters evaluated: gross composition and others.	Perotti et al. (2014)
4	Greek sheep milk yogurt	*L. paracasei*subsp. *paracasei* DC412.	Revealed the presence of a peptideas having both antihypertensive and opiate-like activity.	Papadimitriouet al. (2007)
5	Fermented milk	*L. acidophilusLA-5* or *B. animalisssp. lactis BB-12*	No significant losses occurred in viability of Bifidobacteria in fermented sheep milks during 6 wk of refrigerated storage.	Varga, S¨uleand Nagy (2014)

Further, the sheep milk was processed in LPT Section of Central Sheep and Wool

Research Institute, Avikanagar, India to develop different dairy products i.e. natural carrot flavoured milk, paneer acidified with 1% citric acid, mozzarella cheese, khoa used for gulab jamun preparation with 3:1 proportion of khoa and maida, milk Kulfi and peda (Fig-1).

Fig.-1 Sheep milk products developed at ICAR-CSWRI, Avikanagar.

https://springsheepnz.com/sheep-milk/full-cream-sheep-milk-powder

Conclusion

Although sheep milk yield is significantly lower as compared to cow and buffalo but have a number of advantages over bovine milk. It has powerful nutrients, trace minerals, functional bioactive peptides, immunity boosters etc. This is the need of hour to find a nutrient enriched, easily available and affordable functional food to combat different body aliments. The future development of sheep enterprises with milk production will be a new direction for the development of functional sheep milk foods which are quickly accepted in the market and incorporated into the regular diet of consumers. Sheep is the dairy animal of the poor because of the lower capital investment, small gestation so as faster generation turnover rate catering the need of immediate fresh milk in quantity that is suitable for immediate household consumption subsequently provides regular source of income and better nutrition to farmers of arid, semi arid and harsh climatic regions.

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Chapter-3

DIETARY INTERVENTION AND FEEDING REGIME FOR ENHANCED PRODUCTION IN SHEEP AND RABBIT

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The importance of livestock is beyond the food production function because of social, environmental, and economic factors. Livestock is an important source of income for millions of landless and small landholders particularly in the resource poor regimes. According to National Sample Survey Organization's Survey (2005), the estimated employment in animal husbandry sector was 11.44 million in principal status and 11.01 million in subsidiary, which was 5.50% of the total working population of the country. Livestock plays an important role in conversion of non-edible crop residues and agricultural by-products into nutritious food. Out of the total earnings from livestock sector (26.6% of total agricultural output), the contribution of meat is about 16.3%. Additionally, the contribution of milk from small ruminant sector cannot be ruled out. The country has the third highest number of sheep (61.4 million) and is increased by @ 1.75% (GOI, 2003). Small ruminants (Sheep and Goat) are preferred to large ruminants in arid and semi-arid regions because of small size, higher reproductive rate, relatively smaller investment and ease in management by sparse family labour. However, its rearing continues to be backward, since it is primarily in the hands of poor, landless or small and marginal farmers who raise their animals on natural vegetation and stubbles supplemented by tree lopping, which is theoretically speaking, a zero input-low output system of rearing.

Feeds and feeding for sheep

Feed is the single largest cost associated with raising livestock animals, typically accounting for 60% or more of total production costs. Nutrition influences the flock reproduction, milk production, and lamb growth. Late-gestation and lactation are the most critical periods for ewe nutrition, with lactation placing the highest nutritional demands on ewes. Lambs with higher growth potential have higher nutritional needs, especially with regards to protein for bone and tissue growth. Animals receiving inadequate diets are more prone to disease and will fail to reach their genetic potential.

Sheep nutritional requirements can be met by feeding a variety of feedstuffs. Feed ingredients can substitute for one another so long as the animals' nutritional requirements are being met. Small ruminant feeding programs should take into account: animal requirements, feed availability, and costs of nutrients. Pasture, forbs, and browse are usually the primary and most economical source of nutrients for sheep. Pasture tends to be high in energy and protein when it is in a vegetative state. However, it can have high moisture content, and sometimes it may be difficult for high-producing animals to eat enough grass to meet their nutrient requirements. As pasture plants mature, palatability and digestibility decline, thus it is important to rotate pastures to keep plants in a vegetative state. During the early part of the grazing season, browse (woody plants, vines and brush) and forbs (weeds) tend to be higher in protein and energy than ordinary pasture. Sheep are excellent weed eaters. Hays/straws are the primary source of nutrients for small ruminants during the lean season (summer at planes and winter at high hills. Silage feeding to small ruminants is very much limited. It is often necessary to feed concentrates to provide the nutrients that forage alone cannot provide, particularly in high-producing animals and/or scarcity seasons. Creep feeding and supplemental feeding of lambs is practiced to sustain high early growth and to attain early finishing weight. A free choice salt-vitamin-mineral premix should be made available to small ruminants at all times, unless a premix has been incorporated into the grain ration or total mixed ration. Provision of ample clean drinking water is a must in any feeding and management situation as water and feed intake are positively correlated. There will be higher requirements when environmental temperatures rise above 70 ^{o}F and it decline with very cold environmental temperatures.

Nutritional requirements

Small ruminants require energy, protein, vitamins, minerals, fibre and water. Energy (calories) is usually the most limiting nutrient, whereas protein is the most expensive. Nonetheless, deficiencies, excesses, and imbalances of vitamins and minerals can limit animal performance and lead to various health problems. Fibre (bulk) is necessary for the rumen fill and to maintain a healthy rumen environment and prevent digestive upsets. Water is the cheapest feed ingredient, yet often the most neglected. Many factors affect the nutritional requirements of small ruminants: maintenance, growth, pregnancy, lactation, fibre production, activity, and environment. As a general rule of thumb, sheep will consume 2-4% of their body weight on DM basis. The exact percentage varies according to the size (weight) of the animal, with smaller animals needing a higher intake (percentage-wise) to maintain their weight. Maintenance requirements increase as the level of the animals' activity increases. For example, migratory sheep that has to travel a farther distance for feed and water will

have a higher maintenance requirement than animals in a feed lot/stall. The maintenance requirement becomes higher in environmental stresses like cold and severe weather to maintain body heat. Then, there is added stresses of pregnancy, lactation, and growth, which further increase the nutrient requirements.

Paul et al. (2003) collected data from 19 feeding trials conducted on growing sheep from different institutes across India and subjected to regression analysis to derive requirements of TDN, CP and DCP for maintenance and body weight gain. The maintenance requirements for TDN, CP and DCP were 37.0, 6.68 and 4.43 g/kg W0.75, respectively for the BW range of 7-15 kg and the corresponding maintenance requirements for the BW range of 15.1-30 kg were 35.3, 6.98 and 4.49 g. The corresponding requirements for 1 g gain in BW were 0.91, 0.47, and 0.31 g, for 7-15 kg BW and 1.21, 0.43 and 0.30 g, respectively for 15-30 kg BW range.

Free ranging and ME requirement

In free ranging, if the food availability is scarce, the animals are forced to travel to meet their energy requirements and this extra energy drain can be an important contributor to the ME need for maintenance. sheep adapts well to environmental conditions prevailing in arid lands, being able to obtain and adequate diet even when forage is scarce and they can feed over rugged and otherwise inaccessible terrain. Energy requirements in open range may increase several fold over values assessed for restrained animals. Both the increased energy expenditure of eating and the energy expended in walking would account to this increased maintenance requirement.

Declining grazing resources

Sedentary flocks of sheep competes with large ruminants throughout the year and poor pasture quality forces animals to utilize forest resources. Overgrazing/browsing is adversely affecting the forest vegetation, and so lack of proper pasture management is leading to forest deterioration. The same is true for pastures grazed by migratory flocks, and thus thorny weeds complicating the situation further are replacing palatable grasses.

Nutritional priorities during scarce feed resources

Coop and Kyriazakis (1999) proposed a framework postulating prioritisation of allocation of nutrients to various body functions in adult, reproducing animals in a situation of scarce resource, which are as under: (i) Maintenance of body protein and survival (ii) Reproductive efforts (iii) Expression of immunity (iv) Attainment of fatness The functions with higher priority are less likely to be affected by host nutrition. Animals would be expected to give the highest priority to the allocation of scarce resources for maintenance functions, i.e. maintenance of body protein, as this will guarantee survival

in the short term. This would include the repair and/or replacement of damaged and/or lost host tissue caused by parasitic infestation.

Underfeeding and altered nutritional ecology

Underfeeding will be taken as the decrease in intake under maintenance energy level, compared to a level of intake at or above maintenance, without modifying the composition of the diet or environmental conditions. Variable degree of underfeeding is a frequent occurrence for small ruminants in all developing countries including India. Lack of forage is the main reason for underfeeding, but other causes may reduce voluntary intake, such as low quality of forages, the depressive effect of high temperatures, water starvation or excessively prolonged search for food. To assess nutritional deficit, irrespective of the cause of food restriction, it is important to study accurately the mechanisms involved in digestibility variations in response to a marked decrease in intake level. Michalet-Doreau and Doreau (2001) showed a non-linear response of digestibility to a strong decrease in feed intake. The response of digestibility to a decrease in intake is variable: it can increase, be stable or decrease. The increase in digestibility was accompanied by a stasis of ruminal content. The decrease in feed input was compensated for by a marked decrease in liquid and solid output of the rumen, which could explain the increase in fibre digestibility. Until now, it has not been possible to determine the animal or nutritional factors, which influence the way of variation, and especially the unexpected decrease in digestibility. However, it has been clearly shown that these decreases are not due to an insufficient retention time of particles in the rumen, or to an insufficient reduction of particle size and also, differences in microbial activity have not been exhibited by in situ measurements. Protozoa population seems to be the highest at medium intake whereas bacterial concentrations tend to decrease with a decreased intake of available energy (Dehority and Orpin, 1988). It is hypothesized that a reduction of bacterial growth or of the expression of microbial degradation potential occurs at very low intakes, but mechanisms are still not elucidated (Doreau et al., 2003). However, practical underfeeding situation involves more activity in relation to search of feed and ultimately, encompass the short-term benefit and make animal susceptible to protein energy malnutrition (PEM) including that of minerals and vitamins. At very low intake the proportion of endogenous materials in faeces increases, especially with low-quality forages which could have an abrasive effect on gut mucosa resulting in decrease in OM digestibility, but not the decrease in fibre digestibility. It can be deduced that: (i) the decrease in digestibility is frequent for very low intakes (less than 50% maintenance requirements) although it is not always the case (Michalet-Doreau and Doreau, 2001); (ii) it seems to be independent of nitrogen supply for the animal (intestinal digestible

proteins) and microbes (ruminal fermentable nitrogen), which may happen with concentraterich diets; (iii) it could be favoured by a low-quality forage, especially by the presence of straw in the diet. Ruminants are able to cope with underfeeding by mobilization of body reserves, even when the level of restriction is very high, as shown in fat-tail ewes. But, there is no adaptation of digestive processes to underfeeding and even, in some cases, a reduction of the efficiency of diet utilization (Doreau et al., 2003). About absorption, only short-term adaptation has been studied. The efficiency of portal absorption of energy is quantitatively unchanged, but the nature of absorbed nutrients is modified. Knowledge on the effect of long-term underfeeding and subsequent re-feeding is scarce and more studies are required. The net transfer of urea across PDV increases, as a percentage of N intake, in underfed ewes (Nozière et al., 2000). This contributes to sparing of N, together with decreases in N uptake by the kidney and in urinary loss. A large proportion of this transfer occurs across the rumen wall, but the efficiency of this recycling is limited in the case of energetic underfeeding, since rumen ammonia is not a limiting factor for the microbial synthesis. In this case, an increase in portal net appearance of ammonia N, as percentage of N intake, occurs. Few authors have attempted to assess the relationship between the levels of intake including underfeeding on the net portal absorption rate of VFA. Although the absorptive capacity of the rumen wall is depressed after a 2- week period of underfeeding (Perrier et al., 1994), the efficiency of VFA net appearance in the portal vein is not depressed. It is likely that this decrease in absorption capacity is related to a rapid decrease in rumen mass (Ortigues and Doreau, 1995) including the mucosal layer where absorption takes place (Nozière and Doreau, 2001). However, the decrease in the ruminal absorption may be compensated for by an absorption in the omasum and abomasum.

Fodder crops suitable for sheep and goats

Legume fodder crops

- Hedge lucerne
- Desmanthus
- Cowpea
- Stylo

Grass fodders

- Co F.S-29, Co.27, Co-4, Co.7, Co.10.
- Fodder Maize

Tree fodders

- Subabul

- Neem
- Agathi
- Glyricidia
- Kodukapuli
- Arasu
- Vagai
- Karuvel
- Velvel
- Seemaikaruvel

Concentrate feed ingredients

- Sorghum
- Maize
- Broken rice
- wheat
- Groundnut cake
-

Feeding schedule for different age of sheep and goats

Feeding of lambs/kids (birth to three months)

- Immediately after birth feed the young ones with colostrum.
- Up to 3 days of birth keep dam and young ones together for 2-3 days for frequent access of milk.
- After 3 days & up to weaning feed the lambs/kids with milk at 2 to 3 times a day.
- At about 2 weeks of age the young ones should be trained to eat green roughages.
- At one month of age the young ones should be provided with the concentrate mixture (Creep feed).

Colostrum feeding of lambs/kids

- The kid should be allowed to suck its dam for the first three or four days so that they can get good amount of colostrum.
- Colostrum feeding is a main factor in limiting kid losses.
- Cow colostrum is also efficient for lambs and kids.
- Colostrum is given at the rate of 100 ml per kg live weight.

- Colostrum can be preserved with 1-1.5% (vol/wt) propionic acid or 0.1% formaldehyde. Propionic acid is preferred for preservation as it keeps the pH value low.
- The chemically treated colostrum is kept at cool place to ensure better quality.

Creep feeding for lambs/kids

- This creep feed may be started from one month of age and up to 2-3 months of age.
- The main purpose of creep feeding is to give more nutrients for their rapid growth.
- The general quantity to be given to the lambs/kids is 50 – 100 gm/animal/day.
- This should contain 22 per cent protein.
- Antibiotics like oxytetracycline or chlortetracycline may be mixed at the rate of 15 to 25 mg/kg of feed.

Composition of ideal creep feed

- Maize - 40%
- Ground nut cake -30 %
- Wheat bran – 10 %
- Deoiled rice bran- 13 %
- Molasses – 5%
- Mineral mixture- 2%
- Salt – 1% fortified with vitamins A, B2 and D3 and antibiotic feed supplements.

Feeding schedule for a kid/lamb from birth to 90 days:

Age of kids/lambs	**Dam's/ewe's milk or cow milk (ml)**	**Creep feed (grams)**	**Forage, green/day (gm)**
1-3 days	Colostrum-300 ml, 3 feedings	-	-
4-14days	350 ml, 3 feedings	-	-
15-30 days	350 ml, 3 feedings	A little	A little
31-60 days	400 ml, 2 feedings	100-150	Free choice
61-90 days	200 ml, 2 feedings	200-250	Free choice

Three months to twelve months of age

- Grazing in the pasture for about 8 hours per day.
- Supplementation of concentrate mixture @ 100 – 200 g/animal/day with protein of 16-18 per cent.
- Dry fodder during night in summer months and during rainy days.

Adult animals

- If the availability of pasture is good there is no need to supplement concentrate mixture.
- In poor grazing condition animals may be supplemented with concentrate mixture @150 – 350 g of concentrate / animal/day depending up on the age, pregnancy and lactation.
- The digestible crude protein level of concentrate mixture used in the adult feed is 12 per cent.

Non pregnant animals

- If the availability of pasture is good no needs to supplement with concentrate mixture.
- In poor grazing condition animals may be supplemented with 150 – 200 g of concentrate / animal/day.

Feeding of ewes from lamb-weaning till flushing

- This is the least critical period with respect to nutrient requirements.
- Ewes may be maintained entirely on pasture.
- Poor quality pastures and other roughages of low quality can be advantageously utilized during this period.

Pregnant animals

During the first four months of pregnancy:

- Pregnant animals should be allowed in good quality pasture 4-5 hours per day.
- Their ration must be supplemented with available green fodder at the rate of 5 kg per head per day.

During the last one month of pregnancy:

- In this period fetal growth increases 60 – 80 per cent until parturition and lack of enough energy in the feed can cause pregnancy toxaemia in ewes. So during this period animals should be allowed in very good quality pasture 4-5 hours per day.
- In addition to grazing, animals should be fed with concentrate mixture @ 250 –350 g/animal/day.
- Their ration should be supplemented with available green fodder at the rate of 7 kg per head per day.

Feeding at lambing time

- As lambing time approaches or immediately after lambing the grain allowance should be reduced but good quality dry roughage is fed free choice.
- It is usually preferable to feed lightly on the day of parturition, but allow plenty of clean, cool water.
- Soon after lambing the ewe must be given just enough of slightly warm water.
- After parturition the ration of the ewe may be gradually increased so that she receives the full ration in divided doses six to seven times in a day.
- Bulky and laxative feedstuffs may be included in the ration during the first few days.
- A mixture of wheat bran and barely or oats or maize at 1: 1 proportion is excellent.

Lactating animals / for 75 days after lambing

The following rations may be recommended,

- 6-8 hours grazing + 10 kg cultivated green fodder/day
- 6-8 hours grazing + 400 g of concentrate mixture/day
- 6-8 hours grazing + 800 g of good quality legume hay/day

Feeding rams for breeding

- The common practice is allowing the rams to graze with ewes.
- Under such conditions the rams will get the same ration as the ewes.
- Usually, it will meet the nutritional requirements of the ram.
- Where there are facilities for separate feeding of the ram, it may be given half a kilogram of a concentrate mixture consisting of three parts oats or barley, one part maize and one part wheat per day.

Rabbit: Digestive System

- Herbivore with a simple stomach
- Hind-gut fermenter
- Microbial digestion occurs in the large intestine and cecum.
- Sensitive to diet changes (specially overload of carbs)
- Coprophagy – rabbits re-ingest their soft night time feces.

Rabbit: Feeding

- Biggest expense
- >75 percent (up to > 90%)
- Rabbits are efficient converters of feed

- 1 kg of meat from 4 kg of feed
- Feed by weight not volume
- Amount depends on size of rabbit and stage of production.
- Control feed wastage!

Rabbit: Diet

- Traditional diets
- Commercial rabbit feed
- 100% balanced
- 16-18% CP
- Pellet
- Dehydrated alfalfa meal is usually the main ingredient.
- Alternative feeds Can reduce feed costs, (be careful)
- Hay Raising rabbits on pasture
- Fresh greens
- Crop residues
- Agricultural by-products
- Pasture
- May reduce performance.
- High moisture feeds can cause diarrhoea.
- Wilted or spoiled feed may cause digestive upsets.
- Always introduce new feeds slowly.

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Expert System for Sheep & Goat, ICAR-TANUVAS-TNAU.

Chapter-4

WOOL FIBER IDENTIFICATION AND ITS QUALITY EVALUATION

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Introduction

Wool is a natural fibre growing out of the follicles in the skin of sheep. It consists mostly of complex mixture of protein called Keratin. Wool fibre enjoys a unique place in the fibre market in-spite of stiff competition from manmade fibres i.e., acrylic, nylon, polypropylene etc., because of its warmth, handle, resilience and other desirable properties.

Structure of Wool Fibre

Wool fibre consist principally one member of a group of proteins called Keratin. Wool is produced in the fibre follicle in the skin of the sheep. The cells of the wool fibre begin growing at the base of the follicles, which is bulbous in shape and complete their growth immediately above the bulb where the process of keratinisation occurs. This process involves the oxidation of thiols to form disulphide bonds, which stabilize the fibre structure.

Morphological Structure

Wool fibres are composed of two layers of cells, namely the cuticle and cortical as given in fig below. The cuticle cells form an outer sheath encasing the inner cortical cells. Together, these two types of cells constitute the major part of the mass of clean wool. The coarse wool fibres may contain a third type cell, the medulla which is a central core of cells, arranged either continuously or intermittently along the fibre axis, often in ladder like manner.

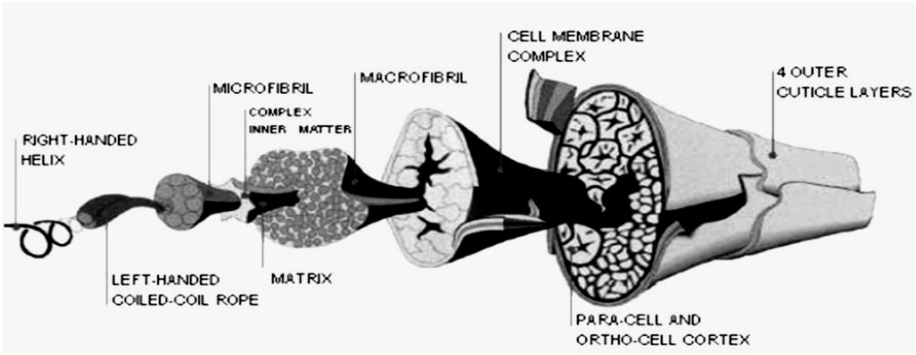


Figure : Fine structure of wool fibre

a) Cuticle

The cuticle cells comprise about 10% of the mass of the whole fibre and overlap each other with the exposed edges pointing towards the tips of the fibres. In textile use, cuticle is responsible for the surface properties of the fibres and also the barrier diffusion of chemical reagents into the cortex of the fibres. The scaly structure wool fibre plays an important role to decide surface characteristics such as frictional and felting behavior. The structure of cuticle cells can be subdivided into four regions, viz. exo-cuticle, epicuticle, endo-cuticle and cell membrane complex (CMC)

b) Cortex

The cortex of wool fibre forms about 90% of fibre volume. It has major influences on the mechanical properties of the fibre. The cortex of wool consists of closely packed overlapping cortical cells arranged parallel to the fibre axis. Each cell is surrounded by cell membrane complex which is a continuous phase and extents throughout the fibre. Packing of micro-fibrils within the macro fibril is dependent on the type of cortical cells from which they originate. The Para cortical macro fibrils has a high matrix content i.e. high sulphur protein whereas the ortho-cortex macro fibrils have low matrix content i.e. low sulphur proteins. The lower cross-link density of the ortho-cortical matrix leads to higher rate of stress relaxation. Differential stress relaxation in ortho- and Para- cortex generates additional crimp in wool fibre. Wool Microfibrils differ in their geometrical arrangement between the orthocortex &Para cortex. The location of these two types of cortical cell within the cortex has a profound effect on the crimp of the wool fibre. Ortho-cortex also has greater amorphous than Para-cortex. A third type, meso cortical, is sometimes present at the boundary between the ortho cortex and Para cortex. Meso cortex usually accounts for less than 4% of the fibre.

c) Medulla

Coarse wool fibres usually of diameter greater than 35 □m have a third type of cell, those of medulla. This is central core of cells arranged either continuously or intermittently along the fibre axis and wedged between the cortical cells, often in ladder like manner, air filled spaces between the medullary cells. Medulla may occupy up to 90% of the cross sectional area of guard hair. The presence of medulla in wool fibre is usually a disadvantage in terms of fibre weight and strength. However, air space in medulla contributes to thermal insulation provided by the fleece. The presence of medulla also increases light scattering properties of fibre.

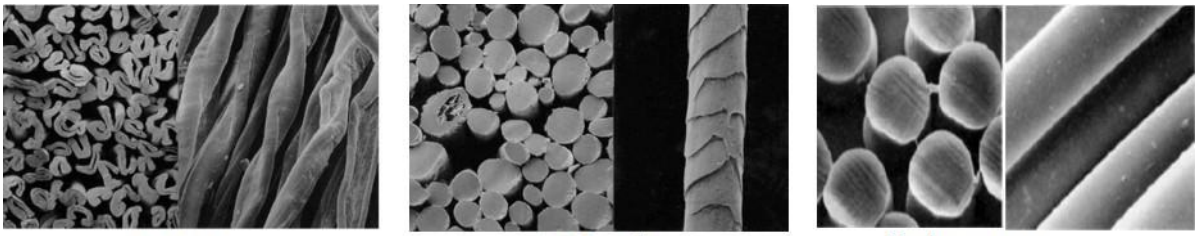
Identification of fibres

Textile fibres are classified into two groups as natural and man-made fibres. Major natural fibres are cotton, wool, silk and Jute and similarly major man-made fibres are polyester, viscose and nylon. It is difficult to identify the fibre just by mere touch or sight. There are three major methods used to identify the fibre.

i) Microscopic test method

In case of microscopic test, fibres are viewed through electron microscope in their longitudinal direction and cross section and then these images are compared with the standard images of fibres and the fibre that matches the particular standard image and matching morphology characteristics is given the name of that fibre. Cotton in cross section is a bean or kidney shaped fibre with lumen and in longitudinal direction it is ribbon like structure with convolutions.

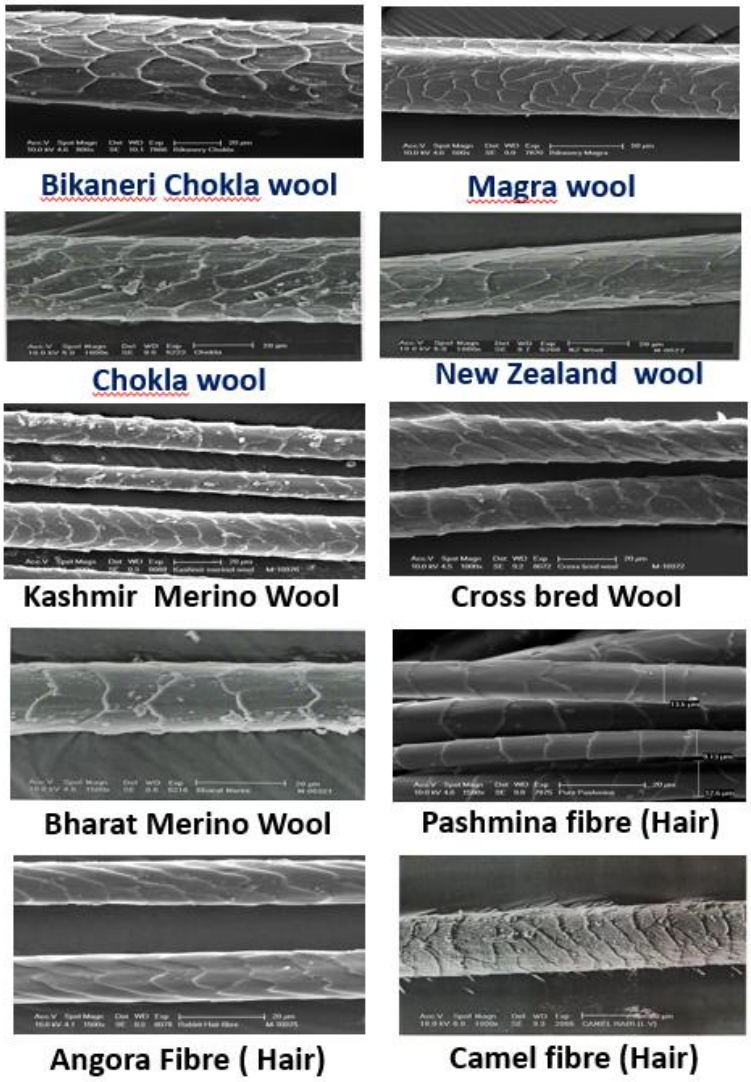
In microscopic view, wool is round, sometimes oval or elliptical shaped in cross section and having cuticle scales when viewed in longitudinal direction. Polyester is having smooth rod like structure with round cross section.



Characterization of Wool and Speciality Fibres Using Scanning Electron Microscopy

The morphological characteristics of wool produced in different indigenous breeds wool such as Chokla, Magra, Bikaneri-chokla, Malpura, Daccani, Bannure and crossbreds such as Bharat

merino, Kashmir Merino etc. animal fibres VIZ. Pashmina, rabbit hair, yak, goat, camel and equine hairs. Broadly scales are varying in number of scales, height and pattern. Animal fibres are grouped into four different classes according to scale patterns. Fine wool and Pashmina fibre has quite similar in scale pattern. Coarser wool, goat and equine hairs show similar scale pattern. Scale patterns of crossbred wool are falling in between coarse and fine wool. Some of the wool like Bikaneri-chokla and crossbred of southern state have showed peculiar diamond shape of scale pattern. Rabbit hair has unique scale pattern not matching any other animal fibres.



ii) Burning test method

The fibres being chemically different, they show different burning characteristics which can be used to identify them. The burning test is a relatively simple test as all that is needed is a flame and a keen observer who should carefully watch and note down the observations made: (a) when approaching the flame, (b) on the burning behaviour inside the flame, (c) during removal from the

flame, (d) relating to the smell emitted, and (e) on the residue left behind after the fibre has burnt out. The burning behaviour of different fibre is given below:

Name of fibre	Burning behaviour and residue
Cotton	Highly inflammable, when approaching to flame burns readily without melting or shrinkage, gives paper burning smell and leaves light grey or black ash
Wool	Wool has self-extinguishing property. It curls away while approaching the flame, burns slowly with melting, smell to burning hair smell and leaves a black bead which easily crushed to ash.
Silk	Burns with melting, smell to burning hair and leaves a crushable bead.
Polyester and other synthetic fibres	Polyester shrinks from the flame, melts and burns, sweet ester smell and leaves a hard bead. Chemical test involves carrying out solubility test for fibres. It works on the method of elimination.

iii) Chemical test method

Chemical test involves carrying out solubility test for fibres. It works on the method of elimination of one of the component of the blended fibres. Solubility test of different fibres are as follows:

Name of fibre	**Solubility test**
Cotton	Treat the fibre with 70% Sulphuric acid and if soluble, it could be cotton or viscose rayon. Confirmatory test - treat the fibre with sodium Zincate and if not soluble, it is cotton fibre.
Wool	Soluble in 5.0% NaoH solution (M:L ratio-1 :100 and 10 minute boiling) gives gelatinous fluid and dissolve. Non-heating test- treat the fibre sample with 0.25-0.50% sodium hypochlorite solution, if soluble, fibre may be wool or silk. Confirmatory test - treat the fibre in cold 70% sulphuric acid solution non-soluble residue is wool otherwise silk.
Silk	Soluble in cold 70% sulphuric acid solution.
Polyester	Treat the fibre with Meta cresol or boil the sample in chlorophenol for 5 minutes, if it is soluble then it is polyester
Nylon	Soluble in cold 30% hydrochloric acid, and cold 20% sulphuric acid

	solution.

The reference standard for identification of textile fibres is IS 667: 1981

Quality evaluation of wool

Gross dimensional properties of wool fibre include characteristics such as fibre fineness, medullation, Crimp and fibre Length. These properties are not only useful for determining machine settings and spinnability of the wool fibres for predicting the processing performance, end use suitability but also determine the physical and mechanical properties of yarn and fabric.

i) Fibre Diameter/ Fineness

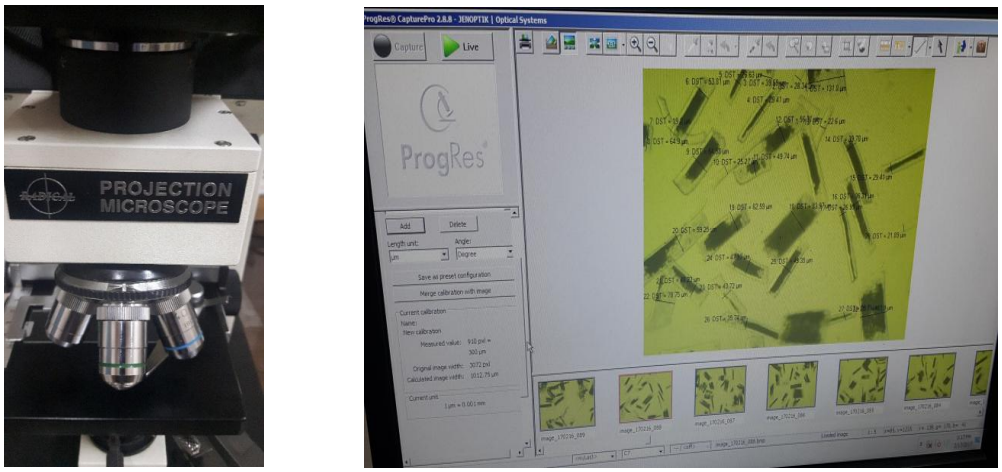
The wool fibre diameter usually denotes to its fineness properties. This most important wool fibre characteristic can influences around 80% of the woollen product performance. The wool spinnability, its processing technique for yarn and fabric manufacturing and quality of end products are mainly governed by diameter of wool fibre. The range of apparel grade wool fibre diameter is between 16 to 24 μm, contribute only to 10% of native wool production. Indian most economic important wool is carpet grade medium-coarse wool which range varies from 28 to 40 μm with medullation to the extent of 40% having component of 50 to 60% of the wool produced in the country. Another component is coarse wools (25-30%) having fibre diameter >45 μm usually utilized in manufacturing Namdas(felt) or local coarse products in different parts of country. The wool fibre diameter can be measured on projection microscope as per standard test method viz. ASTM- D 2130, IS-744(2000). The mean fibre diameter of a wool is without any doubt one of its most important characteristics, but the dispersion about mean or coefficient of variation (CV %) is also an important parameter which influences the quality of the product and spinnability of the wool fibre. The coefficient of variation in the merino type wool is generally varying from 20- 26% while it varies quite larger 30-50% in Indian wool fibres.

The principle of measuring fibre diameter is taking profile images of short pieces of the fibres and projecting it to a screen and then measuring diameter of these magnified images. In the procedure of test sample of about 1000 fibres and wash firstly in benzene or petroleum ether. Press it gently between two pads of filter paper and subsequently dry it. Take the specimens obtained as and place a representative	

part of the specimen in the open microtome slot.	

Then insert the steel tongue and push it strongly to compress the specimen. With a razor blade cut off the projecting fibres flush with both faces of the steel plate. The cut part of the fibres will then remain in the microtome slot. But forcing the pusher from one side, the cut fibres can be forced out at the other side to a length of 0.6 mm. With a razor blade, cut the emerging fibres flush with the steel plate. Transfer the conditioned fibre pieces on to a slide and put a few drops of any suitable mounting medium, such as cedar wood oil, to fibre pieces. Disperse the fibre pieces with a dissecting needle into the oil to obtain a uniform distribution. Prepare a slide for each sample. Put a cover glass by placing one of its edges in contact with the shorter side of-the slide and gently lowering the opposite edge. A gentle movement of the dissecting needle on the cover glass will give uniform distribution of fibre pieces in the mounting medium avoiding the formation of air bubbles. Mount the slide on the stage.

Capture the images using CCD camera and image processing software. Open the images in image processing software and draw lines from one edge of the fibre to the other edge. Repeat the measurement for 300 fibres. During measuring fibre diameter, observe the fibre for the presence of medulla and note down. Transfer the data to excel sheet and calculate, average fibre diameter and medullation percentage. Report the average fibre meter in microns. The reference standard for fibre diameter and medullation percentage is IS 744: 2000



Projection microscope and image processing

Table 2: Fibre diameter and medullation of different sheep breed and speciality fibres in India

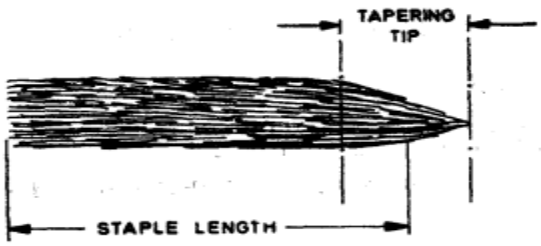
Breed	Diameter (µm)	± SE	CV (%)	Hetro (%)	Hairy (%)	Medullation (%)	SL (cm)
Australian Merino	20.01	0.38	33.23	1.83	-	1.83	8.99
Bharat Merino	21.57	0.30	24.77	0.08	0.01	0.09	6.38
Cross bred wool (HP)	26.78	0.73	47.21	5.4	3.4	8.8	-
J&K cross bred	27.26	0.75	47.65	5.33	9.33	14.67	-
Nilgiri	25.56	0.67	45.40	8.00	20.00	28.00	6.6
Sandyno	22.30	0.30	22.96	-	-	-	6.3
Chokla	31.52	0.72	41.53	6.81	11.53	18.34	6.27
Magra	31.46	0.66	39.92	12.66	18.06	30.72	7.49
Magra (Utarada)	34.90	0.69	34.40	17.0	38.00	55.00	6.2
Avikalin	33.63	1.0	54.06	15.17	28.04	43.21	6.37
Jaisalmari	36.46	0.95	44.91	18.67	47.33	66.00	6.00
Khari	33.55	0.87	46.27	28.61	41.18	69.79	3.30*
Mujaffarnagri	45.41	1.49	51.06	12.81	70.25	83.06	5.0
Pattanwadi	54.43	2.06	65.38	15.66	33.33	49.00	6.2
Daccani	38.76	1.18	53.18	7.67	64.50	72.17	4.17
Malpura	50.98	1.83	60.26	20.24	47.65	67.89	6.5
Turuchi Black	50.80	1.57	50.73	100% pigmented			4.1
Speciality hair							
Angora fibre	13.51	0.36	48.92	0	0.59	0.59	-
Pashmina fibre	12.87	0.30	40.69	0.33	1.00	1.33	-
Camel calf fibre	26.25	0.44	32.73	8.00	68.33	76.33	-
Yak Fibre (inner coat)	28.65	0.58	35.42	2.66	0.66	3.32	3.3

ii) Fibre Length

Fibre length is another important characteristic of wool fibre, which determines suitability of the spinning system in order to spin an economical quality yarn. It contributes about 15-20% to spinnability of worsted yarns. The fibre length in fine wool is 1.2 to 1.3 times of staple length because of crimp whereas it is almost similar to staple length in Indian wool due to lower crimps. Staple length of wool though governed to breed inheritance but also depends on environmental conditions during the growth of the wool. In general, the staple length increases with fibre diameter. The fibre length of different wools varies from 55 mm to 200 mm. The wool fibre length along with fibre diameter decides the spinning limit and spinning system to be used for particular wool. Wool fibre length can be estimated as per ASTM standard method ASTM-D 1575 on USTER Almeter AL100.

Measurement of Staple length (SL)

Staple is a bunch or tuft of fibres which naturally cling together in a fleece. Staple Length is the length of a staple obtained by measuring it in the unstretched condition. Draw the samples from the bale in such a way that different depths of the package are sampled. For example, make the first draw from the centre of the package, the next about two-thirds of the distance from the outside of the centre, and the third about one-third the distance from the outside to the centre. In the procedure, apparatus required are a velvet board of size around 50 cm^2 in a colour contrast with that of the wool and scale that is graduated in cm and mm. The diameter of the each staple shall be about 10 mm, if larger, it should be reduced to this size. Place the scale on the velvet board along the length of the board. Take a staple and place it along the scale on the velvet board. Gently straighten the staple if it is in a bent state. Remove the scale without disturbing the staple on the board and carefully adjust the zero mark of the scale with the base of the staple. Read the length of the staple to the nearest 5 mm. In case the staple does not have a clearly defined tip, that is, if it has tapering tip, take the reading from the base of the staple to the point on the tapering tip where the majority of the fibres end. Similarly measure other test specimens. Test at least 100 test specimens. Calculate the average staple length from the individual measurements obtained and express in cm. Reference standard for measurement of wool staple length is IS 6653: 1972 (Reaffirmed 2010).



Wool staple

iii) Fibre Crimp

The waves or curls present in the wool fibre are called crimp. Uniformity and abundance of crimp are called indices of good quality wool. Crimp in the wool occurs mainly due to bilateral arrangement of ortho- and para-cortex cells fine wool fibre consist distinct arrangement of ortho and Para cortex. The ortho-cortex always lies on the outside at crests and troughs. These ortho and Para cortex grows at different rate during the fibre growth, which causes the fibre to develop a spiral crimp. Crimp is assessed by counting the number of waves or curls present in the fibre and expressing it as the number of waver or curls per unit length. Fine merino wool fibres have 6-10 crimps per cm. The coarse wool do not have bilateral arrangement of the ortho- and Para- cortex, these cells are arranged in concentric which results low crimp in the fibre.

Fibre crimp influences the spinnability of the yarn and quality of the product. It gives more cohesiveness between fibres, which improves the spinning performance. The fibre crimp plays an important role in yarn and fabric extensibility and improves fabric quality. The fibre crimp influence also major functional characteristics of the fabric in terms of thermal insulation and tactile comfort properties. It can be measure on AWTA LTD Crimp Meter an instrument developed by CSIRO for Staple crimp frequency and fine crimp as per IWTO CTF 01-2003. In the procedure, wool fibre sample is prepared through sampling technique and an individual fibre specimen is placed on a velvet pad and then number of crimps along the entire length of the fibre is counted. After counting, the fibre is straightened without deformation and uncrimped length is measured. Crimp frequency is reported as number of crimps per unit of extended length. Reference standard for wool crimp measurement is ASTM D3937-12

iv) Determination of Moisture Content & Regain of wool

Wool is a highly hygroscopic fibre and absorbs different amount of moisture under different atmospheric conditions. The amount of moisture present in the material is important especially at the time of making sales or purchase and during process.

Moisture Content: The amount of moisture in wool expressed as percentage of the total mass.

Moisture Regain: The amount of moisture in wool expressed as a percentage of oven-dry mass.

A sample of wool is weighed and dried to constant mass in an oven at 105$\pm$ 2^0C. The loss in mass of the specimen is taken as loss of moisture and calculations are made for moisture content. The same sample is then left for 24 hours for moisture regain and weight to calculate moisture regain of wool.

Calculation: Calculate the moisture content and moisture regain by the following formula:

Moisture content % $= \frac{M1-M2}{M1}$ X 100

Moisture regain % $= \frac{M1-M2}{M2}$ X 100

Where: M_1 = Original mass of the specimen and M_2 = Oven-dry mass of the specimen

In procedure of moisture assessment of wool take a specimen weighing about 250 g (M_1) if the drying oven is fitted with a weighing balance and about 10 g if the oven-dry mass is to be determined outside after cooling in desiccator. Put the specimen in a suitable container and dry it to constant mass. The constant mass shall be deemed to have reached when two successive weighing made at an interval of 20 minutes do not differ by more than 0.05 percent. Determine the oven dry mass of the specimen (M_2) without removing it from the oven with the airflow stopped. In case the drying oven is not provided with the weighing balance, remove the specimen from the oven and transfer it to a weighing container of known mass and close the lid. The transfer of specimen should be done as quickly as possible. Cool the specimen and the container in a desiccator to room temperature and weigh. Find out the dry mass (M2) of the specimen. Test at least 3 test specimen if the drying oven is fitted with a weighing balance, otherwise test at least 5 test specimen. Calculate and report average moisture content and moisture regain of the specimen to one place of decimal. Reference standard for measurement of moisture in wool is IS 6637: 1972

v) Fibre bundle strength

Strength of fibre contributes substantially to the quality assessment of specimen fibres. The method of estimating the tenacity by testing individual fibres is tedious and time consuming. For both commercial and technical purposes, quicker methods have been developed which test the fibres in the form of bundles.

In the procedure firstly a flat bundle of wool fibres is fastened in a pair of clamps and the fibres protruding beyond the clamps are cut. Place the prepared clamps in adjustable jaw of instrument

(stelometer), increasing force is applied to the specimen until it ruptures/break of specimen followed to recording of the breaking load. Remove the clamps from the instrument, check to see that all fibres are broken and place the clamps in the vice. Open the clamps, carefully collect all the broken fibres with the help of forceps, and weigh them to the nearest 0.01 mg. The ratio of the breaking load to the weight of fibres is determined and the tenacity is calculated therefrom. The test may be carried out either at zero or at 3.175 mm (1 /8 in) gauge length. Perform the test on a total of at least 10 specimens.

Breaking Tenacity

For test made at zero gauge lengthy based on a bundle length of 11.81 mm (0.465 in), use the following formula:

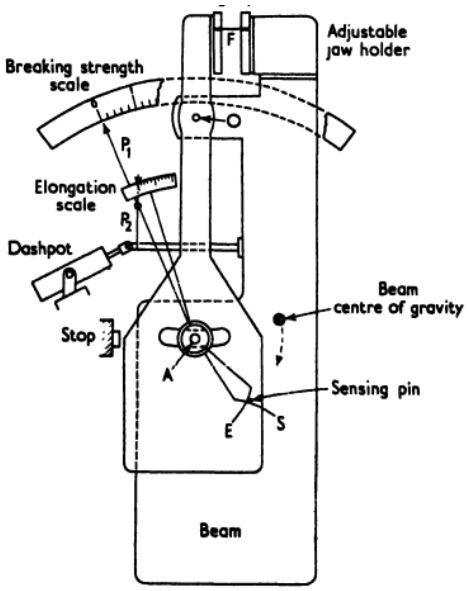
$$\text{Breaking tenacity (g/tex)} = \frac{Breaking\ load\ in\ kg \times 11.81}{Bundle\ weight\ in\ mg}$$

For test made at a 3.175 mm (1/8 in) gauge length, based on the bundle length of 15 mm (0.590 in) use the following formula:

$$\text{Breaking tenacity (g/tex)} = \frac{Breaking\ load\ in\ kg \times 15.00}{Bundle\ weight\ in\ mg}$$

Calculate the mean of all values and express it as the breaking tenacity of the fibres. Test report shall include the following:

a) The average breaking tenacity (g per tex) correct to one decimal place,
b) Type of strength testing instrument used, and gauge length
Reference standard for measurement of bundle strength of cotton is IS 3675: 1966



Stelometer

vi) Wool Colour

The greasy wool contains a high level chemical residue in terms of wool wax, sweat and pesticides which is undergone soiling too prior to shearing. The exposure to sunlight such chemical/ soiled wool

tend to photo yellowing of wool. The colour of wool range from very bright white to dull yellow/orange. The marketing prices of wool are invariably according to its whiteness. Being a very week relationship between greasy and scoured wool, it is difficult to predict clean wool colour by visual assessment. Thus it is suggested to objectively test the colour of wool. The colour of wool can be measure in terms of yellowness, it is a measure of the degree to which the wool colour is shifted from preferred white towards yellow. Spectrophotometer is used to measure as per standard test Method ASTM -E313.

$$\text{Yellowness Index (YIE313)} = \frac{100\,(Cx\,X - Cz\,Z)}{Y}$$

Where- X, Y, Z are the CIE tristimulus values/coefficients, these are depends on the illuminant D65 and observer 10^{O}, the values for C_x and C_zZ at D65/ 10 degree is 1.3 and 1.15 respectively

At D65/10 degree colour space, illustration of wool yellowness index indicated to range given below :	
Colour description	**Y-Z unit (Yellowness Index)**
Very White	< 8
White	8-11
Creamy (off-White)	11-16
Yellow	>16

vii) Wool Brightness/ Lustre

It is the ability of wool to reflect light, It can be measure to reflected light over wool fibre surface in a very specific area of the spectrum as per standard test method ISO R457. It entails a filter with a maximum transmission curve of 457-nm wavelength (lambda 457) and a specific half peak width. Wool with lustre/ brightness, when dyed, has a brighter appearance than wool without lustre. Coarse wool with fewer scales has more lustre than fine wool because of smoothness of fibre. The surface shine of wool fibres can also be evaluation through Glossmeter, though it mend for gloss/ shine measurement of smooth surfaces only. ICAR-CSWRI developed a sample mounting platform and standard operating procedures for lustre evaluation of fibres on Glossmeter.

At D 65/ 10 degree colour space , the illustration of wool Brightness index indicated to range given below :		**Gloss 60^{o} value**
Brightness (Colour) description	**Y-Z unit (Yellowness Index)**	
Very bright	>72	> 5
Bright	71-65	4-5
Less bright	64-60	3-4
Dull	< 60	< 2

Estimation of Impurities in wool

Wool in its raw state known to greasy wool contains many impurities. The natural impurities are high level of valuable wool wax- lanolin, sweat residue deposited on the wool fibre during its growth, acquired impurities during sheep grazing viz. dust, dirt, straw, burrs and twinges etc. and applied impurities i.e. substances used in treatment against diseases viz. Dipping & drenching and pesticides or coloration marks for identification purposes. In order to obtain quality products, it is essential to remove these impurities, otherwise will be damage the fibre and reduces the serviceable life of carding clothing. Thus, removal of these impurities is also have a economic importance.

i) Clean fleece yield

Clean wool yield is the amount of wool left after scouring (washing). It is usually expressed as a percentage of the original "grease" fleece weight at standard condition of 13.8 moisture content estimated as per standard method IS: 1349-1964. In lab process, firstly oven dry the wool specimen and recorded the oven dry weight (W_1). The specimen is to hand opened and is treated with solution contains 0.3 % anhydrous Na_2CO_3 and 0.1% non-ionic synthetic detergent with three filled tubs at solution temprature to 52 ± 5^0C. Ratio of wool weight to volume of solution used for scouring bath shall be less than 15g per litres. Agitates the specimen (enclosed in a 40 mesh net bag) in the tub for 3 to 5 minutes with hands. Agitates the scouring solution with bags. Remove the mesh bags with the specimen and squeeze between the rollers of wringers before its passed on to the next tub. Treat the specimen similarly in the second and third tub. Fill the fourth tub with soft water at 52 ± 5^0c and rinse the specimen in it. Remove the specimen an spray it with strong stream of water so as to flush out as much as possible, sand and other soil, pass the specimen through the rollers of wringers and centrifuge to remove excess of water. Dry the specimen in drying oven at 105 ± 2^0C to constant weight. Note the oven-dry weight (W_2) of the specimen accurately.

$$CFY = \frac{W1-W2}{W1} \text{ X } 100$$

The clean fleece yield in wool is quite variable (e.g. 40 to 70 percent) and it is affected by many factors, both genetic and environmental. Bulkiness of fleece generally indicates a high yield. The clean fleece yield of wool from for few Indian Sheep breeds are given below.

Table 3: Clean fleece yield of different sheep breed

S. No.	Sheep breed	Lot Size (kg)	Dusting loss (%)	Scouring loss (%)	CFY/Scouring yield (%)
1.	Chokla	594.0	5.73	13.04	81.98
2.	Malpura	708.0	6.78	13.18	80.93
3.	Kheri	196	2.04	14.59	83.67
4.	Magra	317.0	3.79	5.58	90.85
5.	Bikaneri Chokla	105.0	9.54	7.37	83.81
6.	Avikalin	300.0	13.33	15.00	73.66
7.	Dumba	33.0	9.10	13.33	21.22
8.	Marwari	54.0	9.26	14.82	85.18
9.	Crossbred wool (Garsa)	1506.0	16.41	50.24	41.56
10.	Bharat Marino (Mannvr.)	144.0	9.77	31.59	52.51
11.	Pattanwadi	136.0	19.86	19.26	63.31
12.	Daccani (Black)	138.0	11.60	14.76	75.36

ii) Vegetable Matter Content

Determine the vegetable matter content of the oven-dry scoured specimen by following method. From each of the scoured oven-dry specimen take approximately equal quantities of wool, so as to make about 40g. Re-dry it in the drying oven at 105$\pm$ 2^0C for such period till two consecutive weighing do not differ by more than 0.1 percent. Take 400ml of sodium hydroxide solution of 10 percent concentration in a beaker and bring it to the boil. Transfer the oven-dried wool to the beaker and boil for 3 minutes stirring the contents all the time. Allow to settle and decant through a 125 micron IS sieve. Add 100ml of cold water to the beaker and transfer the residue to the sieve. Wash the residue thoroughly with distil water and rinse with dilute acetic acid to remove last traces of alkali. Wash finally with distilled water until the filtrate is neutral to litmus paper. Remove with the help of a

tweezers, all vegetable fibres and tag material from the residue. Transfer the residue to porcelain dish of crucible and dry it at 105± 2^0C for the period till two consecutive weighing do not differ by more than 0.1%.

Calculation the vegetable matter content, percent, in the sample by the following formula:

V= $\frac{a \times F \times 100}{b}$

Where, V = vegetable matter content, percent of the oven-dry scoured specimen.

a= oven-dry weight in gram, of the residue.

F= the correction factor taken to be equal to 1.1

b= Oven-dry weight in gram of the specimen.

ECONOMIC IMPORTANCE OF IMPORTANT WOOL QUALITY PARAMETERS

These above gross dimensional properties of wool fibre determine the marketing of wool is practices viz. on the basis of grading of wool. The different methods of wool grading is detailed below:

Wool grading

Sheep rearing is usually a communal farming system and these land less small scale farmers has lack sufficient quantity of wool due to small herd size as well as lesser knowledge about pre marketing practices viz. sorting, classing and packing made them to exploited by middleman/ broker. Keeping in view and standard for wool export, wool grading was first introduced in India with Agmark in 1961. The wool grading standard are follows:

Fibre fineness	Fibre Length	Wool colour	Burr content
Super fine as 58s up	2 ″ up long	White light Yellow (LY)	Low Burr-up to 3%
Fine-A as 54s/ 56s up	2 ″ down sort	Heavy Yellow (HY)	Midium burr-up to 3-6%
Medium –B as 46s/ 50s	-	-	-
Strong-C as 40s/ 44s	-	-	-
Coarse- D as 40s down	-	-	-

The above grading system was developed by experts from New Zealand, and they do not have exposure of medium coarse carpet grade wools which is the major stake to marketable Indian wool. A new grading system known to “Style grading” was introduced on demands of carpet yarn industries.

Feature of Style Grading System mainly for Rajasthan Wool

Fineness grades	Quality	Micron range	Length grade	Lower grade specification
A	48 (+)	33.5	upto 2" indicated by single letters **and** 2"- 4" indicated in double letters i.e. AA, BB, CC, DD	Colour, cotts, pieces, Black wool and Stains
B	40/48	39.0-34.0		
C	36/40	43.0-39.5		
D	32 (-)	43.0 (+)		

Style specifications

Style	Code No.	Description
Good	1	Good colour, well washed, skirted, V M up to 3%, Reasonable quality and length
Good average	2	Yellow colour, skirted, V M 3%, Reasonable quality and leng
Average	3	Average washing, skirted, V M between 3% to 6%
Inferior	4	Poorly washed, V M above 6%.
This system was formulated in a way that a large portion clip from particular areas would fall in one standard and in total had 39 grades i.e. much simple than FAO grading system.		

For Export and organised marketing of wool in India BIS grading system is compulsory which is detailed below :

Finesses Range	Length	Burr	Colour
Bellow 34.4 - A	Above 75 mm	LB- Below 3%	White
34.5 to 37.0 B	Below 75mm	MB-3 to 5%	Tinged White (TW)
37.1 to 40-C		HB- above 5%	Light Yellow (LY)
40.1 & above - D			Heavy Yellow (HY other colour)

However, as far as we know, license to operate the above system is need.

Chapter-5

COMMERCIAL SHEEP AND RABBIT FARMING

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Introduction:

Livestock is an important component of Agriculture and plays a crucial role in the national economy by significantly contributing towards socio-economic upliftment of a large population in the country. Among livestock, small ruminants (sheep and goat) together contributed 1.60 million tonnes meat, 5.75 million tonnes milk and 43.54 million kg wool per 2016-17 estimates (BAHS, 2017). Small ruminant farming is preferred by the farmers due to its certain advantages, mostly in terms of lower financial and labour investment, easy upkeep, availability of suitable local market, faster return etc. over other livestock.

Traditionally, sheep and goats are reared by the poor, landless, small and marginal farmers of the country. Due to increasing human population, faster urbanization and increasing purchasing power of individuals is boosting the demands for meat, milk, wool and other animal produces in the country. In recent years, livestock, particularly small ruminant farming has ensured the income generation mechanism to the farmers as well as for educated youth for developing commercial venture. The multi-faceted utility of sheep and goat in terms of meat, milk, wool, fibre, skin and manure will further increasing the scope of these species in developing business under intensive system.

Role of livestock in farmers' economy

The farmers in the country generally maintain integrated farming system in a combination of crop, fruit tree, vegetable and livestock where the output of one enterprise becomes the input of another enterprise thereby realize the resource efficiency. Livestock is a source of subsidiary income for many families of poor and marginal farmers. Sheep and goats serve as sources of income during emergencies also. A large number of people being less literate, unskilled, poor depend upon livestock for utilizing their labour during lean agriculture season. The livestock products like milk, meat, wool and manure are important source of income. The animals offer social security to the owners in terms

of their status and wealth in the society. Sheep was initially reared for wool production but due to use of synthetic fibre in the market its utility has been diverted towards mainly for meat production. Majority of sheep breeds in the country are meat type and some of them are known for better meat producing sheep like Marwari, Malpura, Jaisalmeri, Patanwadi, Muzaffarnagari etc. in northern part of country and Mandya, Madras Red, Mecheri, Nellore and Coimbatore are from southern part of country.

Sheep are generally reared on extensive system of feed management depending on the availability of pasture land and common property resources with minimum concentrate feeding. Under traditionally feeding the genetic potential of animal is not exploited due to poor nutrient input from dam, grazing with mother as well as supplementation during pre- and post-weaning period from scanty available resources. In this system the body weight gain in lambs in active phase of growth was very low and lambs could attain market weight of 15 to 20 kg at 9 to 12 months of age, whereas when these lambs were well fed under intensive feeding system get 18-20 kg body weight at 3 month and 30-32 kg weight at 6 month of age (Sahoo et al, 2015). So, it revealed that productivity of sheep in active phase of growth can be enhanced by planned feeding management. Therefore, the intensive feeding system of management is recommended for commercial sheep farming.

Intensive system of management:

Sheep rearing being important component of small animal production system provides economic stability to the farmers. However, in **extensive system** of management the animals are reared on poor and degraded grazing lands that follows short and long-distance migration in cultivated and uncultivated, forest lands, etc. The animals are mostly remains on low plane of nutrition resulting in low production and reproduction (Patil and Patel, 2007). In **semi-intensive system** animals are allowed to graze on CPRs, cultivable/ fallow land for day time and then supplemented either with concentrate or with tree leaves/shrubs/ crop residues. This system seems to be more economic viable as the animals meet their main feeding requirement through grazing and minor requirement through supplementation during critical period of feed scarcity. The major reasons for low productivity in semi-intensive and extensive rearing system are inadequate grazing resources, diseases causing high mortality, morbidity, exploitation by middle man, low adoption of improved management technologies and improper breeding management. The intensive system often involves the higher use of purchased inputs such as grains, concentrate and dry fodder in the form of crop residues and dry grasses. The studies indicated that under intensive system concentrate

supplementation along with grazing or intensive management results in better production performance in goats (Mathur, et al., 2000 and Singh and Ramachandran, 2007). This system is mostly common in peri urban areas driven by better market access to cater the demand of meat. In this system animals are generally stall fed on cultivated fodder, crop residues, top feeds, concentrates or compounded feeds based on Total Mixed Ration (TMR). Animals are reared in a scientific housing system where covered and open areas are available for their free movement as per weather condition under loose housing principle. The preventive health care measures including deworming and vaccination against contagious diseases are taken to protect the animals from ailment.

Dry matter intake in different rearing systems:

Sheep can graze closely to the ground as they have the ability to pick up very low level vegetation and grasses that cannot be used by other livestock. They also have the ability to cover long distances in search of forage and water, making them suitable for dry land agriculture. Ananda Rao et al., (2013) reported that, the average grazing time (h) and grazing distance (km) were 8.48 ± 0.06 and 6.02 ± 0.17 in summer and 6.08 ± 0.05 and 3.78 ± 0.03 in seasons other than summer. In intensive farming systems higher dry matter intake is due to quantum and quality of feed intake, which results in animal comfort and improves the production performance. In extensive group, the lambs are allowed for grazing on the fields in adverse environmental conditions which might decrease the dry matter intake (Bharambe and Burte 2012). The DMI (g/day /animal), DMI (g/kg/BW), DMI (g/kg 0.75) reported as 944.7 ± 36.6, 36.5 ± 1.22, 83.4 ± 1.22 in intensively management system, where as 743.9 ± 48.65, 32.3 ± 2.17, 70.7 ± 4.50 in semi intensively management system in Avivastra lambs (Shinde et al., 1995). Lower DMI, DCP and TDN intake was found in Malpura weaners lambs but, the growth rate was higher under grazing with supplementation than that in intensive feeding (Karim and Verma 2001).

Average daily gains in different rearing systems:

The average daily gain will be higher in intensive rearing system as compared to semi-intensive and extensive raring systems because of supplementation of concentrate feed along with limited hours of grazing which will have a limited stress factors (Sari et al., 2014). ADG of 91.33 g in a growth trial in Nellore weaner lambs were found under intensive system of feeding and management (Prasad et al., 1991). The average daily gain was 35 and 79 g in sole grazing and concentrate supplementation group respectively reported by Chellapandian and Balachandran (2003). Extensive, semi-intensive and intensive system of feeding management recorded an average daily gain of 72.6 ± 5.40, 160.9 ±10.52 and 135.9 ± 7.50 g respectively in Kheri male weaners (Porwal et

al., 2006). Yeaman et al., (2013) reported that the, mean ADG was 340 ± 9.2 g for Dorper lambs and 346 ± 8.6 g for Rambouillet lambs in intensive feeding system. In arid zone the average daily gain (ADG g/d) in pre-weaning (0-3 month) period was higher than post-weaning (3-6 month) period in Marwari lambs. The values of ADG (g/d) in pre-weaning periods were 110.6, 159.3 and 176.6 in extensive, semi-intensive and intensive management systems, respectively, whereas the values of ADG (g/d) in post weaning (3 to 6 month) were 78.1, 90.8 and 114.7 in Group-I, Group-II and Group-III, respectively (Patel, 2020).

Body weight gains in different rearing systems:

The comparatively higher body weight gains in intensive group followed by semi-intensive and extensive group indicates the advantage of intensive system. Semi-intensive group will achieve higher weight gains when compared to extensive group due to the supplementation of concentrate feed along with 4 hours of grazing and lesser time exposure to environment stress. Extensive group will achieve comparatively lower weight gains than other rearing systems indicating that extensive farming system has limited feeding resources for sheep flocks. Porwal et al., (2005) also found higher body weight gains for the lambs reared under semi-intensive and intensive system of feeding when compared to extensive system. Carvalho et al., (2007) observed that more quantity of roughage and less concentrate feed in the diets lowers the live weight gain of the lambs. Avivastra weaner lambs had achieved higher finishing weight in intensively (33.5 Kg) fed lambs compared to semi-intensively (27.3 kg) fed lambs (Shinde et al., 1995). During growth studies Meenakshi Sundaram et al., (2002) found that in the lambs of age fifth to twelfth month in intensively reared lambs (slatted and mud floor groups) maintained their superiority in growth rate than those reared under semi intensive system of management. Bharambe and Burte (2012) compared Deccani lambs under grazing, semi stall fed and stall fed systems and found that the body weight, body length, body height, chest girth and total greasy fleece yield was significantly higher ($P< 0.01$) in stall fed system than grazing and semi stall fed systems. The effect of management was found significant on body weights of Marwari lambs in arid zone. The male lambs of intensive and semi-intensive groups attained 46.9 and 24.1% higher body weight gains over lambs of control group at 6 months of age (Patel, 2020). The average body weights of male lambs were 20.55, 25.51 and 30.19 kg in extensive, semin-intensive and intensive management systems, respectively at 6month age.

Feed conversion efficiency:

The feed conversion efficiency in intensive rearing system will be more as compared to semi-intensive and extensive system of rearing. In intensive system cultivated green fodder will be

provided along with concentrate supplementation, so the digestibility will be more and body weight gain will be more. But in case of semi-intensive system of rearing the animal will be allowed for grazing for half a day and little quantity of concentrate feed will be supplemented which will decrease the feed conversion efficiency as compared to intensive system of rearing. In case of extensive system of rearing the animals allowed for grazing on common grazing lands and pasture. The nutritive value of grasses and pasture are low. Sari et al., (2014) reported that, the poor nutritive value of grasses and grazing material decreases the feed conversion efficiency in extensive system. Yeaman et al., (2013) reported that the, feed conversion efficiency was 0.153 ± 0.003 for Dorper lambs and 0.158 ± 0.003 for Rambouillet lambs in intensive feeding system. Patel, 2020 estimated feed conversion efficiency (FCE) was estimated as DMI per kg live weight gain and which were 6.36 kg and 5.77 kg in semi-intensive and intensive group for male Marwari lambs during 3 to 6 month period. The B:C ratio was 3.22 and 3.13 in Group-II & III showed that rearing of male lambs for 3 to 6 month period was a profitable venture for additional meat production under intensive management system.

Economics of sheep rearing systems:

The intensive rearing system requires high investment but, the productivity is also high. The semi-intensive rearing system requires a fairly high investment cost than extensive, though little lower than that of the total intensive rearing system, but the productive performance will be better than extensive rearing system. The cost of production per kg live meat in intensive system will be more as compared to semi-intensive and extensive group Kochewad, et al., (2017). The cost of production one kg of meat was higher because of the cost of feed compared to semi-intensive and extensive. In intensive system the animals are stall fed so, cost of fodder and concentrate feed will increase the production cost. In semi-intensive system, the cost of fodder as well the cost of concentrate was half of the intensive system so the cost of production will be low. Therefore, the B:C ratio was higher in semi-intensive (3.22) than intensive group of lambs (3.13), showed that rearing of male lambs for 3 to 6 month period was a profitable venture for additional meat production under both groups in comparison to extensive group (Patel, 2020).

In extensive system of rearing the animals are not offered additional feeds, however, the animals are allowed only on grazing system the cost of production will be very low compared to other two systems. But the average body weight gained was significantly lower than intensive and semi-intensive systems. Karim et al., (2004) reported that under intensive feeding 70 kg complete feed was consumed at a cost of Rs 274/ head, while grazing with supplementation consumed 27 kg

concentrate costing Rs 162/ head. Accordingly the cost of feeding/ gain in live weight was Rs 31 in intensive system and Rs 23 in grazing with supplementation. Porwal et al., (2006) reported that disposal of the finisher by slaughter provided 225, 266 and 303 per cent higher income under extensive, semi intensive and intensive than sale of live animals. Chaturvedi et al., (2010) reported that, the lambs of concentrated supplemented ewes were sold at higher rates (Rs. 1900/lamb) than those of non-supplemented ewes (Rs. 1400/lamb). Malisetty (2013) reported extra weight gain in ram lambs supplemented with concentrate was 3.82 kg, with a cost benefit ratio of 1:2.08

Scientific Rabbit Rearing

Rabbit rearing has been emerging as a new enterprise in our country. Rabbits are reared in the form of small scale farming to large scale enterprises in the country. Rabbits utilize vegetation in the best way to produce high quality wholesome meat. Manure of rabbits can be used to prepare high quality compost which increases production of crops and vegetables in the field. lf rabbits are fed good quality fodder, its dependence upon ration feed can be reduced up to 50 percent. High protein content, low fat, low cholesterol and low sodium content in the rabbit meat increases its importance when compared with meat of other livestock species. Skin of rabbit is used to prepare apparels like coats, jackets, caps etc. The other important feature of rabbits are high prolificacy and growth rate, short gestation period and high kindling rate. Rabbit rearing can be started at small scale to large scale. At small scale rabbits can be reared in the backyard of a house. At large scale, rabbits are reared in cages in a well organized way. Rabbits have calm temperament, therefore they can be handled easily by men and women in a family. Now-a-days farmers are adopting rabbit rearing along with large and small ruminants to utilise their spare time and thus enhancing farmers' income. ln current scenario of ever increasing demand of meat, country will not be able to meet its meat consumption demand alone from existing livestock, bird and fish species, rather has to find new ways like rabbit production for that. As the rabbit rearing is totally new enterprise for farmers, so keeping the huge demand of rabbit farming, the institute provide regular 8-days duration Skill Development Training Program on scientific rabbit rearing to start their own enterprise.

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Chapter-6

INDIAN SMALL RUMINANT MEAT INDUSTRY: OPPORTUNITIES & CHALLENGES

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India is a unique country with 2.4% of the world's land area, 11.6% of the world's livestock population, and 17.7% of the global human population. The average farm size in India is declining with time and has reduced from 2 hectares in 1976-77 to 1.08 hectares in 2015-16. In one dozen Indian states average farm size is less than a hectare. The Majority (86%) of land holdings belong to small and marginal farmers (SAS, 2021). The livestock sector has been very promising, depicting an impressive growth of 8.15% CAGR with improved GVA contribution from 24.32 to 29.35 from 2014-15 to 2019-20. The livestock sector contributes 4.35% of the total GVA. The livestock sector provided livelihood to the 2/3rd of the rural community and employment to the 8.8% of Indians.

Small ruminants i.e., sheep and goat rearing is the backbone of the rural economy in India as it helps in sustaining the livelihood of rural poor in difficult terrains. They provide meat, milk, and wool in addition to skin and manure. The small ruminants satisfy the need of small landholders and village systems due to advantages like small initial investment, good return, low risk, less space requirement, ease of rearing, and mobile ATMs. The goat sector generates about 5 % of rural employment and about 20 million families belonging to small and marginal farmers and landless labourers are engaged in goat keeping. Sheep contribute livelihood to 2 lakh people in rural areas and employment to 20 lakh people in the woolen sector. The value output from the sheep and goat meat sector has been worth Rs 89,768 crores during 2019-20 (Central Statistical Organisation, GoI).

In India, 44 sheep and 34 goats breeds are registered with the ICAR- National Bureau of Animal Genetic Resources. The sheep and goat population has colossally increased by 90% (39.1 vs 74.3 million) and 215% (47.2 vs 148.9 million) from 1951 to 2019. Of late, the last two censuses indicate that the sheep and goat population in the country increased by 14.1 (65.06 to 74.26 million) and 10.1% (135.17 to 148.88 million) respectively. The goats and sheep are 27.8 and 13.9% of the total livestock population in the country. Their contribution to total meat production is 13.72 and

8.94% respectively for goats and sheep. The goat and sheep contributed 1948 million kg of meat and 36.76 million kg of wool in 2019-20 (BAHS, 2020).

Table 1. Goats and sheep in India

Species	Breeds (Registered)	Population (millions)	No. of animals slaughtered (M)	Slaughter rate (%)	Carcass yield (kg)	Meat production (MT)
Goats	34	148.9	97.1	65.22	10	1.09
Sheep	44	74.26	50.86	68.48	12	0.68

During the inter-census period, the goat and sheep populations have shown both increasing and declining trends in states. This may be attributed to promotional state government schemes, increase in slaughter rate, early disposal of kids and lambs by the farmers, etc. The carcass yield of Indian sheep and goats is relatively low as compared to the world average due to neglected feeding, zero input system, an extensive system of rearing, etc.

Table 2. Indian states with goat and sheep population

GOAT		SHEEP	
State	**Population (million)**	**State**	**Population (million)**
Rajasthan	20.84(-3.81%)	Telangana	19.1 (48.51%)
West Bengal	16.28(41.49%)	Andhra Pradesh	17.6 (30%)
Uttar Pradesh	15.59 (14.48%)	Karnataka	11.1 (15.31)
Bihar	12.82 (5.49%)	Rajasthan	7.9 (-12.95%)
Madhya Pradesh	11.06 (38.07%)	Tamil Nadu	4.5 (-5.98%)

Source: 20th Livestock Census (values in parenthesis indicates percent inter-census change)

The mutton and chevon production in the country is showing an increasing trend. Telangana and Andhra Pradesh produce more than half (62%) of the mutton in the country. Further, West Bengal, Maharashtra, and Bihar are the top three chevon-producing states contributing 44% of total chevon produced in the country (Table 3).

Table 3. Top five mutton and chevon producing Indian states, 2019-20

State	Mutton Production (000 tonnes)	State	Chevon Production (000 tonnes)
Telangana	288 (37.45)	West Bengal	291 (24.68)
Andhra Pradesh	193 (25.10)	Maharashtra	127 (10.77)
Karnataka	72 (9.36)	Bihar	101 (8.57)
Tamil Nadu	64 (8.32)	Rajasthan	92 (7.80)
Rajasthan	40 (5.20)	Uttar Pradesh	88 (7.46)
All India	**769**	**All India**	**1179**

Source: BAH&FS, 2020; Values in parenthesis indicate per cent contribution to the nation

Meat Export

Genuine halal meat, close proximity to a Middle Eastern market, vast population, and leaner and organic carcass are the added advantages for India. During the year 2021-22, 8695.97 MT of sheep and goat meat was exported to the world worth Rs. 447.58 Crores (Table 4). The major destinations for the export of Indian sheep/goat meat are United Arab Emirates, Saudi Qatar, Kuwait Arabia, and Oman. At present, there are 86 APEDA-approved Indian abattoirs-cum-meat processing plants in India. Sheep meat is exported in the form of fresh and chilled lambs and sheep, boneless mutton, frozen lambs, and sheep.

Table 4. Export profile of sheep/goat meat

2019-20		2020-21		2021-22	
Qty in MT	**Rs. Crores**	**Qty in MT**	**Rs. Crores**	**Qty in MT**	**Rs. Crores**
14,128.84	646.69	7,050.55	329.96	8,695.97	447.58

Source: APEDA, 2022

In spite of the nutrient-rich food, meat consumption in the country is far below (6.52kg/head/annum) the recommended level of 11 kg of meat/ head/annum. Deficiency of the quality proteins in the diets leads to undernourishment/malnourishment.

Opportunities in Small Ruminant Meat Industry

1. **Breed diversity and population**: India is bestowed with 148.88 million goats, and 74.26 million sheep with diverse genetic resources comprising 44 sheep breeds, and 34 goat breeds.

2. **Organic rearing:** In India**,** most sheep and goats are reared under an extensive system with little or no supplementation. No growth promoters are used. This makes the meat of sheep and goats nearly organic without any antibiotic/pesticide residues.
3. **Short generation interval:** Sheep and goats have a short generation interval compared to large ruminants and hence meat can be harvested in a short period of time.
4. **Increasing demand**: Goat meat (chevon) is one of the most preferred meat types by consumers. Similarly, sheep meat (mutton) is in great demand in southern states and Jammu & Kashmir. The demand for sheep and goat meat in domestic and international markets is growing.
5. **No religious restrictions**: Unlike beef and pork chevon and mutton are free from religious taboos and are widely accepted throughout the country. Delivery of meat and meat products through an online platform/e-market by a few start-ups in major cities
6. **Adaptability**: Sheep and goats are very sturdy animals and have extraordinary hardiness and ability to adapt to harsh regions and facility of movement in rugged and harsher terrains. These animals can be maintained on sparse vegetation. Moreover, the space requirement is also very less. Animals can be managed by housewives.
7. **Control of weeds through grazing animal:** Sheep and goats can consume a wide variety of plants and thereby helps to minimize weeds. Similarly, small ruminants play a crucial role to improve soil fertility. Thousand small ruminants can produce 2.5-3.00 tonnes of manure daily and help to improve soil productivity.
8. **Untapped indigenous breeds with good potential:** The indigenous breeds have great potential for meat production. If optimum feeding, management, and health care are provided, a good quantum of meat can be harvested.
9. **Competitive chevon and mutton production in India:** India's producer prices of goat & sheep are competitive compared to most of the other countries of the world. Among major goat-producing countries, only Australia and Thailand (along with Brazil and Germany) are more competitive than India in terms of producer prices. Sheep, India is more competitive than most countries- next to Australia. China is equally competitive with India in the case of both goats & sheep. Indian small ruminant meat production is competitive at the producer level (Suresh and Kavita, 2012).

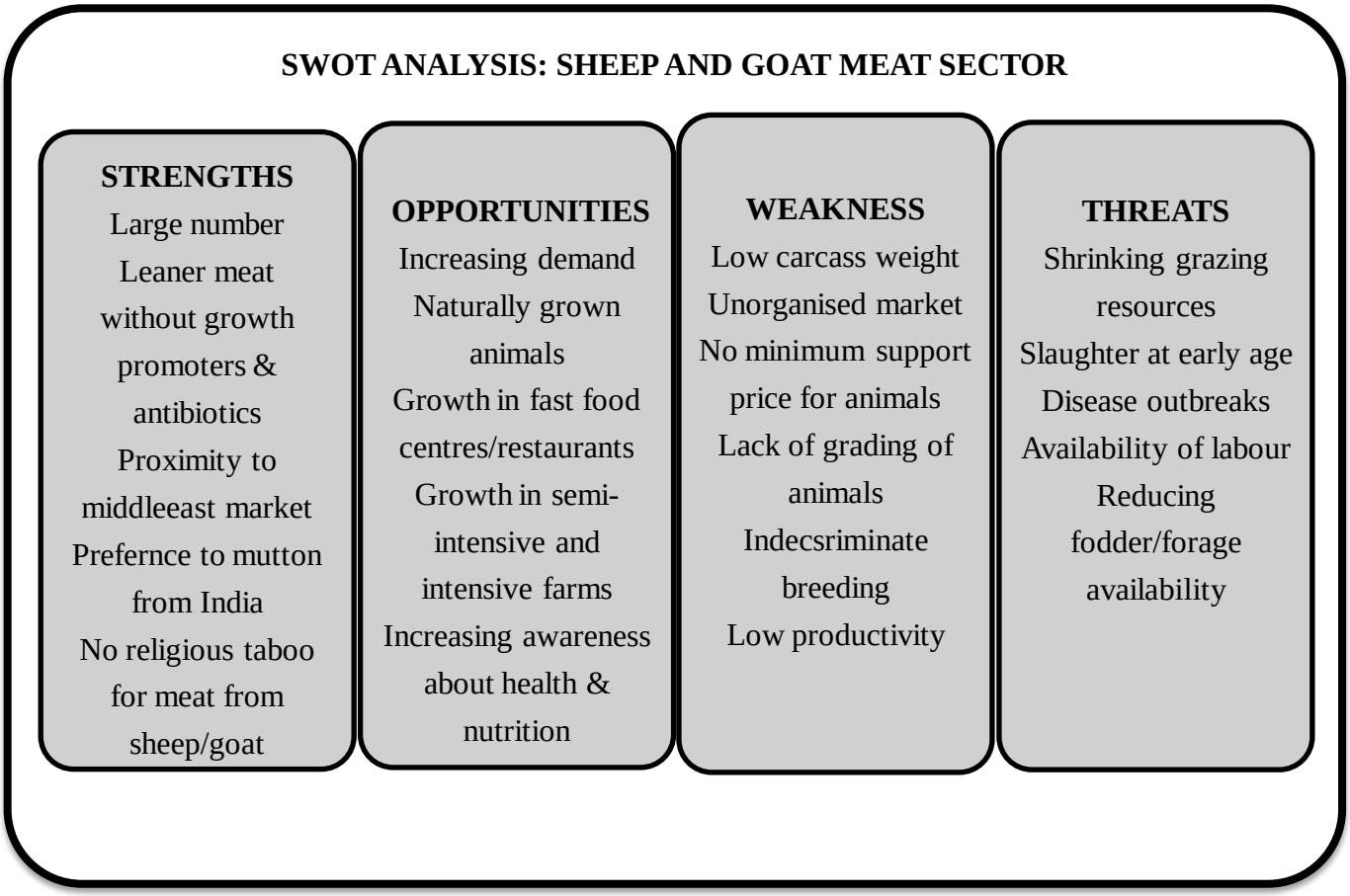
Challenges in Small Ruminant Meat Industry

1. **Slaughter of lambs at an early age:** The majority of sheep keepers dispose of lambs at an early age. There are number of reasons for early disposal and a few of them are poor availability of forage from grazing lands, fear of lamb mortality losses, and money required for household uses. This affects the country's meat production as the full potential of active growth is not utilized.
2. **Lambs/kids diseases and mortality losses:** Mortality in kids & lambs during the pre-weaning stage is a major problem. Farmers incur around 18-20% production losses due to diseases and mortality.
3. **Low carcass weight:** The carcass yield of animals is far below the world average (Sheep 13vs17kg; goats: 10 vs12kg). (FAO, 2020). The reasons for low carcass weight are lack of breeding policy, inadequate nutrition, early disposal of lambs/kids, the poor genetic make-up of animals, and the unavailability of exclusive meat animals.
4. **Infrastructure facility**: For hygienic, and wholesome meat production, suitable infrastructure facilities for slaughter and processing of meat are the need of the hour. Export-oriented abattoirs are well equipped with state of art facilities catering to the export market. However, unregistered slaughterhouses need attention for quality meat production.
5. **Traceability and safety assurance**: Globally, traceability has been gaining importance. To compete at the global level, the implementation of traceability is urgently required. In India, production by masses has been the major constraint for traceability implementation. The government of India has taken initiatives for animal identification to facilitate traceability. Food safety, implementation of HACCP, GMP, Food safety certification, and ISO certification are required for quality assurance.
6. **Indiscriminate breeding:** Due to a lack of breeding policy, indiscriminate breeding of livestock is there which has resulted in a decline in purebred sheep and goats. The latest data suggest that In India, there are 53.5% and 63.5% Nondescript Sheep and goats.
7. **Non-utilization of slaughter coproducts**: Considerable portion of the bodyweight of animals during the slaughter of animals is unsuitable for human consumption. In India, by-products utilization is the most neglected sector and needs to be given attention for increasing profit and protecting the environment besides providing employment opportunities.
8. **Marketing of live animals**: Marketing of sheep and goats is a major challenge as a key share of income goes to traders/middlemen. The present condition of livestock haat/mandi is very

poor and lacks basic facilities like watering, feeding, animal holding facilities, and lighting during night hours. The electronic weighing balance, weighing platforms, treatment facility, etc. should be equipped for the animals.

9. **Feed/grazing resources**: During livestock rearing feed accounts for a major (70%) expenditure. Similarly, urbanization, deforestation, and human encroachments in common property resources (CPRs) are affecting animal husbandry practices. The reports of ICAR-Indian Grassland and Fodder Research Institute, Jhansi, indicated that there is a deficit of 23.4% in the availability of dry fodder, 11.24% in that of green fodder, and 28.9% for concentrates (Roy et al., 2019).
10. **Reluctance for migration**: Nomadic pastoralism is prevalent in the country. The sheep/goat keepers take animals in different parts of the country for months together away from home. Of late, the younger generations are reluctant to go on migration, and thereby sheep and goat keepers are forced to sell animals. This is resulting in declining flock size.

The sheep and goats are vital in Indian Meat Industry. Improving per animal productivity, better feeding & management practices & adoption of the latest technologies pertaining to small ruminants is the need of the hour. In view of declining grazing lands, an extensive grazing system should be substituted by a semi/intensive commercial system. Similarly, there is an urgent need for infrastructure creation in animal Markets, abattoirs.



The farmers/sheep and goat keepers must be united to form FPOs, FPCs, Cooperatives, and contract farming. There is a need to establish a direct tie-up of farmers with processors and consumers in order to get remunerative prices for their produce. Efforts towards empowering them with market-related information are required. Further, Media, portals, and exposure to successful animal keepers/entrepreneurs would help in improving production.

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Chapter-7

APPROACHES TO IMPROVE REPRODUCTIVE PERFORMANCE IN SHEEP AND RABBIT

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Sheep and Goats are widely distributed in all agro-ecological zones of India and play critical role in socio- economic development of the rural poor by providing dependable source of income to 40 per cent of the rural population below the poverty line in India and thus, it ensures the livelihood security to many marginal farmers and landless agricultural labourers. These species contribute greatly to food, rural employment and Gross Domestic Product (GDP). It is known as the "poor man's cow" and ATM (Any Time Milk) machine in India. It uses grazing land pasture to render high-value animal protein and can be maintained on zero-input production system.

As per livestock census (2019), India holds 3rd position in the world for sheep population i.e. 74.26 million heads. The organized dairy segment, which accounts for 26-30% of industry (by value), has seen faster growth, compared to the unorganized segment. The country has exported 7,050.55 MT of sheep and goat meat to the world for the worth of Rs. 329.96 Crores/ 44.57 USD Millions during the year 2020-21. This indicates that the production potential of small ruminants in India is yet to exploit at its fullest and there is plenty of growth opportunities in this sector.

Scope and Opportunities

The current world population is 7.9 billion as of December 2021 according to the most recent United Nations estimates elaborated by Worldometer, which is continuously growing every instant. On the other hand, agriculture land is constant and even reducing day by day and falling insufficient to supply the increasing demand for food. Thus, the rising food demands have become the global challenge nowadays and the nutritional security is a major concern of the current era. Beside the global scenario, the following considerations show the growth opportunities in sheep and goat farming in Indian context.

Currently, there is lowest level of meat consumption in India as compared to global consumption (3.6 kg vs 38.7 kg/capita/annum). However owing to rapid urbanization, there is an

increasing demand for meat products with 80% of demand from urban areas. Further, a barely 1% of the total meat produced is used for processing and remaining meat is sold in fresh or frozen form which indicates the market opportunities for processed and value added meat products in India. Meat industry for export has attracted heavy investment as major meat exporters are expanding their processing capacities. The livestock sector has grown at a CAGR (Compound Annual Growth Rate) of 8.15% over the last five years by the end of year 2020. Whereas, India is the second fastest growing processed meat market worldwide with a CAGR of 22 per cent.

To further expand this sector, there is a need to make the entrepreneur more profitable and sustainable. Sheep farmers have to adopt the modern systems of sheep rearing and scientific breeding strategies. The productivity and profitability of our meat and milk industries effectively depend on reproductive performance. Optimum reproductive efficiency is essential for the exploitation of maximum productive potential. These chapter overviews recent approaches to improve the reproductive efficiency of sheep and rabbit.

Factors affecting production performance

The cost effective and efficient production of sheep for meat, milk and wool is contingent on proper feeding, breeding, health care and reproductive management.

1. **Nutrition**

Dietary composition and intake by the animal influences the production potential, health and immunity as well as reproductive efficiency. Maintenance of breeding animals, a high percentage of the lamb crop weaned, growth of lambs, optimal weaning weights, and a heavy fleece weight and fleece quality are important to efficiency. The nutritional requirements for maintenance, reproduction, growth, finishing, and wool production are complex because sheep are maintained under a wide variety of environmental conditions; however, attempts should be made to ensure each production unit or individual sheep has adequate nutrient intake to be healthy and productive.

Several established facts of the effect of nutrition on the different components of reproduction can be drawn out of the published studies. Right from the intrauterine life, mal-nutrition has a negative effect in female’s later reproductive development and adult function. Reproductive function in young animals appears to be more susceptible to dietary restrictions of energy and protein than in adult and may lead to permanent histological changes at the level of gonads. In females, the most prominent effect is around the time of mating on the follicular

development, embryo survival and twinning rate (Vinoles, 2003). Changes in levels of dietary intake are associated to changes in gonadotropin secretion, hence of the functioning of the gonads, which also respond to dietary-induced blood-borne metabolic hormones and substrates (Rhind, 1992; O'Callaghan and Boland, 1999).

2. Breeding management

Scientific sheep breeding management considers the health and safety of animals while producing the best performing animals through genetic improvement. Selection of breed should be done meticulously for optimum production considering the disease resistance, fertility attributes and breed adaptability in the particular geographical location. Reproductive performance especially prolificacy and age at first lambing can vary obviously with breed. The characteristics and performance of sheep breeds around the world differ enormously. Breeds for breeding stock should be fertile and prolific, with easy lambing and having good maternal instincts, high milk production and longevity, and be adaptable to environment (grassland, confinement, hilly tracks) and management systems. Some regions commonly use a crossbred sheep that includes traits from several breeds. In a crossbreeding system, maternal heterosis is used to improve performance, i.e. the offspring (F1 generation) possess traits that are better than the average of their parents, also known as hybrid vigor. Composite breeds are the result of a planned crossbreeding program coupled with stringent selection based on preselected production traits. The more successful are phenotypically stable and are considered new breeds. The examples of popular composites include the Polypay (US sheep, a very prolific and hardy and has excellent wool production), Katahdin (North American haired sheep), Dorper (South Africa and North America), Coopworth (New Zealand and Australia), Corriedale (New Zealand), and British Milk Sheep (UK and Canada) and Avishaan (India). These ewes are very prolific, heavy milkers, and excellent mothers and are frequently used in accelerated lambing programs.

3. Health care

Apart from general health of animal, reproductive soundness also plays crucial role in production performance. Flock diseases of infectious in origin should be strictly monitored and prevented to enter the flock, as many of such diseases render the animal infertile or sterile even after recovery. Infectious agents causing fetal death, abortion, still birth and infertility in sheep include Brucellosis, Campylobacteriosis, Listeriosis, Leptospirosis, Chlamydiosis, Coxiellosis, Salmonellosis, Bluetongue, Border disease, Enzootic Abortion of ewes (EAE), Cache Valley virus and Toxoplasmosis.

Monitoring of the flock for evidence of abortion allows early detection and the best chance of obtaining diagnostic samples. An accurate diagnosis may allow cost-effective intervention on encounter of the problem in subsequent seasons. Hence, a systematic approach is essential for the diagnosis of abortions in any species. The practitioner must obtain a good nutritional and clinical history, including possible exposure to carrier animals. The owner should be made aware about importance of detailed record keeping and identify aborting animal and the stage of gestation at which the animal aborted, accurately. The laboratory personnel needs to be aware of the infectious agent and common diseases most likely to be present in the area. Additionally, the regular screening, vaccination, deworming and vector control in the flock should be practiced on routine basis, whereas quarantine and isolation should be exercised when and wherever required to control the spread of such infectious disease.

4. **Reproductive management**

In spite of the best possible efforts, the problem of low fertility is the prime concern as it affects the profitability of livestock enterprise. Reproductive rate in Indian sheep is lower due to (Goel et al., 2013)

- Delayed puberty,
- Long postpartum and lambing/kidding intervals,
- Less prolificacy and
- Existence of non-breeding season

Manipulation of reproduction to optimize the reproductive efficiency allows the rapid and dramatic alteration of the conformation and productivity of domestic animals.

Approaches to reproductive efficiency:

Fecundity or litter size is one of the important attributes determining reproductive efficiency. The number of lambs weaned per breeding ewe is influenced by a number of factors including ovulation rate, fertilization rate, embryonic losses, fetal development, still births and neonatal mortalities (Juengel, 2018). Reproductive efficiency can be improved by:

1. Minimizing the non-productive period
2. Maximizing the potential litter size by augmenting ovulation rate
3. Minimizing post-fertilization wastage by ensuring successful embryonic and fetal development

4. Ensure the survival of the new-born, and their ability to grow and mature into productive life efficiently

1. Minimizing the non-productive period

Being seasonal breeder, reproduction rate of ewe is limited to one lambing/ year. Besides, seasonal breeding also results in seasonal fluctuations in prices, as most lambs/kids are born in the first half of the year and marketed in the second half. From a producer's standpoint, out-of-season and accelerated breeding can increase profits by improving reproductive and marketing efficiency. A gestation length of 150 days makes it possible for a sheep to produce lambs more than once per year, if estrus can be induced by external means.

Sudden introduction of novel males can induce ovulation in females that are reproductively quiescent because they are out of season or lactating. It might also work for advancing the first cycle in young ewes, although this needs experimental verification because the literature in this area is confusing. Pheromones may be utilized by introduction of the ram to a flock of ewes, which will induce ovulation and may even synchronize the ewes. Ewes must be isolated from males (sight, smell) for at least 2-3 weeks before joining. Ewes that are kept separate from the ram will show signs of estrus, and ovulate within 6–10 days when introduced to a ram. The ratio of ewes to ram should be maintained as 15 to 1. Vaginal pessaries of fluorogestone acetate left *in situ* for 12 days followed by an injection of pregnant mare serum gonadotrophin (PMSG) at the time of pessary removal also has proven successful. Nevertheless, the use of the male effect may be a viable and inexpensive alternative as a co-treatment in progesterone-based synchronization schemes for anoestrous females.

Additionally, the induction of estrus in seasonal breeders like sheep can also be done by controlling light exposure (day length). The change of day length from long days to short days initiates estrus in sheep. Ewes should be exposed to long days for 8-12 weeks and then exposed to short days for 8-12 weeks. The difference in illumination between short and long days should be 6-8 hrs. A minimum of 100 luxes of light for daylight and < 10 luxes for darkness can suffice the purpose. If all protocols are rigidly observed, conception rates of over 80% and more than 1 estrus cycle can be achieved. Best mating time should be determined by targeting the lambing season when there is minimum environmental stress, adequate pasture supply for dams to produce optimum milk for lambs and so as to get benefits from opportunities in seasonal markets.

Generally, two breeding seasons round the year are followed in sheep at CSWRI, Avikanagar viz. 15 March- 30 April wherein lambing occurs during 15 August -30 September; and the second

breeding season is 1 September – 15 October, where the lambing happens during 1 February – 15 March. In each breeding season, at least 2 estrous cycles may be covered for mating. Estrus detection may be initiated two weeks prior to the onset of breeding seasons so that infertile ewes may be diagnosed and treated well in time.

Anestrus management:

Anestrus is one of the most commonly occurring reproductive problems that is mostly ignored in sheep and goat flocks. Being multifactorial in origin, it is caused by factors including nutritional deficiencies, environmental stress, lactation, suckling, parasitic infestations and periparturient diseases. It can be treated by following approaches:

A. Elimination of predisposing factors

i. Nutritional management:
   - Dietary micronutrients supplementation: P, Co, Cu, Mn, Vit A,
   - In case of energy deficiency : Energy rich concentrate feeding

ii. Reduction of climatic stress

iii. Early Weaning

iv. Efficient oestrus detection

v. Prevention of periparturient diseases

vi. Deworming

vii. Routine pregnancy diagnosis

B. Non-hormonal treatment

i. Plant Based Heat Inducers:
   - *Murraya koenigii* (Curry leaves),
   - *Moringa oleifera* (Sejna/Sahjan/Drumstick)
   - *Trigonella foenum–graecum* (Methi),
   - *Asparagus recemosus* (Shatavari) etc. alone or in combinations

Indigenous herbal preparations i.e. Prajana HS (Indian Herbs), Janova (Dabur), Sajani (Sarabhai), Heat up (Century), Heat raj (Ranjan), Fertivet (Ar Ex Labs) etc.

ii. Clomiphene citrate: an oral non-steroidal selective oestrogen receptor modulator

C. Hormonal treatment

i. Progesterone
   - Vaginal implants/Sponges: Insert the implant & left in situ for 9-12 days
   - $PGF_{2\alpha}$. can be administered 24 hours before removal

- Folligon (Intervet) @ 200-400 IU i.m. at sponge withdrawal

ii. Prostaglandin

- Treatment of choice for PCL, luteal cyst & sub estrus
- Synthetic PGs: Cloprostenol (Vetmate, Estrumate, Synchromate) @125 mcg i.m.

iii. Melatonin

Single s/c melatonin @18mg/sheep resulted in 80% estrus induction in anestrus ewes (*Kumar et al., 2022; unpublished data*).

iv. Dopamine receptor antagonist:

Sulpiride @0.6 mg/kg s/c twice a day till the onset of estrus has been reported to induce 83.3% ewes in estrus within 2-9 days (Saxena et al., 2015).

2. Maximizing the potential litter size by augmenting ovulation rate

In addition to genetic up gradation of indigenous low prolific breeds, nutritional approach has also been practiced to maximize the potential litter size by augmenting ovulation rate. Flushing, or focused feeding, is a strategy in which a nutritional boost is supplied in a short period of time to enhance reproductive efficiency in small ruminants. Its purpose is to increase the rate of ovulation and, thereby lambing rate. Animals with BCSs below 3.0 are flushed for 2-3 weeks before breeding to increase in BCS by a half-score. Increased intake of nutrients, particularly protein, effectively increases levels of hepatic steroid metabolizing enzymes (SME). A high level of hepatic SME is associated with an increased clearance rate of steroids, and a decrease in steroids is associated with an increase in gonadotropins and thus an increase in ovulation. Besides, the flushing leads to a positive energy balance, which increases leptin and insulin concentrations, enhances glucose uptake, and is associated with increased folliculogenesis and ovulation rate. In addition to increasing the number of follicles released and reducing EEDs (Early Embryonic Deaths), elevated energy is believed to increase the number of embryos that implant in the uterus.

Recently we have observed that supplementation of n-3 PUFA rich fish oil (FO) in ewes for two months showed a higher proportion of ewes with multiple pre-ovulatory follicles as compared to pre-supplementation status (68% vs. 8%, respectively). The mean number of POF was 77.78% higher ($P < 0.01$) in n-3 PUFA rich FO supplemented ewes than the palm oil (PO) fed control ewes. The FO supplemented ewes showed 59.25% more ovulations ($P < 0.01$) than control ewes (1.72 ± 0.15 vs 1.08 ± 0.05). Further, the number of fetuses improved by 46% ($P<0.01$) in FO fed ewes than the PO (mean fetal count 1.54 ± 0.13 vs 1.08 ± 0.06), with total 45.8% ewes carrying multiple fetuses. The

twinning percent in FO supplemented ewes was 3 times higher than those of PO fed (27.27 vs 9.09%).

3. Minimizing post-fertilization wastage

Embryonic losses are major cause of reproductive failure in all farm species. The epidemiology of embryonic losses/ abortion in sheep is not well investigated in India. The reason being, ewes are generally allowed to run with the ram during the breeding season and not segregated; hence estrus and mating is not recorded properly, thus the abortions are not frequently encountered. If abortions in flock are observed, the causes of these abortions remain undiagnosed because either farmer fail to report to the veterinarians or the cause of the abortion remains undiagnosed due to lack of diagnostic infrastructure in the country. A majority of the embryonic loss occurs between days 8 and 16 post-breeding (Sreenan and Diskin, 1986).

Changes in the progesterone profile after mating are critical for the establishment of pregnancy. During MRP, a delicate balance between the luteolytic and anti-luteolytic hormonal mechanisms is important for successful establishment of pregnancy (Binelli et al., 2001). It is believed that at critical time of MRP, some embryos may not reach the appropriate size to inhibit PGF2α for luteolysis to occur. Inhibition of PGF2α synthesis could increase the embryo survival and pregnancy. An increased concentration of progesterone during early luteal phase is associated with enhanced embryonic production of the anti-luteolytic signal, IFNι. That prevents uterine release of luteolytic PGF2α. Hernandez-Ledezma et al. (1992) also suggested that embryonic mortality between day 14 and 19 is caused by luteal failure and occurs because certain embryos develop more slowly than normal and do not produce enough IFNι to prevent luteolysis and maintain the pregnancy.

- Antiluteolytic strategies:
    - hCG Inj. 5 Days after insemination
    - GnRH Inj. 11 Days after insemination
    - PMSG Inj. 7 Days after estrus
    - Progesterone Sponge insert on 6-8 of insemination
    - Interferon on Day 17 post insemination
    - ω-3 fatty acids supplementation around the period of breeding

Supplementation of ω-3 PUFA rich diet around the period of breeding has been found to inhibit the $PGF_{2\alpha}$ secretion and act as antiluteolytic agent thus improve embryonic survival and

conception rate (Mahla et al., 2017). The use of such “clean, green and ethical” tools can be cost-effective and augment reproductive efficiency and productivity of the livestock and improve the image of products in marketplace.

- ❖ Care of prolific dam
    - Approximately 70% of fetal growth occurs during the last 4-6 weeks of pregnancy
    - Does/ewes should be fed to gain 110-220 gm/head/day during the last 4-6 weeks of gestation
    - Feeding of high energy dense concentrate @500-700g/dam/day

4. Ensure the survival of the new-born

- ❖ Isolate the dam 4-5 days prior to tentative date of parturition
    - Prepare a pen for the first 1-3 days
    - Clean and dry
    - Sufficient bedding
    - Warm and protected from wind/rain
    - Easy access to regular checks

- ❖ Colostrum feeding
    - Weight the kids / lambs
    - Warm (but not overheat) colostrum in clean bottle/nipples
    - Store fresh extra colostrum in fridge (small bags)
    - Total volume of milk to feed in 24hs = Weight of kid/lamb(in kilograms) x 0.20 x 1000 = Total volume of milk to feed in 24hs
    - Total volume of milk to feed in 24hs / 6 (number of intakes during one day) = Volume to give per feeding

Reproductive Efficiency in Rabbit

Increasing rabbit productivity as a solution to improve quality of life and economics for farmers is touted by the Chinese say” if a family has several rabbits, it will not lack in oil, salt and vinegar, if a family has hundred rabbits it will not lack clothes and pants, if a family has some hundreds of rabbits, it will not lack a building”. To meet ever increasing demand of animal protein other alternatives for the traditional meat sources is mandated. Rabbits are known to be 2.5-4.0 times

more efficient in extracting proteins from forages than sheep, and beef animals (Rastogi, 2000). In view of no religious taboo against consuming rabbit meat raising rabbits is an excellent choice. Furthermore, rabbit meat as compared to chicken, beef and pork meat is high in protein and low in fat (McNitt et al., 2013).

Reproductive performance is the main factor which assures high productivity on rabbit farms. Reproductive activity is under the control of the neuro-endocrine axis. The genetics, feeding and management factors strongly modify hormonal release and consequent effects. Sexual receptivity (SR), parity, lactation status at the time of mating and pseudo pregnancy influence reproductive performance. Rabbit does do not show sexual cycles with regular heat periods during which ovulation occurs spontaneously. There are alternate periods of acceptance (oestrus) and of refusal of mating (diestrus).

- Sexual receptivity is determined at the time of mating by:
  - Colour of vulva: presence of red or pink indicates receptive rabbit, and purple or white indicates non-receptive rabbit
  - Rectal temperature : >38°C
  - Percentage of keratinized vagina cells : >50%
- Sexual receptivity in rabbit is associated with
  - Better fertility
  - Possessing a higher number of pre-ovulatory follicles
  - High prolificacy, higher ovulation intensity, fertilization rate, and higher embryo survival

Rabbit does can mate immediately after kindling but, several studies have shown that a continuous intensive rhythm reduces litter size, fertility rate and the length of reproductive activity. Reproductive rhythms (RR) can be categorized as

Intensive:

Mating postpartum or within 4 days of kindling; 35 days RR)

- Rabbit does managed with intensive RR needed a higher number of inseminations to become pregnant

Semi-intensive:

Mating at 11 days postpartum; 42 days RR

- Widely used in large commercial set ups but does not take into consideration the physiology of lactating does
- Leads to high replacement of does, high mortality and culling rate, low sexual receptivity, poor body condition score and low fertility rates

Extensive:

Mating after weaning or on day 25 days; 56 days RR

- Maintains a more sustainable equilibrium of body weight and fat deposit
- Favorable impact on the economic performance of the enterprise and a low level of economic risk

Managemental Practices

- Selection: Choosing kits from large litters with birth weight higher than the average with 10 (or a minimum 9) teats is advantageous.
- After weaning, either restricted feeding or high fibre diets are suggested for future does until 6 to 8 days before first mating.
- Mating does twice immediately one after the other gives the best results.
- Biostimulation method like dam-litter separation helps in estrus synchronization.
- Fostering is suggested to form homogeneous litters in terms of size and birth weight.
- Avoid breeding in peak summer as lower number of kits is born in summer due to the higher embryonic mortality caused by high temperature.

Chapter-8

VALUE-ADDITION OF COARSE WOOL AND ENTREPRENEURSHIP OPPORTUNITIES

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Introduction

Wool is the oldest fibre that has been employed for the manufacturing of textile goods since early civilization. The fibres that grow on sheep are termed wool. Wool fibre is an international and industrial commodity. The trade starts from wool harvesting to its processing, value addition, and eventually sale to the consumer. This entire process flow requires several manual and industrial processes which are necessary to ensure a good quality product. The important processes include grading, scouring, carbonizing, spinning, fabric manufacturing, and chemical processing.

Wool has certain unique properties. The crimp (natural waviness) of wool is a property that helps the fabric to trap air, making it a good thermal insulator. It also gives a springiness that helps for crease resistance. The fibre has overlapping scales on its surface. These scales lock into each other permanently when the fabric is washed or heated resulting in shrinkage. This can be a disadvantage of wool as far as the dimensional stability of fabric is concerned. However, the same property is beneficial in felt manufacturing. The exterior of the fibre is hydrophobic (resists water) and the inside is hygroscopic (attracts water). This means it resists water well and when it does get wet it can absorb up to 30% of its bulk without feeling wet. Wool has naturally fire- resistant properties and needs a high temperature to ignite. Therefore, it is not surprising that wool is being used in making a diverse range of products. This chapter introduces the reader to the traditional and newer applications cum products made from wool.

Association between wool fibre properties and choice of application

Wool can be obtained from different sheep breeds. Currently, 44 sheep breeds are registered in India. Sheep breed has a significant influence on wool fibre quality. Fibre quality parameters such as diameter, length, crimp, and colour vary from breed to breed. For instance, Bharat Merino, Chokla, and Patanwadi breeds have average fibre diameters of 22 µm, 30 µm, and 40 µm,

respectively. The fibre diameter is the most important quality parameter which decides the end uses and spinning limit of fibre. Based on the fibre diameter, wool is divided intothree grades: fine wool, medium wool, and coarse wool (Table 1).

Table 1 Wool grade, quality, and end-uses.

Wool grade	Fibre diameter	Processing route	End product
Fine	15–25 µm	Worsted	Apparel (suiting, shirting, sweaters, jackets)
Medium	25–40 µm	Semi-worsted, Woollen	Carpet, shawl, blanket
Coarse	> 40 µm	Woollen, Felting, Braiding	Felt, technical textiles

All these varying fibre diameters cannot be processed similarly. Wool fibre can be converted into yarn by three different processing setups, namely, woolen, semi-worsted, and worsted yarn. The worsted yarn is known for its better quality and requires fine quality wool. The worsted yarns are mainly used for suiting and shirting. The semi-worsted yarns are relativelyinferior to that of worsted yarn. Semi-worsted yarns are suitable for shawls, knitwear, and soft blankets. While, the woolen yarns are prepared from medium to coarse wool and used to make blanket and carpet yarns.

Traditional products

Fig. 1 shows the traditional products prepared from wool, viz. apparel, carpets, blankets, shawls,felts, namda, and handicrafts.

Fig. 1 Traditional wool products

Apparels

Wool apparel is mainly made from worsted yarns. The worsted yarn-making process requires fine wool and it involves a sequence of processing namely oiling, carding, gilling-1, combing, gilling-2, roving, spinning, doubling, and winding. Worsted yarns are converted intothe fabric using projectile or rapier weaving machines and then fabrics are converted into the garment using sewing machines. Men suiting and women overcoat are made from woven fabrics.Sweaters are made in fully fashioned knitting machines using worsted yarns. In our country hardly 5% of the wool produced is suitable for making apparel, whereas in Australia 85% ofwool production is directed towards worsted processing. In wool apparel products across the globe, the wool sweater is the highest contributor which is due to the excellent thermal insulationproperty of wool. The conventional products, associated with comfort, warmth, and cold protection, are shirting, suiting, and overcoat.

Carpets

Indian carpet industry is exporting wool carpets worth Rs. 10000 crore. Carpet making requires two types of yarn i.e. one for pile and the other for backing. Pile yarn to be selected carefully and it has to have properties like soil release and resiliency. Carpet yarns are made from wool fibres that are broader in fibre diameter compared to apparel-grade fibre. The most popular fibres that are used in pile yarns are wool, nylon, and polypropylene. Cotton andpolyester are used for backing in the carpet. The wool that is used in carpet making generally hasa micron value of 27 to 37. India is popular for hand-knotted carpets and is one of the major consumers of carpet-grade wool. Apart from using indigenous wool, wool is imported from New Zealand for the manufacture of carpets. The minimum wool length required for making woollen yarns is around 4.0 cm. The bulk of loose wool is of desirable property and a bulk value of 19-22cm^3/g is desirable for carpet making. High bulk fibres tend to give good resiliency characteristics to the carpet. In India, Chokla and Magra breed wools are preferred for making carpets. The major three methods used in carpet making in our country are hand-knotting, tufting, and weaving. Highly intricate designs can be produced in hand-knotted carpets.

Blankets

Blankets and quilts are used in the winter season to protect from the cold. Natural fibre like wool is the preferred raw material for the preparation of eco-friendly blankets. Woollen blankets are

prepared from coarse woollen yarns of having a yarn count of 3.5 Nm. The typical constructional particulars for woollen blankets are as follows: ends per inch: 22, picks per inch: 19, areal density: 525 g/$m^{2,}$ and twill weave. Blankets can be made from fine wool such as Bharat Merino and carpet-grade wool such as Chokla. The thermal insulation value of blankets ranged from 2.68 Tog to 3.88 Tog. It has been observed that 50% medium coarse wool can be used in blends with fine wool to manufacture good quality woollen blankets.

Woollen shawls

Jammu & Kashmir, Himachal Pradesh, Punjab, and Uttarakhand are the states that produce woollen shawls from fine wool. Woolen shawl making is the sustainable livelihood of many families in the northern states of India.

Felts

Felting is unique to wool. It is a permanent interlocking of scales as a result of the directional friction effect which can be accelerated in presence of heat and moisture. Felts produced from fine wool are being used as technical textiles in automobiles and other industries. Felts from coarse wool are being used to prepare namda, floor covering, sitting mats, and handicrafts.

Namda and namda handicraft

Namdas are felted mats made from sheep fleece. Namda making is a traditional craft practiced in the Tonk district of Rajasthan for many centuries. They use a carding machine to prepare the fleece. The fleece is sprinkled with soapy water and rolled and kneaded until the layers of wool are felted. The namda is then soaked in water and finally laid flat to dry in open air. Namdas of various thicknesses are prepared. The high areal density is used as a base sheet and thin sheets are pasted over the thick one to produce various designs. By this combination, several products can be made such as wall hangings, soft toys, and household articles. The handicrafts are being exported to western countries. This craft sector has been a source of sustainable livelihood to thousands of artisans and the sector has a high potential for entrepreneurship development.

Value-added unconventional products

Fig. 2 shows the value-added newer products from wool. This includes Rajai, sapling bags, wool reinforced composites, and fertilizer in agriculture, SIRO spun khadi yarns, and braided mats.

Fig. 2 Value-added newer unconventional wool products

Rajai (Quilt)

Quilts were introduced into the market as an alternative to a blanket. They are also called duvets. The quilt consists of two layers of fabrics filled with fibre material in the middle. It is well known that wool products are warmer and are more comfortable due to their breathability behaviour compared to synthetic fibres, which do not have this characteristic. A processing technique has been developed in the institute for the preparation of lightweight Rajai (quilt) using coarse wool (Malpura breed wool). This new coarse wool Rajai looks similar to Jaipuri Rajai and has a total weight of 975 grams in size of 7 ft x 5 ft. Normally Jaipuri Rajai is preparedwith a filling of cotton or in some cases polyester fibre. The disadvantage of cotton is that it is expensive by 2.5 times of wool and polyester has the problem of environmental pollution during its manufacture as well as after disposal. In the preparation of the quilt, first, a sheet of the coarsewool web was prepared and then it is laid inside a cotton cloth and then stitched manually.Coarse wool is having high stiffness and hence it protrudes through the interlacement gaps of warp and weft and creates hairiness in the end products. Closely woven compact fabric is used to reduce the protrusion fibres through the fabric surface. The thermal insulation value of coarse wool quilt was assessed using thermal conductivity apparatus and it was found to have a tog value of 3.23. This shows that the prepared quilt will protect the user from cold during normal winter. The subjective analysis of the woolen Rajai showed that the sleep quality of the users is

improved. The users highly rated this Rajai for softness, warmth, and lightweights. CSWRI has filed a patent for the product and process of wool Rajai.

Sapling bags

The sapling bag is prepared from wool. The bag is prepared in such a way that it can offer air and moisture to pass through which gives natural conditions for the sapling to grow better. The bag can retain moisture for a long time without being wet. The degradation rate of the bag is slow (almost 3 months). Even after degradation, the material offers nitrogen to the soil which will enhance soil fertility. The product and process have been patented. Currently, the bag is commercially being sold through an agri-business incubated entrepreneur of the institute. The research showed that the germination rate in wool sapling bags was 50% higher than that of conventional plastic bags. Therefore, it is a good alternative to plastic bags.

Wool reinforced composites

Most of the wool produced in the southern part of India is of coarse grade. The coarse wool has a high fibre diameter (higher than 35 µm) besides being weak and brittle. Such wool is not desirable for apparel textiles. Hence the coarse wool has poor sale value and has very less demand. However, coarse wool fibre has scope in technical textiles due to its excellent properties in wool-like thermal and sound insulation. For better utilization and identification of diversified applications, coarse wool reinforced composites have been prepared using a hand lay-up technique. The composites have showed good mechanical strength (> 30 MPa), bending properties (> 30 MPa), and a high noise reduction coefficient (NRC) of 0.8. The developed composite samples have prospective applications in door panels, false ceiling panels, and sound- absorbing walls.

Coarse waste wool for agriculture and horticulture

Wool contains high quantities of nitrogen, sulphur, and carbon. It is a rich source of important nutrients which are necessary for plant growth. When wool breaks down partially by alkaline hydrolysis due to its enriched source of nutrients it can act as a slow-release fertilizer. The use of waste wool for crops showed a 30% higher yield for tomato and pepper crops. The Barley plant growth, green fodder, and grain yield were markedly improved using coarse wool in agriculture. The improvements have been also observed in the Kharif gaur crop as well.

Siro spun khadi yarn

Indian decentralized wool sector commonly deploys new model charkha (NMC) to produce woollen yarn. It is difficult to obtain the maximum realization of native wool fibre properties into a single spun yarn on a ring spinning system. This is due to the shorter length and higher fibre diameter of indigenous and crossbred wool. A siro spun yarn is produced on a ring frame by twisting together two strands, which have been separated in the drafting zone. It creates a yarn with

two strands, and the resultant yarn is essentially a single yarn. It is found to have higher abrasion resistance than equivalent single worsted yarn. It can be used as a warp without two plying/doubling, resulted in reductions in production cost as compared to conventional two plied yarn. Apart from low production cost, siro spun yarn also provides a better handle and thermal insulation as compared to traditional worsted yarn. SIRO attachment improved the yarn quality of crossbred wool over the conventional NMC spun yarns. The tenacity and elongation were improved by > 38% and 65%, respectively. Yarn evenness was found better for siro attachment fitted charkha yarn than conventional one. The attachment is easy to link with existing NMC and hence recommended for spinning of all native and crossbred wool. The union khadi fabric made up of wool cotton shows excellent comfort properties.

Braided mats

The braiding technique was used to develop braided rope with coarse wool in the core and medium coarse wool yarn in the sheath. Braided yarns were then woven using handloom and converted to home furnishings. The products developed from braided rope include a doormat, picnic mat, and yoga mat. The weight range of these products is 400 gm to 2 kg/piece. These braided products comprised coarse wool (more than 50%). This is good diversification of the non-spinnable wool.

Sliver woven technique

Coarse wool sliver was produced by wool carding process. The hank of sliver produced was 4.8 kTex. The silver is twisted and converted into sliver rope form by the traditional method of manual twisting. The sliver rope was used as a weft strand with cotton yarn as a warp on a handloom. Fabric made out of this method was dyed. After dyeing the length and width sides protruding ends are converted into fancy fringes. The item made out of this technique are i) Turquoise Bath mat ii) Striped doormat and iii) Elliptical Bath mat.

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Chapter-9

VALUE ADDITION TO SHEEP MEAT AND MILK

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INTRODUCTION

Sheep husbandry has excellent resource of revenue generation and nutritional security for farmers especially resource-poor, landless, small, and marginal one. In the scenario of harsh climatic conditions and rare available grazing resources, sheep is considered as a future animal for rural people. Sheep has better adaptability to a wide range of climate conditions and better efficiency of poor feed resource utilization. In India mutton is consuming mainly in fresh form; a very little amount of meat (hardly 4%) is being sold as processed meat into different products. The demand for processed and functional meat products are increasing due to consumer awareness and inadequate hour for fresh preparation. Value addition means adding value to the term i.e. in terms of quality, functionality, or shelf life. It also broadens the consumer base. Value-added meat products developed from mutton are ready-to-eat, ready to serve and eat, and more appealing. Non-meat components like low-value meat cuts, edible meat by-products can be used. Processing promotes entrepreneurship and employment. Meat & Milk are highly perishable food, so value addition increases its shelf-life. Functional and healthy meat products like low fat, low sodium/salt, fibre rich and natural antioxidants fortified meat products could be developed. ICAR–CSWRI, Avikangar has developed numerous value added meat products (nuggets, patties, kabab, sausages, loaf, salami, kofta, cookies, pickles, *etc.*) and milk products (paneer, cheese, kulfi, peda, gulabjamun, flavoured milk etc.). These products are ready to eat and heat for serving to the consumers. There is a need to organize the sheep and meat production sector to reduce the cost of production and encourage the value addition of meat into diversified meat products for consumers.

SHEEP RESORESES

As per the recent 20th livestock census, India has 74.26 million sheep, contribute 678 million

kg of mutton, 40.26 million kg of wool (BAHS 2019), 31 million kg manure, and 41.6 million pieces of skin. The top states with sheep populations are Telangana (19.1 million), Andhra Pradesh (17.6 million), Karnataka (11.1 million), and Rajasthan (7.9 million).

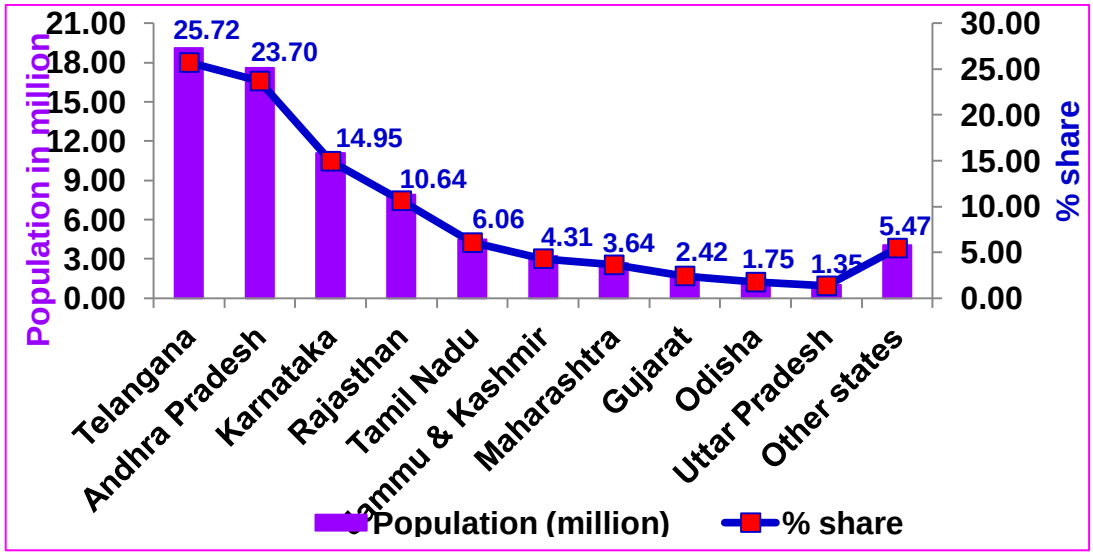

Fig. Contribution (% share) of sheep population of different states (Livestock Census, 2020)

As per the National Bureau of Animal Genetic Resources (NBGAR), Karnal, India has diverse sheep germplasm with 44 breeds. In the country, there are 41.08% nondescript sheep. Major sheep breeds are Nellore, Deccani, Marwari, Bellari, Jaisalmeri, Mecheri, Hassan, Ramnad White, Patanwadi, and Kenguri which contributes 19.17, 10.15, 6.70, 3.79, 2.92, 2.33, 1.40, 1.39, 1.25, 1.10 %, respectively of the total sheep population and remaining sheep breeds contribute < 1% (DHADF, 2016). 70% of sheep found in southern regions and mostly produce meat, 15% of sheep found in Rajasthan, Gujarat and Uttar Pradesh produce carpet type wool and meat and only 6% of sheep found in Jammu & Kashmir, Himachal Pradesh and Uttrakhand produce fine wool and meat.

Value addition in sheep meat

Convenience of meat and meat products is a concept dating back at least to Antiquity, mostly under the form of (commercial) availability and outsourced preparation by cooks, even as fast food. Its importance was boosted during the 19th century, in parallel with the development of large slaughterhouses, increased logistic capacities, and stability-enhancing technologies, including canning, refrigeration, and freezing. The 20th century was characterized by a further development and globalization of meat convenience, culminating in the emergence of a worldwide fast food culture. With regard to meat and meat products, convenience is mostly generated through technological processing in view of minimal preparation requirements at household level, preferably with substantial shelf-life stabilisation. In addition, the wide availability of fully prepared meat snacks has become an important constituent of current eating patterns. Yet to fully understand its nature and

impact, the concept should be tackled in its broadest sense by exploring the opportunities and constraints imposed by societal expectations and food-related lifestyles. A product is classified as 'value added' if its raw material has been processed to achieve an increased market value. Value added products have applications in both food and non-food markets. Meat for table consumption is the major product from a carcass and currently 80 per cent of the total carcass value is derived from just 40 per cent of the carcass weight. The profitability of the meat industry is critically dependent in deriving extra value from lower-value meat cuts and from the non-meat parts of the animal, such as skins, offal and blood products that make up 60 per cent of the total carcass weight. All parts of the animal contribute to increased revenue per carcass and profit.

List of some popular variety meat products:

1. Comminuted products
2. Emulsion type products
3. Restructured meat products
4. Enrobed meat products
5. Cured and smoked products
6. Retorted products

Advantages of Convenience meat products:

- *f* Preparation time is reduced to a great extent.
- *f* No storing, buying or planning of ingredients.
- *f* Can hardly get any leftovers.
- *f* Could have a variety of items especially for inexperienced cooks.
- *f* Faster presentation and easy cleaning up.
- *f* Less spoilage and waste occur with packaged convenience foods.
- *f* Transportation of packaged foods is cheaper especially in concentrated form.
- *f* Cost efficient for mass production and distribution.
- *f* Ready to eat cereal and instant breakfast difficult to prepare at home because of its expensive product technology used in preparation.

Value addition in sheep milk

Value addition means adding value to the term i.e. in terms of quality, functionality, or shelf life. It also broadens the consumer base. Milk is a highly perishable food, so value addition increases its shelf-life like infant formulas from milk. Value-addition in sheep milk can boost revenue. It can be converted to consumable or non-consumable products. Consumable products from sheep milk include

cheese, yogurt, ice-cream, kulfi, paneer, etc. which makes milk more palatable. Non-consumable products include soaps, shampoo, lotions, lip balms, etc. These are mainly skincare products as sheep milk is rich in beneficial fats and essential minerals and vitamins.

Sheep do not have milk production potential similar to cow and buffalo, but sheep milk can be stored without hindering its quality. For maintaining protein stability for more than 12 months sheep milk should be rapidly frozen and stored below -20^0 C. Internationally sheep milk is not popular in its native form but famous for value-added product forms like cheese, yogurt, ice cream, infant formula, etc. Feta, Roquefort, Manchego, Ricotta, and Pecorino Romano are some well-known cheese developed from sheep milk in different countries. Sheep milk cheese is not only delicious but its appearance, texture, and nutrient-dense quality make it a world-famous value-added product. As sheep milk casein is bound to calcium, so there is no need of adding $CaCl_2$ to milk for cheese preparation. Italy (36%) and France (20%) are leading sheep milk cheese exporters.

Sheep milk ice cream needs no more addition of fat or protein. As sheep milk is naturally homogenized, no more homogenization is needed in ice-cream preparation from sheep milk. Due to higher protein and fat content, several probiotics that can survive in cold temperatures can safely be delivered to gastrointestinal sites by sheep milk ice creams (Rasika et al., 2020). Concentrated form sheep milk fat can be obtained in butter, ghee, paneer and cheese formulations while fat free milk can be obtained in form of skim milk. Sheep milk is also a perfect raw material for sweets preparation.

Value addition not only increases shelf life and quality of milk rather it adds functional quality to milk. Sheep milk bio-peptides are gaining attention these days by most health cautious consumers as it has anti-aging property, anti-microbial property, anti-oxidant nature, anti-hypertensive qualities, etc. Nowadays along with a nutrition interest, medical and therapeutic industries are also interested in sheep milk.

Newer technology intervention for enhancing sheep production

A good number of newer technologies have been developed by the ICAR-CSWRI, Avikanagar for enhancing mutton production in the country (Shinde et al., 2017). These sheep technologies and innovations are summarized below:

- Traditional philosophy of “More sheep means more money to more money from less sheep”
- Introduce prolificacy in sheep to produce twins/triplets
- Introduce sheep of extraordinary growth and feed efficiency
- Accelerated lambing system to produce 3 lambs in 2 year
- Marketing of sheep on live weights for better realization of value

- Estrus synchronisation to produce lambs as per market demand
- Stall feeding of sheep on balance ration for higher meat yield and quality
- Disease management practices to reduce mortality losses
- Market-oriented production to attract prime price for produce
- Diversified functional and healthy meat products
- Establish state of art slaughterhouse in production areas
- Skill development of farmers in commercial lamb production

Chapter-10

ORGANIC SHEEP AND RABBIT HUSBANDRY

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Organic simply and primarily reflects something very close to nature, ethics and tradition in general. It involves principles that generate products of high quality, coherent with environment in particular or are in constant phase of relationship with environment (Shubeena *et al.*, 2017). The concept of organic farming is mentioned in the Vedas of the ‚later Vedic Period', 1,000 BC to 600 BC. The essence of it is, to live in harmony with nature. The ‚Vrikshayurveda' (Science of plants), the ‚Krishishastra' (Science of agriculture), and the ‚Mrigayurveda' (Animal science) are the main works (Rajesh Singh, 2022). Organic livestock farming (OLF) differs from conventional farming in many aspects including pasture management, animal nutrition, housing, animal health maintenance and animal disease management (Rahmann, 2001). OLF promotes the use of organic and bio-degradable inputs from the ecosystem. Use of synthetic inputs like drugs, feed additives and genetically engineered breeding inputs should be avoided as much as possible (Chander et al., 2011)

General principles for organic sheep and rabbit husbandry

- Natural breeding;
- Protection of animal health and welfare;
- Fed with organic feed and fodder;
- Access to grazing in organic fields;
- Freedom to express natural behavior;
- Reduction of stress and
- Prohibition of use of chemically synthesized allopathic veterinary drugs, antibiotics, hormones, growth boosters, feed additives etc.

Organic Management Plan for sheep and rabbits

During the registration of the farm by the accredited Certification Body, the producer has to present an organic management plan which requires to be verified during the inspection. This plan shall be

updated annually.

(A)Choice of Breeds, Source and Origin

Choice of breeds

i. Breeds have adaptation to the local climatic conditions and
ii. Good vitality and resistance to diseases

Sources/ Origin

i. Animals must have been born from production units complying with organic production standard or must be the offspring of parents raised under organic production
ii. Transfer of livestock between organic and non-organic units shall not be permitted
iii. The accredited Certification Body shall ensure that brought in livestock from other units comply with these Guidelines;
iv. Livestock raised on non-organic production units shall be converted to organic as per NPOP guideline;

If the organic source livestock are not available, the accredited Certification Body may allow such livestock under the following circumstances:

a. When the producer is establishing an organic livestock operation for the first time;
b. When the producer wants to change the livestock breed or when new livestock is developed;
c. For the renewal of a herd, e.g., due to high mortality of animals caused by catastrophic circumstances and
d. When the producer wishes to introduce breeding males into the farm
e. In all such cases product of such animals shall qualify for organic only after completion of conversion period

(B) Livestock Identification and Animal Record Keeping

a) Livestock identification

- Each animal/ herd/ batch shall bear unique identification number.
- Sheep shall bear individual number in the form of tag,

- while Rabbit shall be identified with herd/ flock/ batch;
- Identification devices on the animals can be printed ear tags, RFID tags, Barcodes or any other suitable tag which is clearly visible

b) Record keeping

Following data for each sheep and rabbit shall be maintained and made available to the accredited certification body for verification during inspection:

I. Parent details;
II. Source and purchase details;
III. Animal details;
IV. Breeding details;
V. Feeding details;
VI. Health care details including details of vaccination, medication, veterinarian prescription and withdrawal period etc.;
VII. Production details;
VIII. Sale details
IX. Any other relevant details

C) Housing and Management

i. The housing shall be planned to suit the specific behavioral needs of the Sheep.

ii. The Sheep should not be tied, however sheep can be confined for specific reasons, such as for some medical procedures, controlled grazing, during night time and for health and safety of animal;

iii. Sheep and rabbit's normal behaviour demands group living, animals shall not be kept in isolation, but shall have company of like kind;

iv. As far as possible two different kinds of animals shall not be kept together, unless for specific purposes, such as, free range poultry birds in sheep shed for scavenging on ticks and other insects

v. The housing system shall ensure prevention of abnormal behaviour, injury and disease;

vi. Housing for sheep shall not be mandatory in areas where appropriate climatic conditions exist to enable animals to live outdoors without compromising their comfort, health and welfare.

viii. Conditions shall be inspected and permitted by the accredited Certification Body on producer and location-to- location basis. Outdoor open areas may be partially covered

ix. Housing conditions shall meet the biological and behavioural needs of the Sheep and Rabbit by providing easy access to feeding and watering and shall ensure:

a. Insulation, heating, cooling and ventilation of the building to ensure that air circulation, dust level, temperature, relative air humidity and gas concentrations are kept within limits which are not harmful to the sheep and rabbit;

b. Plentiful natural ventilation and light to enter;

c. Appropriate fencing not harmful to the animals

ix. Confinement shall be permitted under following conditions:

a. Inclement weather to protect animals from injury;

b. Ensure health safety or welfare;

c. To protect plant, soil and water quality;

i. The outdoor stocking density of livestock kept on pasture, grassland, or other natural or semi-natural habitats, must be low enough to prevent degradation of the soil and over-grazing of vegetation.

Table1: Space requirement for Sheep

Livestock	**Indoor Area (net area available to animals)**	**Outdoor Area (exercise area, excluding pasturage)**
Lamb/Kid	0.35 m^2/head	0.5 m^2/head
Ewe /Ram	1.5 m^2/head	2.5 m^2/head

Special conditions of housing for Rabbits

- The keeping of rabbits in cages shall not be permitted
- If required for comfort and safety rabbits may be temporarily confined, for example overnight, in cages or hutches.
- Continuous confinement is prohibited;
- Rabbits shall have space to run, hop and dig, and to sit upright on their back legs with ears erect

Table1: Space requirement for Rabbits

Rabbits	Indoor space	Outdoor –runs and concrete exercise	Outdoor – pasture
From Weaning to slaughter	0.3 m^2/head	2 m^2/head	5 m^2/head
Pregnant does	0.5 m^2/head	2 m^2/head	5 m^2/head
Does with litters	0.7 m^2/head	2 m^2/head	-
Bucks	0.3 m^2/head	2 m^2/head	5 m^2/head

D) Conversion Period for Animal Production

- Simultaneous conversion of Sheep and rabbit and land used for raising feed/fodder within the same unit should be a preferred approach
- Land for production of feed, fodder, pasture, grazing etc shall be certified organic as per the provisions of NPOP guideline.
- In case of annual and biennial crops, plant products produced can be certified organic when the requirements prescribed under these Standards have been met during the conversion period of at least two (2) years (organic Management) before sowing (the start of the production cycle)
- In case of perennial plants other than grassland (excluding pastures and meadows), the first harvest may be certified as organic after at least thirty-six (36) months of organic management according to the requirements prescribed under these Standards
- Organic products in conversion shall be sold as "produce of organic agriculture in conversion" or of a similar description, when the requirements prescribed under these Standards have been met for at least twelve months.
- When a livestock production unit (Sheep and Rabbit), is in transition to organic production, pasture and feed produced on the land undergone a minimum period of 12 months of conversion period may be considered organic for feeding to organic livestock;
- The conversion period shall be determined by the accredited Certification Body and the conversion period shall be accounted from the date of first inspection;
- In cases, where the land and livestock (Sheep and Rabbit) conversion to organic status is not

simultaneous and the land alone has reached organic status and the livestock from a non-organic source is introduced,

- These must be reared according to these guidelines for at least the following compliance periods before their products are sold as organic:
- **For Sheep**

i. Meat products: Six (6) months;

ii. Milk products: Six (6) months.

- **For Rabbits**

Meat products: From the second week after their birth to the entire life span as determined by the accredited Certification Body

E) Feed

- Livestock shall provide maximum diet from feedstuffs (including 'in conversion' feedstuff) produced as organic as per the requirements of NPOP guidelines
- Agricultural processed residues of organic origin, such as from grain fermentation, fruit processing, vegetable processing, etc., shall be permitted for purpose of feeding, provided that the overall feeding practices satisfy the daily energy and nutrient requirements of the concerned animals
- During the operations, the products shall maintain their organic status provided that livestock are fed with at least 85% for ruminants and 80% for non-ruminants calculated on a dry matter basis, feed obtained from organic sources that have been produced in compliance with these guidelines

Choice of Crops and Varieties

- All seeds and plant material shall be certified organic
- Species and varieties cultivated shall be adapted to the soil and climatic conditions and be resistant to pests and diseases.
- In the choice of varieties, genetic diversity shall be taken into consideration
- When organic seed and plant materials are available, they shall be used
- When certified organic seed and plant materials are not available, chemically untreated conventional seed and plant material shall be used
- The use of genetically engineered seeds, transgenic plants or plant material is prohibited

Specific Criteria for Feedstuffs and Nutritional Elements

- The feedstuffs should not be prepared by using chemical solvents and chemical treatment.

- All the ingredients of the feed including supplements, fed to organic animals should be from organic sources
- In case of shortage of these substances, or in exceptional circumstances, well defined analogic substances may also be used;
- Feedstuffs of animal origin, with the exception of milk and milk products, fish, other marine animals and products derived thereof shall not be used
- The feeding of mammalian material to ruminants is not permitted with the exception of milk and milk products;
- Synthetic nitrogen or non-protein nitrogen compounds shall not be used.

Specific Criteria for Additives and Processing Aids

a. Feed processing aid supplements like binders, anti-caking agents, emulsifiers, stabilizers, thickeners, surfactants, coagulants if used should be from natural sources;

b) Antioxidants: only from natural sources shall be permitted;

c) Preservatives: only natural acids are allowed; iv. Colouring agents (including pigments), flavors, odor masking agents and appetite stimulants: only natural sources are allowed;

d) Probiotics, enzymes and microorganisms are allowed but should not be from genetically modified sources;

e) Any synthetic chemicals, such as, antibiotics, coccidiostat, medicine, growth promoters or any other substance supplemented for purpose to stimulate growth or production shall not be fed to the organic livestock;

f) Silage additives, additives for enriching crop residues and processing aids may not be derived from genetically engineered/modified organisms or products thereof, and may be comprised of only:

   a. Sea salt;

   b. Coarse rock salt;

   c. Yeasts;

   d. Enzymes;

e. Whey;

f. Sugar; or sugar products such as molasses, jaggery, grain bran;

g. Honey;

h. Lactic, acetic, formic and propionic bacteria, or their natural acid product when the weather conditions do not allow for adequate fermentation and their use to be approved by the accredited Certification Body

F) Health management under organic sheep and rabbit production

The organic livestock, in general, should follow the basic principles of preventive health and productivity management wherein the focus would be on preventing diseases, detecting underlying fertility and production problems and its correction primarily on correcting management, nutrition and sanitation. The producer in consultation with veterinarian should draw a program of health management of animals and carry out testing of the herd as per the common diseases of Sheep: Brucellosis, Leptospirosis, Tuberculosis, Para-tuberculosis.

Principles for health care under organic sheep production that should be followed in:

a. The choice of appropriate breeds or strains of animals that can acclimatize, adapt to environment
b. The setting up of the animal husbandry practices should be appropriate to the requirements of each species and should focus on encouraging strong resistance to disease and prevention of infections;
c. The use of good quality organic feed, together with regular exercise and access to fodder/roughages, and/or open-air runs, so as to have positive effects on natural immunological defense of the animal;
d. Appropriate stocking density of livestock & poultry so as to avoid overcrowding and spread of infections or competition to feeding.
e. The farm should have an established system of detection of sub-clinical, sick or injured animals and if, so detected, must be treated immediately

The use of veterinary medicinal products in organic farming shall comply with the following principles:

a. All vaccinations required by law of the land shall be permitted.

b. Where specific disease or health problems occur, or is predicted to occur, and there are no alternative permitted treatment or management practice exist, use of parasiticides, or therapeutic use of veterinary drugs are permitted under prescription and supervision of a registered veterinarian, provided that the mandatory withdrawal periods are observed

c. In drugs where withdrawal period is not prescribed in these guidelines, a minimum of 48 hours of withdrawal period shall be observed;

Sl. No.	**Drugs**	**Pre-slaughter withdrawal time (days)**
1	Chlortetracycline (Oral)	2
2	Procaine penicillin-G	9
3	Procaine penicillin-G, dihydrostreptomycin sulphate	30
4	dihydrostreptomycin sulphate	30
5	Erythromycin	3
6	Sulphamethazine	10
7	Sulphamethazine (Oral)	10
8	Sulphaquinoxaline(Oral)	10
9	Sulpfisoxazole(Oral)	10
10	Thiabendazole (Oral)	30

d. For purpose of treatment and prevention of diseases and underperformances, herbal/phyto-therapeutic (excluding antibiotics), homeopathic or ayurvedic products shall be preferred to allopathic veterinary drugs or antibiotics, provided that their therapeutic effect is effective for the sheep and rabbit and the condition for which the treatment is intended;

e. In case alternative therapeutic or preventive measures are unlikely to be effective in combating illness or injury, allopathic veterinary drugs or antibiotics may be used under the responsibility and supervision of a veterinarian.

f. The use of allopathic veterinary drugs or antibiotics or drugs derived from genetically modified source for preventative treatments and for enhancing productivity or fertility is prohibited;

g. Hormonal treatment may only be used for therapeutic reasons and under veterinary supervision;

h. Growth stimulants, agents or substances used for the purpose of stimulating growth or production shall not be permitted

G) Breeding and Management

a) The major focus of livestock management shall be to provide care, comfort, and respect to the animals and ensure their welfare in the farming system;

b) Livestock breeding methods shall be in accordance with and in compliance with the principles of organic farming and shall take into account:

c) The breeds and strains most suited to local conditions;

d) The preference for reproduction through natural methods, although artificial insemination may be used;

e) ET techniques and any other breeding techniques employing genetic engineering shall not be used;

f) The use of hormonal reproductive treatment shall not be used unless prescribed therapeutic, directed towards correcting the physiological problem

iii. Mutilation, such as, tail docking, cutting of teeth and dehorning are not permitted.

- In exceptional cases, some of these may be authorized by the accredited Certification Body for reasons of safety (e.g hoof trimming) or if they are intended to improve the health and welfare of the livestock and poultry.
- Such surgical procedures shall be carried out by a registered veterinarian at the most appropriate age; and any suffering to and pain shall be reduced to a minimum.
- Wherever possible, anesthetic and analgesics shall be used. Physical castration is allowed only in order to maintain the quality of products and traditional production practices.

H) Manure and Urine Excreta Management

I. The collection, handling and disposal of the dung and urine from shed, paddock, open run or grazing areas shall be implemented in a manner that:

a. Minimizes soil and water degradation;

b. Does not significantly contribute to contamination of water by nitrates, phosphates, and pathogenic bacteria;

c. Optimize recycling of nutrients

d. Does not include burning or any practice inconsistent with organic practices

I. All manure storage and handling facilities, including composting facilities shall be designed, constructed and operated to prevent contamination of ground and/or surface water;

II. Manure application rates shall be at levels that do not contribute to ground and/or surface water contamination.

- The accredited Certification Body shall establish maximum application rates for manure or stocking densities as per local conditions
- The timing of application and application methods shall not increase the potential for run-off into ponds, rivers and streams

I) Products Authorized for Cleaning and Disinfection of Livestock Buildings and Installations

- Hydrogen peroxide
- Natural essences of plants
- Citric, per acetic acid, formic, lactic, oxalic and acetic acid
- Alcohol
- Nitric acid (dairy equipment)
- Phosphoric acid (dairy equipment)
- Formaldehyde
- Sodium carbonate Potassium and sodium soap
- Water and steam
- Milk of lime
- Lime
- Quicklime
- Sodium hypochlorite (e.g. as liquid bleach)
- Caustic potash

J) Process to get Organic Certification in India

Meeting the basic requirements

⇩

Applying for the NPOP Certification

⇩

Paying the prescribed fees

⇩

Review of your application

⇩

Scheduling of inspection

⇩

Verification during Inspection

⇩

Issuance of NPOP Certificate if everything is found to be correct

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