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P. C. MAHALANOBIS MEDAL LECTURE–1981*

SCIENCE AND TECHNOLOGY—DEVELOPMENT OF INDIAN LEATHER INDUSTRY

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A Happy New Year

I am conscious of the honor you have done me. This honour is really not to me but to my colleagues and students and their work at Central Leather Research Institute in the past three decades.

It is indeed a privilege to deliver a lecture associated with the name of an eminent scholar, scientist, restless visionary and planner—Professor Mahalanobis—who shot into promise with his draft outline of the Second Five Year Plan in 1956 and became a defacto member of the Planning Commission. The Central Statistical Office, National Sample Survey, Indian Statistical Institute, International Statistical Training Centre and others are living monuments for this remarkably greatman, who did so much for science and planned development. In consonance with this, the topic for this Lecture has been chosen as—Science and Technology and Development of Leather Industry.

An attempt is made here to present the unique characteristics of skin and its conversion into leather by tailoring of skin protein molecule interacting with organic, inorganic, natural and synthetic agents; an interplay of a number of different scientific disciplines; the interweaving of modern scientific knowledge into traditional tapestry, the economic and social aspects, the international relations involved, future directions in leather research and the contributions of Central Leather Research Institute (CLRI) in the development of leather industry.

WHAT IS LEATHER?

Technically speaking, leather is a natural protein polymer treated with tanning agents to make it resistant to enzymes and putrifaction and to improve the physical properties.

It is an ubiquitous substance, serving a multitude of human needs, for ages immemorial both in times of peace and war. The caveman used leather for covering his body; the jungle man for bows, arrows and leather telegraph; the desert man for

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tents, wine and water casks and the modern man, for over 350 different purposes for personal, agricultural, industrial and defense needs.

Processes have to be designed to make leather to meet the specific need. Look at a shoe. A shoe should protect the feet, should retain the shape; be fashionable and comfortable acting as a thermostat against heat and cold and resistant to fire, fungi. For this purpose the bottom sole leather should be solid, compact, resistant to puncture, nails, slip, stretch, wear, tear and water. The upper leather should be soft, supple, shining and able to 'breathe'. Similarly, chamcis leather is made for quick wetting and drying and for cleaning dirt, water, lenses and diamonds; orthopedic leather for flexibility and mouldability; glove leather to stretch and yet to grip, while upholstery leather should not stretch; luggage and baggage leather for rough, tough, and life long wear; hydraulic leathers to resist oil, water, heat and humidity and textile leathers for grip and flexural fatigue; leather for art and culture for puppets and musical instruments and leather as a major dollar earner.

'As comfortable as an old shoe' is the old adage. What really constitutes this comfort? Partly it is the style, design, fashion, colour, distinction and psychology. But the characteristic properties of leather score over others. The leather has the three dimentional character with an ability to give, stretch, flex, grip, compress, resilience, strength, plasticity, elasticity, density, permeability to water vapour, air, breathing, rate of absorption and desorption of water, wicking property, heat of wetting, rate of drying, thermal insulation, reservoir capacity and resistance to perspiration, stiffening, oil, water, wear, tear, scuff, heat and fatigue and ability to mould itself according to the anatomy of the feet, height, weight and gait of the wearer, type of soils, roads and climate, giving foot hygiene and care. The tanner, designer, shoe maker and the medical people need to understand this unique comfort character of leather shoe.

How is Leather Made?

The art of leather making is as old as man; the application of science to this craft was made however only towards the end of 19th Century.

Raw materials for making leather are the raw hides and skins. Skin is the hide of a small animal. The skins come from a variety of animals, varying in size, shape, substance, structure, texture and character, depending upon the animal, its age, sex, breed, food, climate and the care of live animals. Raw skin is readily putrescible; not leather. Leather is more resistant to heat, hydrolysis and microorganisms.

The animal skin is composed of 60 per cent water, 35 per cent fibrous and non-fibrous proteins, collagen being the leather making material and the rest lipids, carbohydrates and mineral salts.

The natural properties of the leather making protein of hide or skin do not coincide with the desirable properties of leather and the art of leather manufacture consists in removing as far as possible the undesirable properties and in augumenting the desirable ones of this protein.

The process of leather making is essentially a sustained series of coordinated, equilibrated chemical and physical reactions to bring about the necessary changes.

It involves pretanning processes like 'Curing' preserving putrescible raw hides and skins treating with common salt; 'soaking' to remove salt, dirt, etc., unhairing with lime and sodium sulphide 'fleshing' 'deliming' and 'bating' with enzymatic agents, to remove undesirable soluble proteins, fat, flesh, hair etc and pickling with acid and salt to preserve. The 'pelt' so obtained is still putriscible but the fibre structure and the reactive groups of collagen are conditioned for tanning with several natural synthetic, organic, inorganic agents (e.g. polyphenols, formaldehyde, basic chromium or Aluminium sulfates, fish oils, etc) or combinations thereof. By tanning, additional cohesive forces are introduced (covalent, coordinate and hydrogen bonding) rivetting the three dimensional network of collagen fibres. The resultant leather is more resistant to heat, hydrolysis and microorganisms. It is further 'finished' by treatment with dyes, finishes, pigments, fillers, fatliquors, etc to obtain the colour, gloss, feel, flexibility, softness, handle, drape, shower and waterproofness to suit the end use. A number of mechanical operations are also involved to obtain uniform thickness, softness, gloss, etc.

In the conversion of raw putriscible hide or skins into finished leather for use, forty eight different distinct operations are involved each affecting the previous and the next step. Any change in one step affects the whole series of steps, making it really complex. The progress in basic sciences has directly contributed to the progress in tanning technology. In turn the advances in leather science contributed to the store of scientific knowledge. Further, leather industry is a clear example where technology has preceded science.

Leather is one of the man's earliest products and it is still modern. Leather is associated with the very history and civilisation of mankind. The tanner learns geography, history, politics and economics as leather is an international marketing commodity. To the artist, it is a delightful medium, for painting, puppet play, for musical instruments etc; to the industrialist it is a business of about 10 billion rupees of which around 4 billion by way of export with a promise of doubling its value and to the scientist leather making is a despair and delight involving twenty different disciplines of science from veterinary science to chemistry, physics, botany, biology, bacteriology, microscopy, polymers etc in the interaction of complex proteins with even more complex treatment materials.

Such is leather ageless and matchless—nature's own fabric tailored by the technologist and the tanner to suit the evergrowing and changing day to day needs of people. The superiority of leather lies in the fact that it combines in itself a number of unique properties and can be tailored to suit specific needs.

What Makes Leather so Unique ?

It is the chemical composition and the three dimensional structure of the skin that make it unique. Of the skin proteins, collagen fibre is the leather making material. Of the many millions of proteins that can be formed from twenty different amino acids, only one makes extensive use of the imino acid hydroxyproline; only one has a melting point close to the body temperature of the animal: only one is involved in every aspect of the construction of human being; and only one has a sufficiently low

rate of metabolic turnover to be considered inert. This protein is collagen and its key functions are protection and mainstay support of the organism. It is this collagen the tanner technologist converts into leather with added properties.

Fortunately for anyone animal species, the chemical composition and physical structure of individual collagen fibre is the same.

Encouraged by CLRI, the molecular structure of collagen was studied and arrived at by G. N. Ramachandran and his group at Madras. The triple helical molecule is approximately 3000 Å long and 14 Å in diameter. The helix is composed of three polypeptide chains, each containing about 1000 amino acids in a left handed helical structure with approximately three amino acids per turn. The three chains are wound around a common axis into a right handed super helix. The helix is mainly stabilised by hydrogen bonds but ionic and hydropholic interactions may also contribute to the stability. The molecules aggregate to form fibres which are stabilised by intermolecular cross linking. Depending on the composition of chains and the amino acid sequence, collagen is qualified as different 'types'. Normal skin is found to contain 70–80 per cent Type I and the remaining Type III. The relative compositions of the types change in pathological conditions. The unusual nature of helix in collagen is largely explained by its unusual amino acid composition (gly-X-Y) where X and Y are very often proline and hydroxyproline but it could be others.

The invertebrate collagens differ widely from those of vertebrates. The only common feature is the wide angle X-ray diffraction pattern. Studies at CLRI show that the differences and peculiarities are due to the fact that these collagens are combined with non-collagenous protein which when removed conforms to typical collagens in most respects. The structure—function relationships are most evident in invertebrate collagens unlike most of vertebrate collagens. It further indicates that performance of similar functions bring about similarity in structural characteristics. Presently studies are being conducted to trace the evolutionary relationships occurring in animal groups.

Chemical Properties

Extensive studies have been conducted at CLRI on skin proteins—their biosynthesis, biochemistry, amino acid sequence, the nature and number of reactive groups, the increase and decrease of cohesive forces and cross links of collagen; biological ageing of collagen with increased crosslinks, the influence of nutrition on the synthesis as well as cross linking of collagen, lathyritic collagen, several collagen diseases; the role of hydrophobic forces; activation or inactivation of reactive groups by chemical or enzymatic action, etc. The knowledge so obtained is well utilized by the leather technologist to understand the mechanism of tanning, to increase cohesive forces in making leather, and to tailor the molecule by the action of acids, salts, bases, vegetable, mineral, oil and other chemical tanning and finishing agents.

Knowledge on cross linking has been applied with advantage in other industrial processes as well—like, photographic industry, lithographic printing, hectograph duplication; surgical sutures with delayed controlled solubility and aborption;

adhesives gelatin, solubilized collagen, collagen sheets for medical purposes, sausage casings, precipitating collagen on other fibres etc.

The practicability of grafting synthetic polymers on to collagen as a means of improving the properties of leather was first shown by CLRI. This is considered to be a new field with great potentialities because of the possibilities of development of a product blending the advantageous properties of leather and synthetic for wearing and comfort properties. Similarly our researches have shown that the peculiarity of glutaraldehyde tanning is due to the formation of stable cyclic structures. Skin homografts by glutaraldehyde tanning prolonged their average survival time. Collagen copolymers show promise as biomaterials for medical fields.

Physical Properties

The histology and microscopic studies at CLRI have been recorded in two monographs indicating the defects of Indian raw hides and skins and leathers made from them. Extensive studies have been conducted using conventional and electron microscopy on the structure of collagen fibres and leathers in regard to its function and performance. Tensile strength varies from region to region in the skin depending upon functional demands in the region e.g., elbow, belly more extensible, as compared to neck. Normally the stress distribution on the skin at a particular region determines the orientation of collagen in that region. Tanning increases cross linkages and reduces tensile strength. Scanning electron microscopic studies reveal the correlation between surface structure and gloss, friction, feel and adhesion. The nature of the surface of finished leather varies with temperature in plating and impregnations give improved gloss. Coefficient of friction depend on the nature of surface and feel of leather.

The breathing character of leather, water vapour permeability, reservoir capacity etc are due to the three dimensional net work structure of leather.

CLRI has done some pioneering work evolving a new shoe sizing system using the ratio of foot length to width as 2.56 + 0.1. Designing footwear for the disabled demand a number of biomedical techniques to determine the distribution of body weight over different segments of foot during standing, walking and angle of flex at different joints.

Leather puppetry is based on the understanding of translusency and transparancy of parchment which in turn depends on the angle of weave of fibres and removal of soluble proteins and other indesirable matters. The traditional puppets are made using cow hide for gods, buffalo for demons and goat and sheep for godesses. This could readily be explained with modern knowledge and also help to improve upon the traditional practice.

Leather and sound is yet another interesting subject of research at CLRI. Leather is used in more than 100 musical instruments. Each drum has a distinct name, shape, playing technique, tonal quality, method of construction and type of leather affected by thickness, density, fibre orientation relative humidity and tension. The relative frequences of the overtones of the skin membrane are higher than theoretical values and also the relative frequency increases. Kanjira drum using the

skin of veranus has a normal playing frequency of 160-180 Hz. CLRI has shown that this costly skin with unique structure with high damping characteristics can be substituted by cheaper bandi-coot skin.

The work at CLRI on leather auxilaries has not only helped to understand more clearly the mechanism of tanning and other reations of collagen with dyes, finishes, polymers, synthetic tannins oils etc but also to develop the industry to manufacture vegetable tannins and synthetic tannin extracts, finishes etc locally reducing or removing exports. Several processes were also developed and transferred to the industry to manufacture and export a variety of finished leathers and leather goods.

Leather Research : Future Directions

What is new in leather research and what are the likely directions it would go? An attempt is made here to give some trends for the development of Indian Leather Industry.

1. Raw Hides and Skins

Animal Husbandry:

- Fuller utilisation of frog bandikoot and other unusual and exotic skins.
- Setting up of organised farms for stallfed, goat, pigs, exotic for bearing animals and crocodiles.
- Genetic engineering for the improvemnent of the quality and thickness of skin.
- Apart from increased meat and milk yields.
- Stallfed goat as poor man's bank.
- Small but organised hygenic slaughter houses to serve a cluster of villages. This way, the village gets hygenic meat, the tanner a better quality raw hids, the byproducts better utilised and the farmer higher returns for his animals.
- Slaughter houses—meat for export.
- Less fallen (naturally dead) animals.
- Animal product corporations to utilise fully every part of the animal.
- Import of raw hides and skins and methods to process them.
- Raw skins and hides as raw material for the purposes other than tanning like, protein foods, shamphoos, wrinkle cream, medical, biomaterials, gelatin etc.
- Reconstituted man made leather, fibres, etc.
- Collagen fragmented peptides, amino acids, etc.
- Skin for grafting.
- Tissue culture of skin.
- Mixtures of hide protein, leaf protein and keratin hydrolysates to get nutritions food.
- Collagen from other sources.

2. Tanning Materials

- Better collection and utilization of mangroves in Andamans and Sunderbans.
- Better utilization of myrobalan and other indigenous tanstuffs.
- Vegetable tannins for oil drilling compounds, resins, adhesives and as a base for chemicals.
- To increase the polyphenolic content in tannin bearing plants by genetic engineering and tissue culture.
- Better utilization of spent tanning materials—for separation and use of lignin and cellulose.
- Identification of microorganisms to polymerise smaller phenols, depolymerise bigger phenols or to destroy phenols in effluents.
- Greater use of the salts of aluminium and titanium in place of chromium.
- Newer tanning agents.

3. Processes

- Single step tanning, dyeing and finishing.
- Supersonic and isotopic dyeing.
- Concentrated tan and dye applications.
- Continuous photographic printing on presensitised leather surface.
- Three dimensional effect produced by leather embossing.
- Instant finishes, stickers, etc for use by village cobbler.
- Graft polymerisation—Casein, latex, chlorinated rubber, acrylics, etc.
- Silicones, flucrocarbon polymers.
- Newer adhesives to replace stitching.
- Moulding, welding and forming into entire garment shape or sports goods etc.
- Use of ultrasonics, radiation, lasers.
- Use of pressure, vacuum for accelerated reactions.
- Energy and pollution saving processes.
- Removing bad odour.
- Remove or reduce safety hazards.

4. Pollution Posers

- To remove or reduce the use of pollutants, toxicants etc.
- To reduce water.
- Recycling of water.
- Recycling of other materials like tanning agents.
- Fuller or complete absorption of materials by the hide and leather.
- Economic methods of treatment and utilization of effluents.
- Utilization of solid and liquid wastes.
- Use of plants like hyacinth and mangroves to remove pollutants.
- Use of microorganisms to treat effluents and destroy pollutants.
- Leather shavings as a filter absorbent for effluents.

5. Energy Related

- Energy saving processes and machinery.
- Reducing number of steps and processes.
- Efficiency in the use of materials and machinery.
- Use of alternate sources of energy like solar energy for drying, heating water, etc.

6. Leathers

- Easy care—wash and wear leather.
- Newer types of leather—grafting etc.
- Newer uses for leather.
- Sports goods from laminated splits, rubberised splits etc.
- Anti-mould, anti-ageing protection of leathers.
- Greater uniformity/quality.
- Higher hydrothermal stability, mouldability, etc.
- Collagen fibres interwoven with synthetic and natural fibres.
- Backing for coating of leather with other fibrous materials.
- Leather laminates.
- Other textile, jute, synthetic fabrics coated with collagen.
- Water proof sole leather.
- Leather for accoustics.
- Leather as artistic medium, puppets, musical instruments etc.

7. Leather and Fur Substitutes

- Three dimensional non leather fabrics.
- Poromerics.
- Reconstituted collagen fabrics.

8. Machinery and Quipment

- Multi-purpose and smaller size machines.
- Improved tools and small machinery for decentralised production.
- Computer aided design and manufacture (CADCAM).
- Computer application to correlate the complex nature and properties of the raw hide and skin and the leather for the end use.
- Microprocessers for process control etc.
- Microprocessers for stitching and sewing for making shoe, leather goods and clothing.
- Scanner for detecting defects in raw hides and finished leather.
- Application of laser techniques for cutting leathers etc.

9. Byproducts

- Utilization of waste or old sandals and shoes, etc.
- Waste leather into leather pulp to be blended with cellulose etc for reinforcement.
- Biogas.
- Fertilisers.
- Retreading of rubber tyres along with leather mix.
- Shavings for airport runways and sports tracks for resilience.
- For desalination as ion exchange columns.
- Hair hydrolysates.
- Amino acids, peptides.
- Pyrodistillation of leather, tannery wastes – the resultant products.
- Better utilization of slaughter house byproducts as well as spent tanstuffs.

10. Basic Research

- Selective cleavage of proteins.
- Aminoacid sequence of collagen.
- Invertebrate and fish collagens.
- Effect of nutrition on the quality of raw hide.
- Structure function relationships and physical properties.
- Modification of collagen to react with given reagents.
- Solubilisation of fibrous proteins—collagen, hair, leather, by fungi sclerotium, A. niger, etc.
- Identification of microorganisms in raw hides and skins, tan liquors etc and to use them for other industrial applications, treatment of effluents etc.
- Newer methods of grafting synthetic monomers/polymers on natural fibres like collagen, coir, jute, etc.
- Blending of hair, wool, collagen fibres with other natural vegetable fibres like coir, jute, palymra, etc.
- Tissue culture and genetic engineering to produce more polyphenols in plants and for skin.
- Use of solid lubricants like colloidal sulfur, graphite, mica etc in place of oils.
- Newer cross linking agents.
- One step, tailor made multifunctional, tanning finishing, filling and fatliquoring agents.
- A single class of dye with equal affinity to differently tanned leathers.
- Leather outer surface to reflect or retain heat to shed wrinkles, dirt, grease, etc.
- Immobilized enzymes on collagen matrix.
- Skin diseases.
- Correlation between chemical and physical properties of skin and leather and the end use.

11. Footwear and Leatherware

- Design of an appropriate footwear for different states in India to suit the people and environment.
- Setting up a separate footwear research Centre at CLRI.
- Study of foot health, care, anatomy, foot survey.
- Blending of other materials with leather.
- Making shoe with crust leather and later finishing it.
- Comfort factors.
- Fashion and design of apparel and leather goods.
- Auxiliary materials.
- Upgrading traditional skills, tools and techniques.
- Leather as a part of material science.

12. Economics, Exports and Marketing

India is the single largest live stock holder in the world. In 1982, India has 182mn cattle (15 per cent of the world's), Buffalo 65 mn (46 per cent), goat 72mn (17 per cent), and sheep 41mn (4 per cent). It produces annually 34mn hides (cow 22 + Buffalo 12) — (12 per cent of the world), 46mn goat skins (25 per cent) and 20mn sheep skins (5 per cent).

The total value of the world leather trade is 12 billion dollars a year and the India's share is 1 billion. In 1953 when CLRI was set up, India's exports were 250 million rupees exporting mainly raw skins and unfinished leather. In 1980, Indian exports reached a peak of 4250 million rupees with a growing share (over 70 per cent in the export of finished leathers, footwear and components instead of the traditional unfinished leathers. There is a promise of exports upto 10 billion rupees, though there is a trend of recession at this time. A number of joint ventures have been set to export meat, leather uppers, footwear, clothing and leather goods. Large houses have come into leather industry assuring quality products and meeting time schedules, etc for export.

India exports its products to countries all over the world, more particularly East and West Europe, U.S.A. etc. Indian industry participates in International Leather Fairs and organises its own Fairs in India and the LEATHER-WEEK—Tanners Get-together and International Leather Fair at CLRI is a much looked for event every year.

Inspite of the two leather Export Promotion Councils, much needs to be done to collect market information and market intelligence and advance information on fashion, designs, colours, etc to compete in international markets. Bold action is called for to buy out well established brand names, or associate with fashion houses or establish our own new brands with agressive sales techniques for Indian Leather ware which are artistically eastern but functionally Western.

India may have to establish warehouses abroad; and ensure quality and delivery schedules on time. India is yet to build competence and courage to accept bulk orders in big way for leather goods, footwear and clothing.

India has the necessary infrastructure, technology, trained personnel and raw materials. With broad vision, enlightened policies and strategies, Indian leather industry has a promise of doubling its present exports by concentrating on a few items where India has strength like high fashion goods from goat skins etc.

It has also a major role to play to assist developing countries in developing their leather industries. Many developing countries are already producing and exporting leathers instead of raw materials.

13. Structure and Organisation

The Indian leather industry exists in large, medium, small and cottage sectors. A large portion of the industry is still in the organised and unorganised small and cottage sector giving an employment for 2 million families. In the past three decades, the conservative traditional tanners particularly in Madras have shown remarkable resilience and foresight and switched over to most modern methods and machinery enabling them to export finished leathers and leather ware. A few Service Facility Centres have also been set up to assist small tanners to get their leathers finished. Several State Leather Development Corporations and a Central Bharat Leather Corporations have sprung up to assist the development of leather industry and State Trading Corporation helps in regard to imports and exports. In addition NSIC, SISI, CLRI and other educational institutions provide technology, manpower and machinery. There are several manufacturing units supplying the needed leather auxiliaries and some machinery. The Leather Development Councils sets the policies, plans and targets. But these would be effective only when the five components, Industry + Government + R & D + Banks + Labour, work together to set and implement the targets. CLRI conducted techno-economic survey of several states indicating their potential for leather industry development.

The likely future trends are :

- Setting up animal farms and small, hygenic, organised slaughter houses as indicated earlier.
- The leathers from the above centres may be finished at a central place with modern tools and techniques.
- Centralised management and decentralised production principle may be applied for the manufacture of shoe uppers, sandals, leather goods, clothing, etc.
- Setting up of additional common facility centres, finishing centres, etc.
- Setting up of sound financial and marketing organisation for internal and international sale.

14. Social Aspects

The people engaged in leather making traditionally were treated as "untouchables" because of the bad odour associated with it. They were denied the light of education and the lead of intelligentia. The view is held by many, more so by the elite, educated abroad that this cottage small traditional tanner has to give way to organised

mechanised leather industry. But then what do you do with two million traditional workers and their families? Their traditional skills and rich experience will be wasted and the can't be offered new jobs. If science were any good, can it not help to remove the bad odour and the stigma attached to leather industry; can science help improving the working and living conditions of these people, reducing drudgery and increasing economic returns and improving their social prestige? Such were the questions faced by Central Leather Research Institute. Here is a gold mine—leather industry with a promise of fetching added foreign exchange and it is easy to follow the route of advanced countries, setting up organised mechanised sophisticated capital intensive industry. But the more challenging task is for technology to deal with the social aspects. It should be said to the credit of CLRI that it accepted this challenge and earned the goodwill and confidence of the traditional tanners upgrading the traditional; weaving in the modern into the traditional tapestry and through extensive extension services. It is heartening to find today the high caste people and moslem women working in leather industry. The technology factors and social change in leather industry would be a fascinating subject to study.

A systematic study has revealed that there is good science behind traditional tanning techniques. The modern books state for making 1 kg of leather, 1000 litres of water is needed. But then the Gujarat and Rajastan tanner uses hardly 1 litre of water for 1 kg of leather. How? similarly the Punjab tanners have used enzymatic unhairing process for ages. The traditional bag tanning and E.I. tanning has unique characteristics utilizing littte or no tools and controls, producing leathers which have won world's acclaim. Similarly tie and dye leathers, the regional footwear like Kolhapuri Rajasthan Chamba chappals etc demand attention. CLRI has conducted researches on several of these processes and improved upon them. Several Ph.D. theses were produced studying these unique traditional processes.

Technology should be coupled with social technology. CLRI has shown how the extension services are as important as technology generation, by 'show-how' of the 'know-how', following the policy of 'profits you take, losses we take' and taking technology to the doors of the people that need it. An extension worker has to have not only technical skills and knowledge but also the modesty, trained sense and keen observation to detect and correct faults, the ability to adopt, make do, to talk in tanner's own language, to be persuasive, polite and patient with good commonsense, business nose an willingness to continuously learn.

15. Education and Employment

The remarkable changes the Indian industry has seen in the last three decades is partly if not mostly due to the well trained technologists entering the industry. Here again the Central Leather Research Institute has done a yeoman service to the industry. Running the Department of Leather Technology of the University of Madras and presently of Anna University, CLRI was the first in the country to offer B. Tech, M. Tech and Ph. D. degree courses. In addition it offers facilities for short term courses in leather technology and certificate courses in leather goods.

CLRI trained personnel are in great demand both in India and abroad. Presently there are 7 schools in India training 100 diploma and 60 certificate holders, a year; 3 colleges offering degrees for 50 people and one (CLRI) offering postgraduate courses. On the basis that one technologist is needed to produce 10–15,000 sq. ft. a day, and as the total production today is around 3 mn sq. ft. a day, it is estimated that the country needs 2–2500 trained people. As the exports are more and more in the direction of finished products, the demand will be for persons trained in footwear, clothing and leather goods. The need is felt for training particularly in finance and marketing and export management and for general managers as contrasted to work managers. Rigorous attempts have to be made to increase productivity and introduce quality control. Consultancy firms are in great demand. Manpower is needed in all these areas. The dire need is for books and education materials in regional languages to upgrade the skills of traditional craftsman, skilled and unskilled workers, puppetry and musical instrument leathers and the text-books for degree and diploma holders. Refresher courses, and correspondence courses have to be thought of. Training in the computer aided programs is an untouched area yet. Training of persons from developing countries must be given additional support.

This account is not exhaustive but only indicative. But clearly the stress in future research will relate to dealing with three important aspects namely effluents, energy, and non uniform quality of raw hides and skins and finished leathers. The emerging technologies may bring about radical changes. Biotechnology/genetic engineering, tissue culture, computer aided design and manufacture, microprocessors for process control in tanning, shoe, garment and leather goods manufacture, laser beams etc will all be used with great advantage. The better understanding of collagen composition and structure may lead to newer collagen products for use in other fields as well as to produce leathers with newer properties and newer uses. The poromerics have only become supplements not substitutes for leather. But as long as hide is a byproduct of meat industry and as long as the alternate use for hide does not fetch higher prices for hide, leather industry will continue to flourish. But leather industry must be sensitized to be alive and aware of leather substitutes and the implications of emerging technologies. The social aspects of this industry is an important if not more important than the economic aspects. Similarly extension service must become the 'third dimension' in addition to training and research. India should take the lead to assist developing countries in training, research, marketing etc sending out Indian experts and training personnel from developing countries, in negotiating terms and conditions for import/exports and in dealing with North-South problems.

CLRI-Unique Character

The unique character of leather was stated at the start. It is but appropriate to close by stating the unique character of CLRI.

- CLRI is reported to be largest of its kind in the world combining all aspects of leather industry under one roof starting from slaughter house

products to finished leathers and leather products; leather auxiliaries, tannery and other byproducts, effluents, machinery, etc.

- CLRI has not only laboratories for conducting basic research in twenty different scientific disciplines but also has commercial tannery, pilot plants, machine manufacture etc.
- CLRI is an ideal example of an inter disciplinary Institution that crosses a lot of borders; it is an excellent interphase between industry and academic, combining education, research and industry. In addition to the areas of industrial and socio-economic relevance problems of basic nature are also investigated.
- CLRI has an unique relationship with the University. The Department of Leather Technology of A.C. College of Technology the University is merged with CLRI, jointly run degree courses in leather technology and offer facilities for Ph. D. in several scientific disciplines.
- CLRI is the first to offer degree courses in Leather Technology in India.
- CLRI's, work in consonance with the growing realisation that scientific research is a practical tool that could be employed to faster economic growth and advance public welfare. CLRI is probably the only but certainly the first National Laboratory to have a full fledged Economics wing.
- CLRI has been known for its extension services with regional centres in Bombay, Rajkot, Jullundur, Kanpur, Calcutta and Madras.
- A large number of modern tanneries are today run by CLRI trained men.
- CLRI has trained a number of people from nearly thirty different countries who have been good ambassadors to India.
- CLRI experts have gone to various developing countries to assist the development of leather industry.
- CLRI has helped to set up U.N. aided Research Institutes in Somalia, Sudan, Nigeria, Turkey, Iran, etc.

Such is the unique character of CLRI With competence and confidence CLRI faces the challenging needs and demands made on the unique and ubiquitous leather and the social and economic development of Indian Leather Industry.