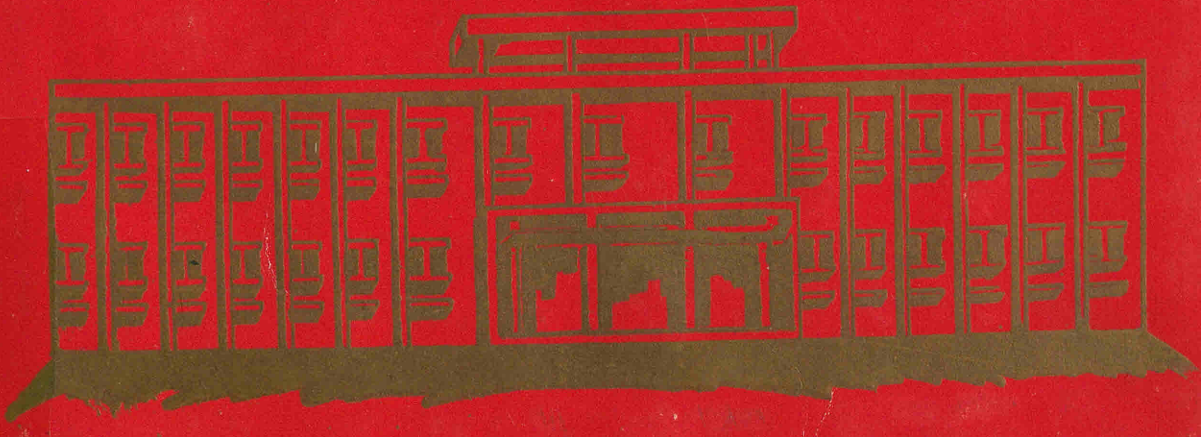


GOLDEN JUBILEE

NATIONAL DAIRY RESEARCH INSTITUTE

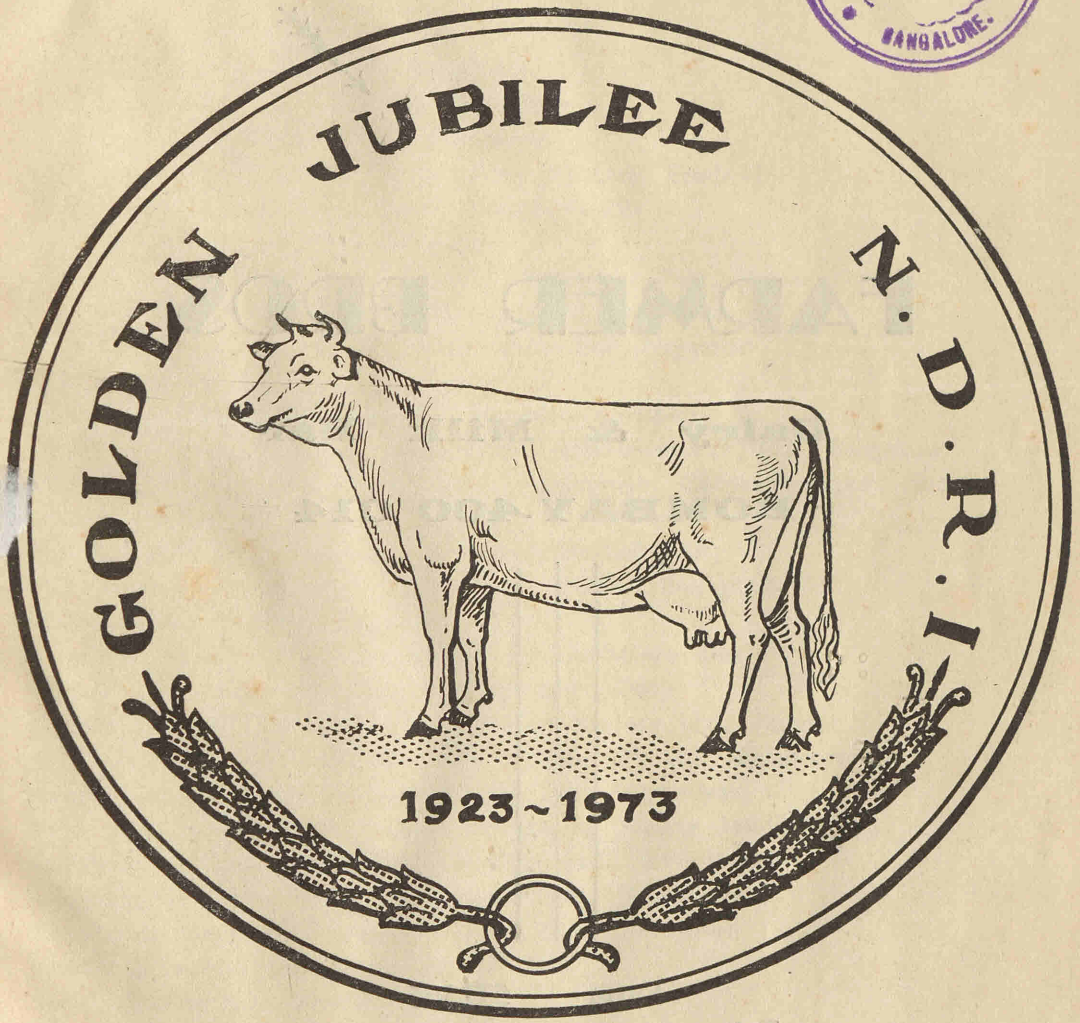
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RASHTRAPATHI BHAVAN
NEW DELHI–4

December 13th, 1973

MESSAGE

I am glad to know that the National Dairy Research Institute, will celebrate its Golden Jubilee in December, 1973

Since the establishment of the Institute in 1923, Dairy Research has received great impetus and the Institute has grown in strength and expanded its activities in many directions. As a result, considerable scientific knowledge regarding animal husbandry is available enabling us to improve the breed of cattle and to increase the production of milk and milk products. But, much more remains to be done and I hope the Institute will carry on its work with unabated zeal

I send my best wishes for the success of the Golden Jubilee celebrations

V. V. GIRI

MINISTER OF AGRICULTURE
GOVERNMENT OF INDIA

NEW DELHI-110001

5th December, 1973

MESSAGE

I am extremely happy that the National Dairy Research Institute is celebrating its Golden Jubilee in the month of December, 1973. From a humble beginning in 1923 at Bangalore, it has grown into a fulfledged research and educational organisation encompassing all the major disciplines in dairying at Karnal with three Regional Stations at Bangalore, Kalyani and Bombay, catering to the needs of the country on different aspects of dairying. The Institute has been instrumental in rendering valuable service to the country by development of pedigree herds of Indian dairy cattle and buffaloes as well as by initiating cross-breeding programmes for improvement of the cattle for increased milk production. The basic and applied research conducted at the Institute has laid the foundation for the modern dairy industry in our country. The Institute has also done a commendable job in the training of students at all levels, thus enabling the growth of modern dairy industry

I wish the Institute continued success in the service of our dairy farms and industry

F. A. AHMED



Prof. SHER SINGH

2826/RM/KM/73
RAJYA MANTRY, KRISHI MANTRALAY
NEW DELHI–110001

December 6th, 1973

MESSAGE

The celebration of the golden jubilee of the National Dairy Research Institute is an important land–mark in the progress of dairy research and development in this country. There have been several significant achievements made during the last fifty years by this Institute which have contributed substantially in establishing a well–knit dairy industry in India. The basic involvement of this Institute is in augmenting the production of milk and processing technology for a number of milk products consumed in this country. It is heartening to find that the research programmes of this Institute cover all the important facets of the dairy industry in the country. India is severely deficient in the availability of animal proteins which can be made up only through the production of more milk and milk products. Since these are important requirements for Nation's health and are linked with economic and social transformation of the people, I am confident that the scientists of this National Institute would continue their endeavour for narrowing the gap in the availability at present existing in this country

I wish the Golden Jubilee celebrations all success

SHER SINGH

GOVERNMENT OF KARNATAKA

No. CMG 649/73

D. DEVARAJ URS
Chief Minister

VIDHANA SOUDHA
BANGALORE-1

Dated 8th October, 1973

MESSAGE

It gives me great pleasure to learn that the National Dairy Research Institute, Bangalore, which has been functioning for the last 50 years as the national centre for the dairy education, research and development, is going to celebrate its Golden Jubilee in December 1973 and a souvenir is being brought out to commemorate the occasion

It is heartening to note that these 50 years in the life of the Institute have been characterised by expansion of its activities to centres like Karnal, Bombay, and Kalyani, besides Bangalore, to such an extent that a large number of cross-bred milch cows owe their origin to the Institute. Though the country ranks high in terms of cattle wealth, much remains to be done to raise the per capita output

The efforts of the Institute to impart instructional courses in modern dairy science and practice, develop pedigree herds and to conduct research will, I am sure, bear rich dividends

I wish the Institute and the Golden Jubilee celebrations all success

D. DEVARAJ URS

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
Krishi Bhavan, Dr. Rajendra Prasad Road
NEW DELHI–110001

Dated December 13th, 1973

Director General, ICAR, &
Secretary to the Government of India

MESSAGE

An improvement in the production of animal products at a compound annual growth rate of 5% is envisaged during the Fifth Plan period. The experience of the last 20 years has, however, shown that progress in this area is very slow and difficult. Just now, there is an acute milk shortage in many parts of the country. Several of our large dairy factories have to depend upon imported milk powder. On the other hand, the work of the National Dairy Research Institute has clearly shown that through appropriate genetic improvement better nutrition and proper health care, milk production can be greatly increased. Many cross–bred cows give not only more milk, but do so at a lower cost. Opportunities for balanced stall feeding can be greatly improved through better crop planning in the area of fodder and feed production. There are also great opportunities for using many agricultural and industrial wastes as animal feed. All this new technology has to be transferred as rapidly as possible to the numerous dairy farmers of our country. It is in this context that the work of the N. D. R. I both in the area of research and training is so significant to the eccnomic and nutritional well being of our people. I have little doubt that in the coming years the work of this Institute and of its alumni will prove crucial to the onward march of our agararian economy.

M. S. SWAMINATHAN

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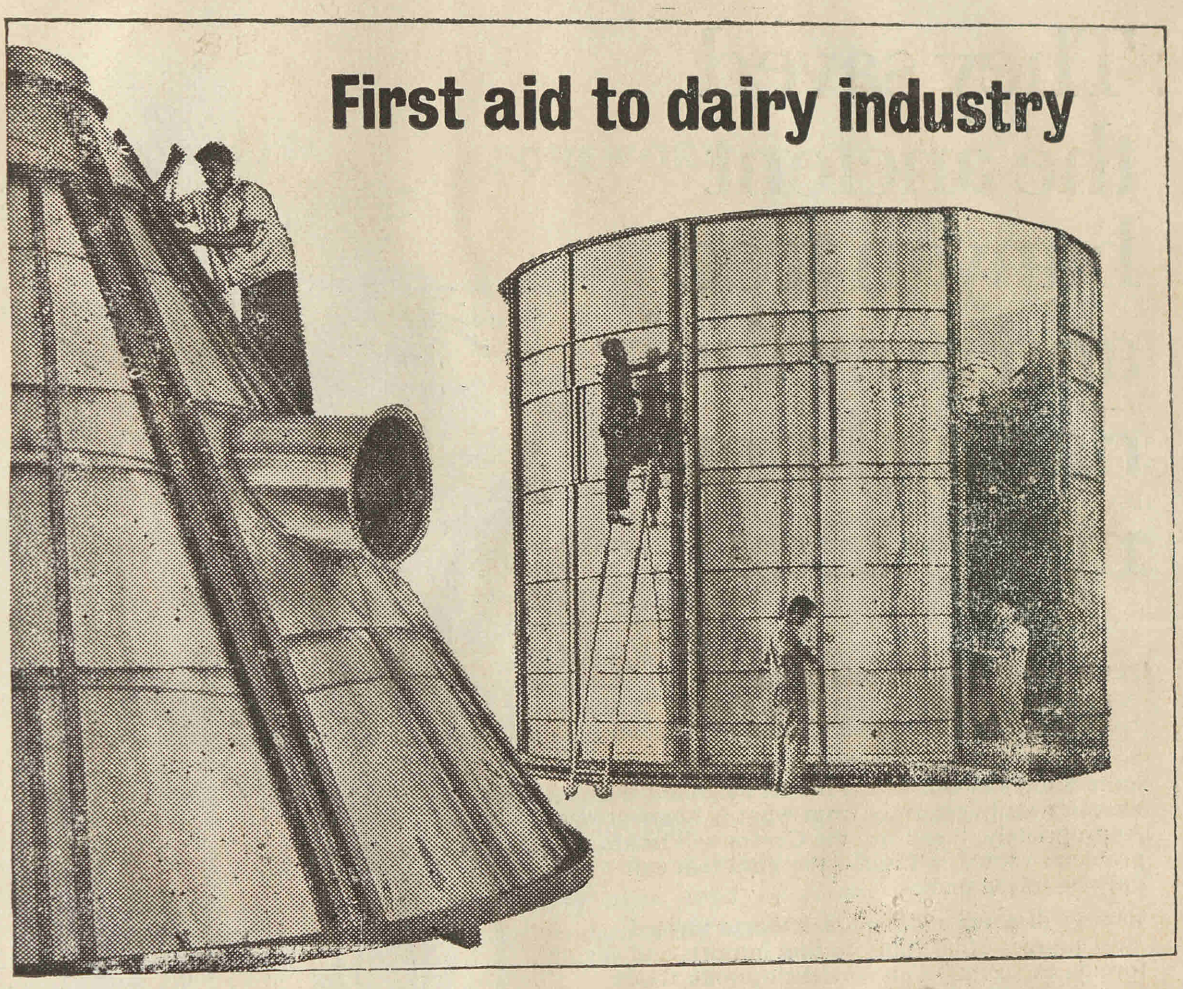
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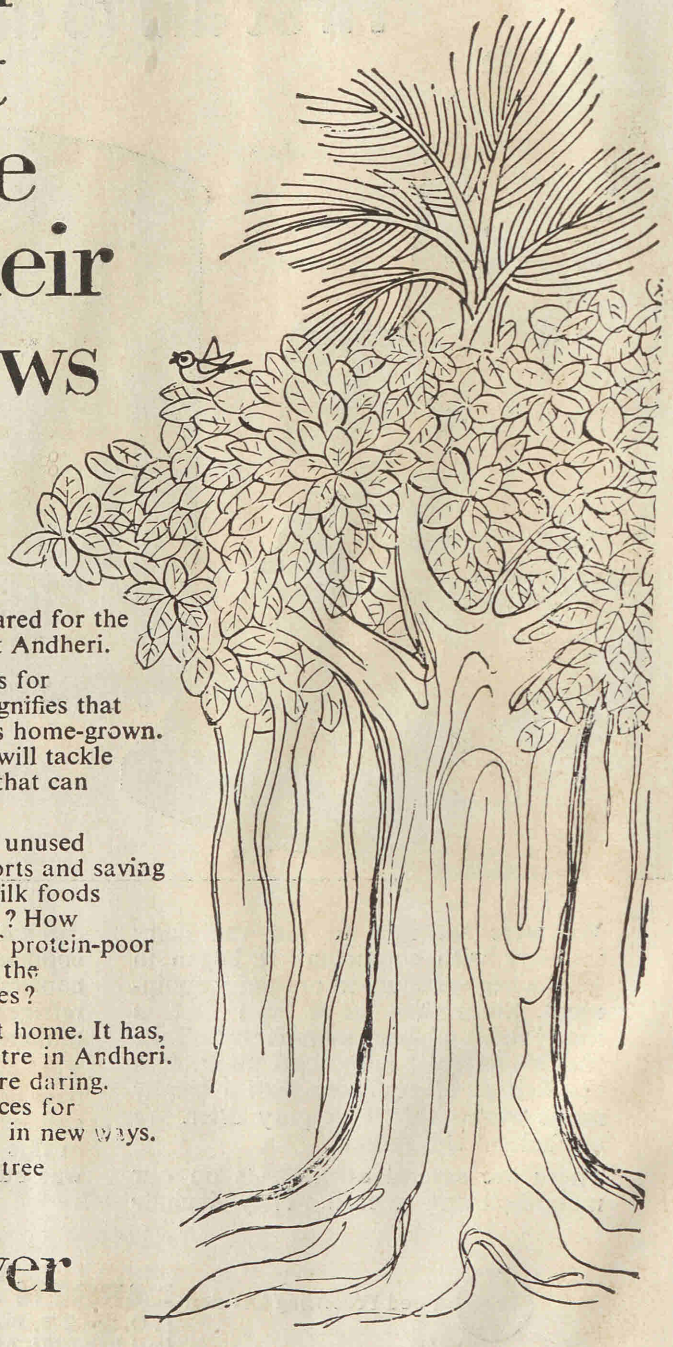
There are several other firsts on our manufacturing record. They include can washers, automatic bottling plants, condensed milk plants, bulk milk coolers, stainless steel butter churns, refrigerated tanks, large size road milk tankers and storage tanks.

Yet our engineers continue to plan new equipment—equipment that may still be the first in India. Our interest in this field never flags. After all, dairy was our first field of manufacture.

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AIV 506(R)

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'Let it stand,' someone said of the banyan tree as the site was being cleared for the Hindustan Lever Research Centre, at Andheri.

So the tree still stands—and it stands for quite a lot. For one thing, the tree signifies that we can't easily get away from what is home-grown. Appropriately, therefore, the Centre will tackle problems rooted in India—the kind that can only be solved here:

Can we discover and exploit hitherto unused *local* sources of oil, thus cutting imports and saving foreign exchange? Can we develop milk foods that are ideally suited to *Indian* needs? How can we improve the nutritive value of protein-poor foods? Can we develop processes for the preservation of Indian type food dishes?

Research on all this can only begin at home. It has, at the Hindustan Lever Research Centre in Andheri. The sweep and thrust of the studies are daring. The scientists are producing new devices for old, making traditional things happen in new ways.

They have, of course, left the banyan tree alone to grow by itself.

Hindustan Lever

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FOREWORD

I have been closely associated with the birth, growth and activities of the National Dairy Research Institute, for about 50 years and it is, therefore, a matter of pride as well as pleasure for me to write a foreword to this souvenir which is being issued on the occasion of its Golden Jubilee

The Institute has developed from a small beginning and all through its career, it has passed from crisis to crisis and its very existence was at stake on one or two occasions. Still the Institute has managed not only to undergo all the trials and tribulations but also strengthen its foundations, gradually increase its scope and activities and attain to the present position of a premier Institute for Dairy Research and Education in the whole of Asia

Dairying plays a vital role in the agricultural economy of the country and the health and nutrition of the population. In this context, the Institute has rendered magnificent service to the country by training a large number of students in modern dairy science and technology who have been entrusted with the task of development of the dairy industry in India. Many of them have held leading positions in Government organisations and the industry and outstanding work has been done in developing high yielding cross bred cattle and solving the problems connected with the application of modern dairy practices under tropical conditions

The souvenir depicts the history of the development of the Institute and giving an account of the achievements in the fields of dairy research, education and extension. I am sure it will provide very interesting and useful reading material to all interested in the work of the Institute and advancement of dairying in India

I wish the National Dairy Research Institute every success in all its endeavours to serve the needs of the country

Zal. R. Kothavalla
(Retd) Dairy Development Adviser
to the Government of India



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NATIONAL DAIRY RESEARCH INSTITUTE

Origin, Development and Achievements

D. Sundaresan

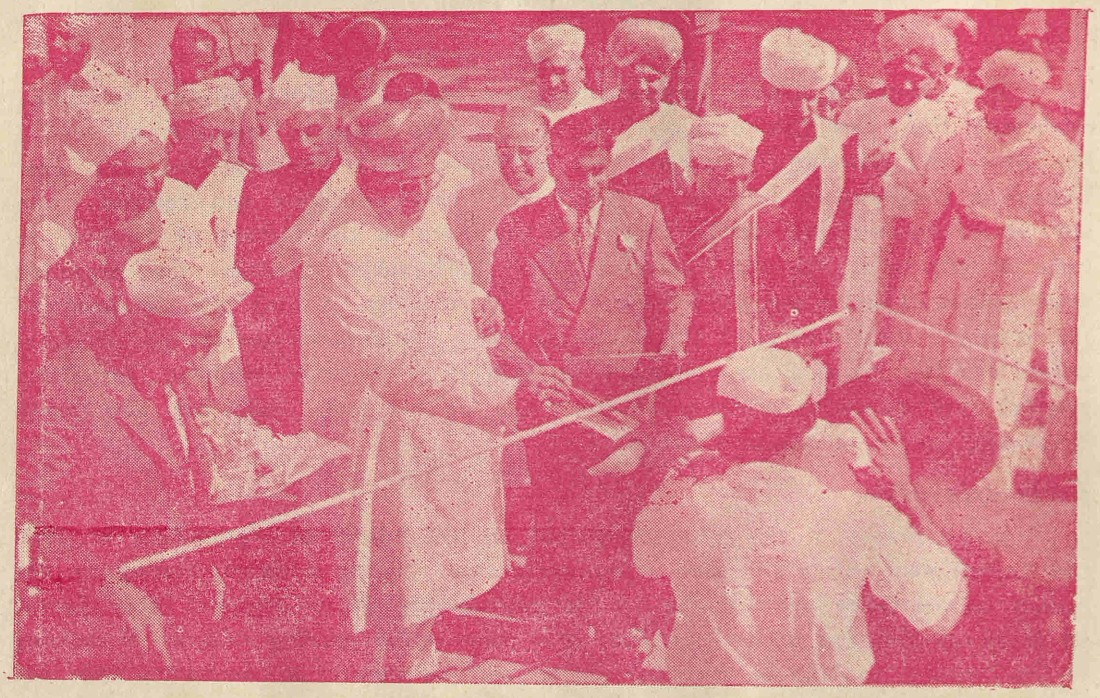
Director, National Dairy Research Institute
Karnal (Haryana)

The National Dairy Research Institute, whose Golden Jubilee is being celebrated this year, has developed from the Old Imperial Institute of Animal Husbandry and Dairying (later designated as Indian Dairy Research Institute) established at Bangalore in 1923 as a centre for dairy education and research. The starting of this Institute was an important land-mark in the history of dairying in India as this was the first concrete step undertaken towards the organised development of cattle and dairy industry in the country. During the 50 years of its existence this Institute has passed through many vicissitudes and changes in status before attaining to its present eminent position of a National Institute for Dairy research and education catering to the needs of not only India but also other developing nations in Asia and Africa

Early History

In pursuance of the recommendations of the Board of Agriculture in 1916 the Government of India took 2 important steps having a direct bearing on the history of the Dairy Institute viz. (i) the appointment of an Imperial Dairy Expert to supervise dairy instruction, to study and improve the existing methods of dairying in the country, to help in the establishment of the industry on commercial lines and to give technical advice and assistance to State Governments on cattle breeding and dairying and (ii) the appointment of a Physiological Chemist to carry out investigations on feeding of dairy animals. Mr. William Smith was the first Imperial Dairy Expert who was appointed in May 1920 with his headquarters at Kasauli (Punjab). The Physiological Chemist's section was started in 1919 at the Imperial Institute of Agriculture, which was then at Pusa, with Dr. F. J. Warth as the first Physiological Chemist. As an outcome of the efforts of Mr. Smith, supported by the recommendations of the Inchcape Committee (1923), the Government of India established the Imperial Institute of Animal Husbandry and Dairying in 1923 as a dairy training and research centre on the premises of the Military Dairy Farm at Bangalore, The new Institute was placed under the charge of the Imperial Dairy Expert whose headquarter was also transferred to Bangalore. The Military Dairy Farm at Bangalore

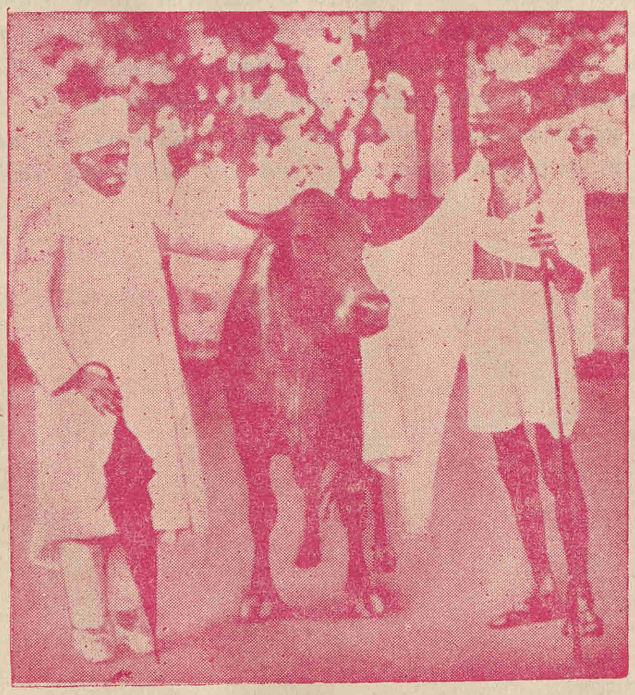
had a large dairy herd consisting mostly of cross-bred cattle (Ayrshire and Holstein crosses with Sindhi and Hariana breeds), which were later supplemented with a few pure bred Sindhi and Gir cows and Murrah buffaloes. This farm was utilised as the main educational and experimental centre. Two other Military Farms, one at Wellington (Nilgiris) and the other at Karnal (Punjab), were also attached to the new Institute to serve as sub-stations. The former offered facilities for training in hill dairy farming and the later was used for mixed farming and development of dual purpose herds of Tharparkar and Hariana cattle. In 1925, the old Military Creamery at Anand (Gujarat) was acquired and used as a centre for training students in milk products manufacture. The Physiological Chemist's Section was also transferred from Pusa and located at the Bangalore Institute.



Maharaja of Mysore, Naming the bull NANDI during Silver Jubilee

In 1923, the Government of India sanctioned the opening of a two-year training course at Bangalore for the Indian Diploma in Dairying on the lines of the National Diploma in Dairying given by the Royal Agricultural Society of England. The first batch of students admitted to the course consisted of 15 candidates selected out of 200 applicants from all over India. In order to meet the demands for trained personnel the Allahabad Agricultural Institute was also recognised as another centre for conducting the IDD course under the supervision of the Bangalore Institute. Two other courses viz. (i) a 15 months' Postgraduate course (subsequently designated as Associateship course) for imparting higher instruction in the science and practice of dairying and research techniques and (ii) short courses of practical

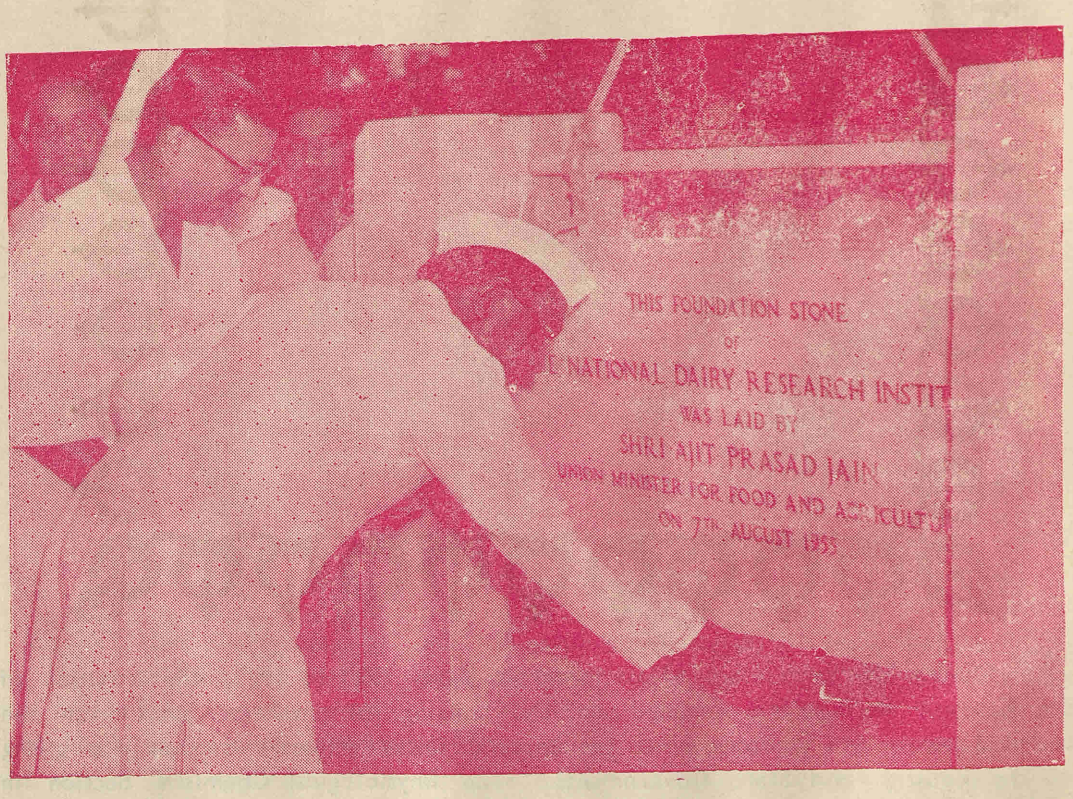
training in dairy farming for the benefit of the men in the industry, were initiated from 1924. A little later special courses of instruction for Cooperative Inspectors and vocational training course for soldiers and ex-service personnel were also introduced.



Mahatma Gandhi and Pandit Malaviya admiring an outstanding cow at the Farm

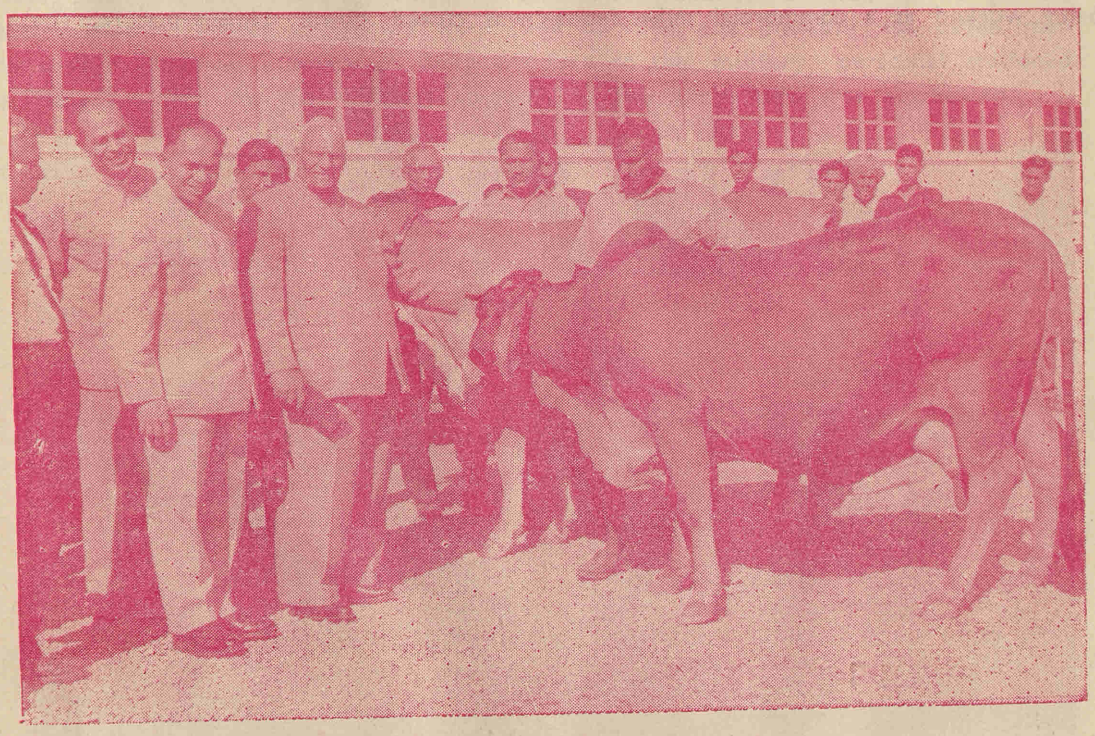
During the early stage of its progress from 1923 to 1932, the activities of the Institute were mainly confined to the training of students apart from the technical advice and guidance which the Imperial Dairy Expert's Section was giving to the industry and State Governments. The Physiological Chemist's Section in addition to conducting investigations on the feeding of animals in relation to milk production and other aspects was also participating in training of postgraduate students in research work. Three important events that took place in this period are worth recording. One was the organisation of a special lecture by Mr. Smith supported by cinema film on the subject of "Importance of cattle breeding and dairy

industry for India" on 21st February 1927 at Elphinstone theatre in Delhi before H. E. the Viceroy and other dignitaries. This was very much appreciated and it helped in focussing attention on the problems of the dairy industry. The second one was the visits of Mahatma Gandhi along with Pandit Madan Mohan Malaviya in 1927 to the Dairy Institute to see the activities of the Institute and get acquainted with modern methods of cattle management. Mahatma Gandhi evinced great interest in the work of Institute and wrote several articles in 'Young India' and 'Harijan' on the importance of dairying and scientific cattle management. Another event was the establishment of the Imperial Council of Agricultural Research (now known as the Indian Council of Agricultural Research) in June 1929 as a central agency for the promotion and coordination of agricultural and animal husbandry research in India. The Council has contributed greatly to the progress and development of the Dairy Institute by coordinating its activities with those of other All-India Institutes, by financing research schemes on important problems and by publishing research papers and articles in its journals.



Mr. Smith, retired in 1931 and Dr. Zal R. Kothavalla was appointed in his place. At this time the Institute came under the axe of the Retrenchment Committee. The Anand Creamery was closed down. Subsequently, in 1936, the Karnal farm was also handed over to the Imperial Institute of Agricultural Research, New Delhi, and the Phosiological Chemist's Section was transferred to Izatnagar under the

Imperial Veterinary Research Institute. There was, howerer, one important favourable development. The Imperial Dairy Expert's Section along with the Bangalore Dairy Institute was separated from the administrative control of the Imperial Agricultural Research Institute, New Delhi, and placed directly under the Department of Education, Health and Lands (the present Ministry of Agriculture). This change helped the Institute in securing greater attention from the Government in its development. The name of the Institute was changed to " Imperial Dairy Institute ".

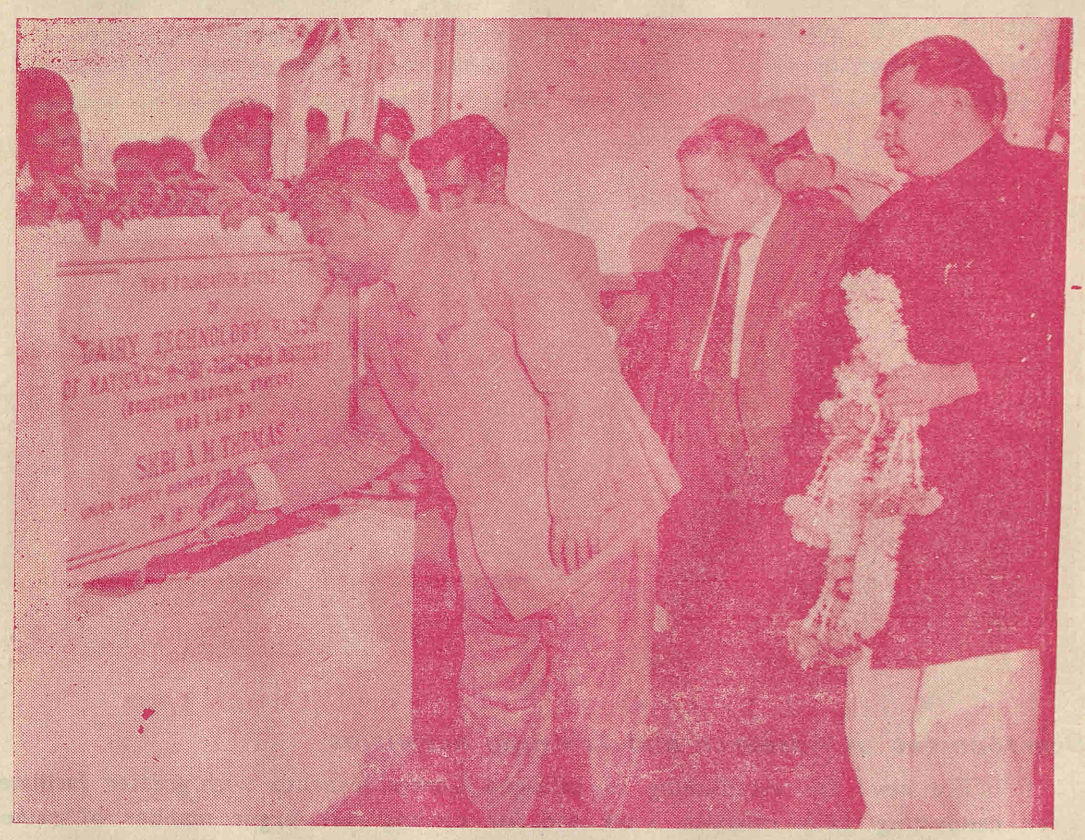


Vice President Giri admiring Karan-Swiss cow at Karnal Farm

Development of Research and Training activities

The need for establishing an enlarged Central Institute with greater facilities for conducting dairy research work and for turning out larger number of trained personnel was realised and endorsed at the first meeting of the Animal Husbandry wing of the Board of Agriculture and Animal Husbandry in February 1933. The Government of India invited Dr. Norman C. Wright, Director of Hannah Dairy Research Institute, Ayr (Scotland) to study the conditions relating to the development of cattle and dairy industry in India. His report was presented in 1937 and one of his important recommendations pertaining to the establishment of a well-equipped Dairy Research Institute at a central place, situated in an intensive dairy tract, was accepted by the Government. As a result, Dr. W. L. Davies of the National Institute of Research in Dairying at Reading (England) was appointed

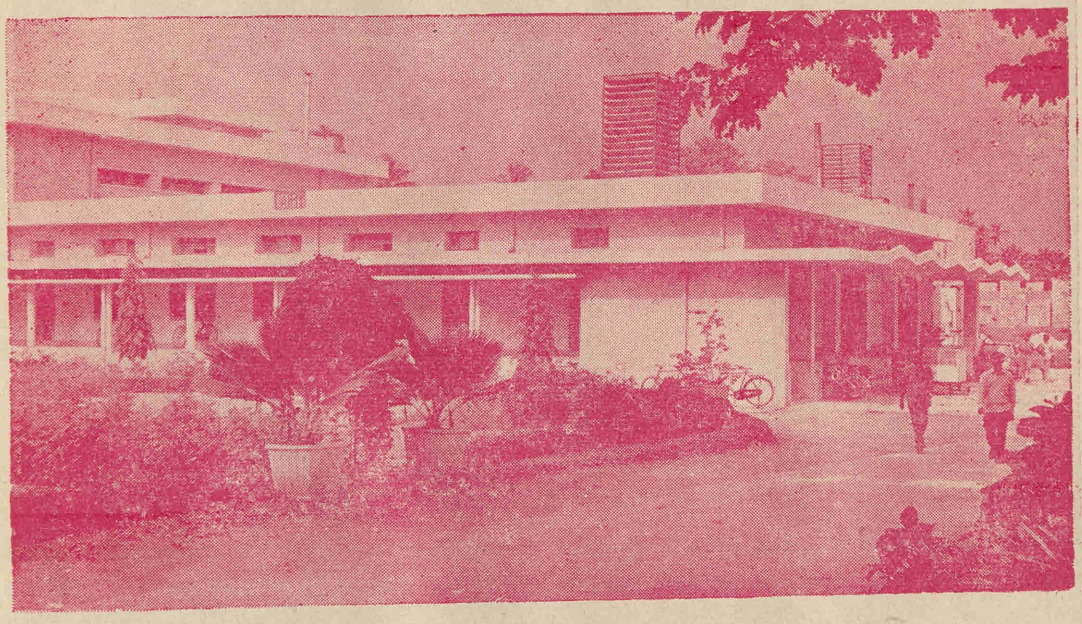
in 1939 as the first Director of Dairy Research with his headquarters at New Delhi. He was instructed to take action for setting up a Central Dairy Research Institute near Delhi. A suitable site in Delhi was also selected and plans for construction of buildings were under way. As advance action in this direction, two sections of Dairy Chemistry and Dairy Bacteriology with a skeleton staff were started in 1941 to form the nucleus of the proposed Institute and temporarily housed at the Imperial Agricultural Research Institute, New Delhi. The post of Imperial Dairy Expert at Bangalore was redesignated as Dairy Husbandry Officer and Principal of the Imperial Dairy Institute. The Wellington sub–station, which was being worked as a commercial milk depot, was closed down. Unfortunately, the



plans for establishment of the new Institute received a set back due to adverse economic conditions created by the second world war and the untimely death of Dr. Davies in May 1941. Dr. Kothavalla, Dairy Husbandry Officer and Principal, was then appointed as Director of Dairy Research and his headquarters together with the newly started sections of Dairy Chemistry and Dairy Bacteriology were transferred to Bangalore and merged with the Bangalore Institute. The existing activities at Bangalore were reorganised to constitute the Dairy Husbandry Section. With these changes, the Imperial Dairy Institute came to be known as the 'Imperial Dairy Research Institute,'

which was further modified to 'Indian Dairy Research Institute', after the attainment of independence by the country in 1947.

The Institute continued to conduct the IDD and postgraduate training courses and to develop pedigree herds of Sindhi and Gir cattle and Murrah buffaloes in addition to the cross bred cattle. Research work on problems concerned with milk production and handling, chemistry and bacteriology of dairy products and related aspects was initiated. The Director of Dairy Research with the help of his technical staff continued the work of the former Imperial Dairy Expert in providing technical advice and guidance to State Governments as well as to private entrepreneurs. During the period from 1943 to 1946, the Institute was called upon to supply increased quantity of dairy produce to the military personnel stationed at Bangalore and for this purpose strength of the dairy herd was augmented.

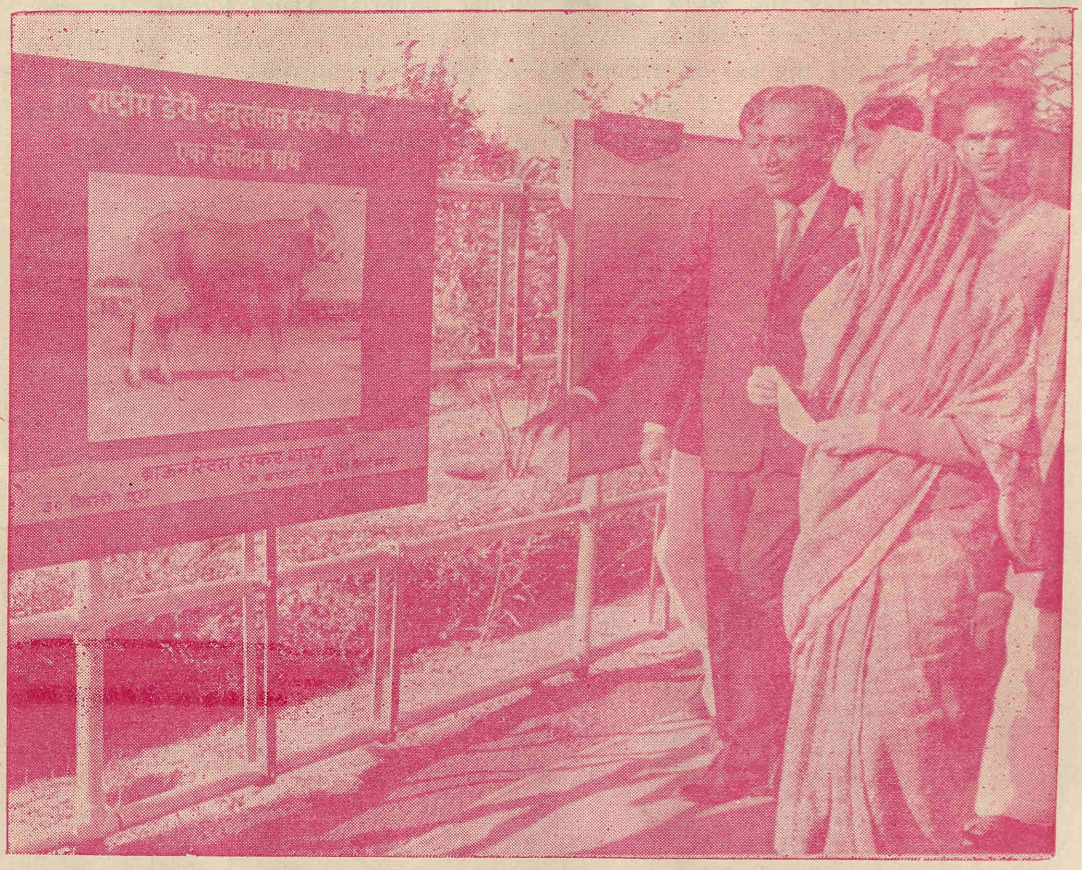


Dairy Technology Block at Bangalore

Consequent to the appointment of Dr. Kothavalla as Dairy Development Adviser in the Ministry of Agricultute, Government of India, in 1944, Dr. K. C, Sen, Officer-in-Charge, of the animal nutrition division, Indian Veterinary Research Institute, Izatnagar was appointed as Director of Dairy Research. In the year 1946, a new section of Dairy Technology was added to the Institute. Laboratory facilities were augmented and additional senior as well as junior research staff appointed. The Institute had now four research sections (Dairy Bacteriology, Dairy Chemistry, Dairy Husbandry and Dairy Technology) to intensify its research and training activities. The fifteen months' Associateship course was discontinued from 1947 and in its place, the Institute was permitted to entertain a limited number of Honorary Research Workers for taking up post-graduate studies leading to the M.Sc. and

Ph.D. Degrees of different Universities. The IDD course was continued and facilities were provided to admit larger number of students each year.

In 1947, the Director and staff of the Institute took a leading part in starting and developing the Indian Dairy Science Association and in publishing the two journals of the Association— Indian Journal of Dairy Science and Indian Dairyman. The Institute celebrated the Silver Jubilee of its foundation in 1948. His Highness the Maharaja of Mysore inaugurated the function.

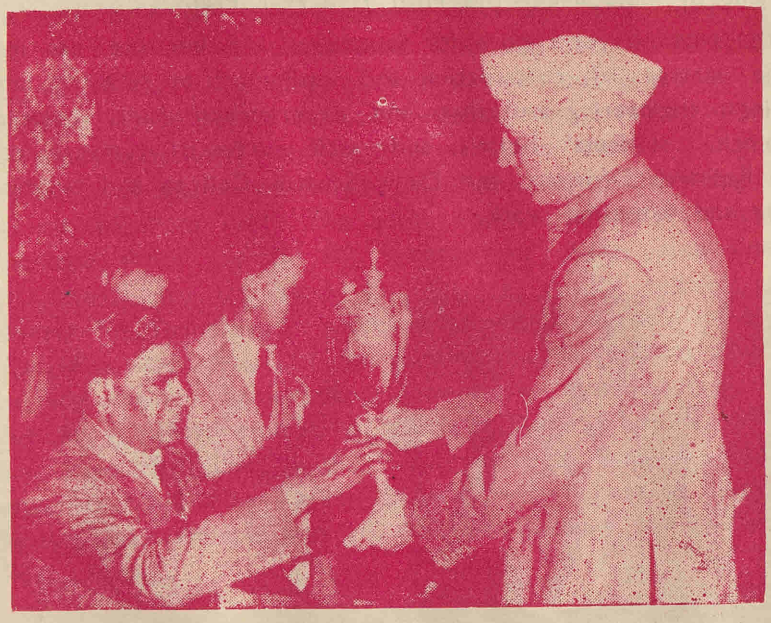


Prime Minister Indira Gandhi going round the Karnal Farm

The activities of the Institute were further increased during 1952-54 following (i) the location of the Southern Regional Animal Nutrition Research Centre at the Institute under an All India coordinated scheme sponsored by the Indian Council of Agricultural Research, (ii) selection of the Institute as one of the Key Village farms and artificial insemination centres for the improvement of local cattle under the All-India Key Village Development programme organised by the Government of India, and (iii) starting of the Central Artificial Insemination centre for the supply of Jersey bull semen to selected centres all over India for improving the milk yield of local cattle.

Establishment of National Dairy Research Institute and Regional stations

The proposal for reorganisation of the Institute was taken up once again in 1946–47 when Prof. H. D. Kay, Director of the National Institute for Research in Dairying, Reading (England) was invited to review the existing set up and make recommendations for the purpose. Prof. Kay recommended the early establishment

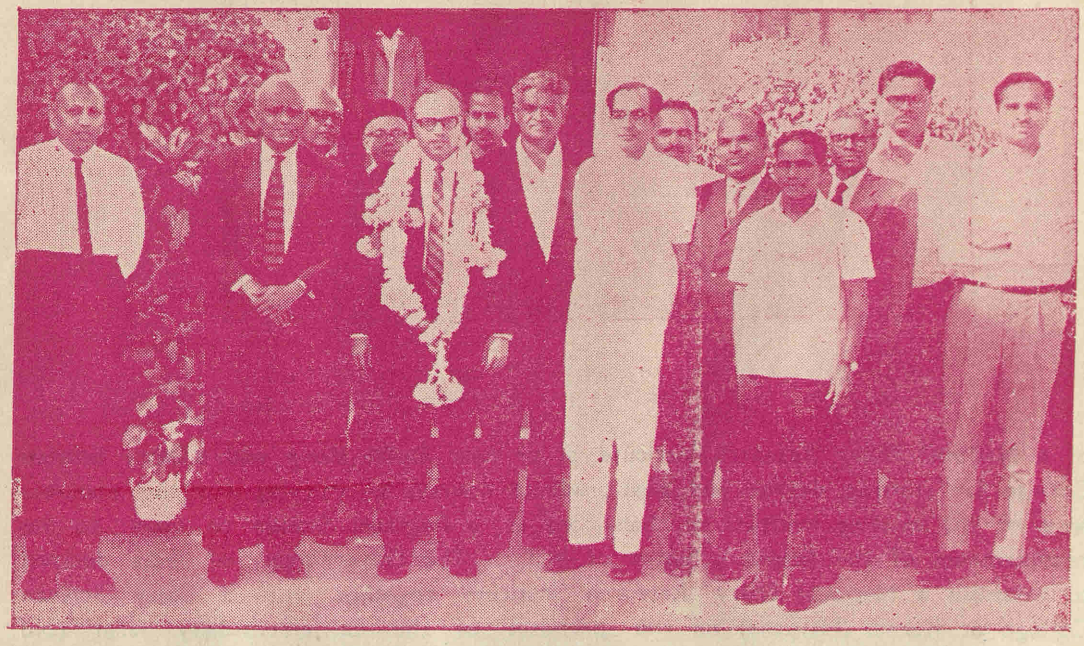


Prime Minister Nehru presenting Championship Cup to Shri A. J. Lazarus (NDRI) at the All India Cattle Show

of a National Dairy Research Institute at or near Delhi along with a Dairy Science College for starting degree and post-graduate courses in dairying and the continuance of the existing Institute at Bangalore as a Regional Station to cater to the requirements of the Southern States of India. The Government of India decided to establish a National Dairy Research Institute together with a Dairy Science College at Karnal (Haryana) on the premises of the cattle-cum-dairy farm (old Karnal farm) which was then functioning under the direct control of the Union Ministry of Food and Agriculture. The headquarters of the Director of Dairy Research was shifted to Karnal in June 1955. A number of senior research and technical staff were also transferred to Karnal to assist in the establishment and organisation of the new Institute. The foundation Stone for the Institute was laid on the 7th August 1955 by Sri Ajit Prasad Jain who was the Union Minister for Food and Agriculture at that time. Dr. K. C. Sen, who had held the post of Director of Dairy Research since 1946, retired in January 1957 and was succeeded by Dr. K. K. Iya, Dairy Bacteriologist at the Bangalore Institute.

The establishment and development of the National Dairy Research Institute, Dairy Science College and the Regional Stations was included as a project under the Second Five Year Plan with a total outlay of Rs. 118 lakhs. Subsequently, further allocations of Rs. 150 lakhs and Rs. 175 lakhs were made under the Third and Fourth Five Year Plans respectively towards the development and expansion of the Institute and the Regional Stations. Proposals for further expansion of facilities for research, training and extension work with an estimated outlay of Rs. 400 lakhs have been made to the Government of India under the Fifth Five Year Plan.

During the past 16 years since its foundation the Institute has made great progress in the matter of construction and equipment of research laboratories, cattle yard buildings, engineering workshop and experimental dairy, construction of administrative block, students' hostels, and staff residential quarters, recruitment of staff for the Research Divisions and Dairy Science College and organisation of research, teaching and extension work.



Dr. M. S. Swaminathan, Director General, ICAR at Bangalore Institute

The Institute was fortunate in receiving aid in the form of dairy plant and laboratory equipment under various foreign aid projects viz., the T. C. M. of U. S. A., Inter–Institutional arrangement with the Ohio State University (U.S.A.), Colombo Plan, UNICEF and Government of Netherlands, Denmark, Sweden, New Zealand and Australia. Many members of staff of the Institute were able to receive advanced training in different fields of dairy science and technology in U. S. A., Canada, Australia and other countries under one or the other Aid programmes. The foreign Experts

stationed at the NDRI under some of these programmes, rendered valuable assistance in the development of the Institute's activities.

The Dairy Science College, which was established in 1957, was affiliated to the Punjab University. The first B. Sc. (Dairying) course was started from July 1957 with only 10 candidates selected from all over India. Dr. Noshir N. Dastur, Head of the Dairy Chemistry Division at the Institute, was appointed as Principal of the College to organise and conduct the training courses. This degree programme offered broad training in the field of dairy science covering both dairy production and manufacture. In 1961, the composite B. Sc. (Dairying) course was bifurcated into B. Sc. (Technology) and B. Sc. (Husbandry) courses to turn out graduates with specialised training in these disciplines. M. Sc., courses in different branches of dairy science were started in 1966 and facilities were also provided to conduct postgraduate research work for the Ph. D. degree of different Universities. A Dairy Engineering Diploma course was started from 1961. The other educational activities undertaken by the Institute included short courses of training in dairy extension, dairy plant management, cheese and ice cream manufacture, quality control and other fields, training courses for farmers and house wives and organisation of Summer Institutes and Seminars. For supervising and coordinating the IDD training courses, being given at the Southern Regional Station, Bangalore as well as at Bombay, Anand, Allahabad and Haringhatta (Calcutta) centres, a Board of Dairy Education with the Director as Chairman was constituted by the Government of India in 1961 and this work was subsequently taken over by the ICAR Sub-Committee on Dairy Education. The IDD course was also bifurcated into IDD (Dairy Technology) and IDD (Dairy Husbandry) from 1961.

The Southern Regional Station at Bangalore has also made considerable progress in the development of facilities for its research and teaching activities. New buildings for students' hostel and technology block, housing the experimental dairy and research laboratories were constructed. The cattle yard buildings have been modernised and construction of a new Engineering Block is under progress. In addition to intensifying the IDD training course a number of short courses of practical training and training courses for farmers and dairy plant workers were started.

The Western Regional Station of NDRI was established at the Aaray Milk Colony, Bombay, in 1962. The Eastern Regional Station was started in 1964 on the campus of the Kalyani University near Calcutta. Negotiations have been in progress to secure suitable sites for the construction of research laboratories and other buildings.

The NDRI at Karnal as well as the Regional Stations have been visited by a number of foreign and Indian Scientists and dignitaries, Central and State Ministers, Members of Parliament and State Legislatures, industrialists and students. Sri V. V. Giri, when he was Vice–President, was the Chief Guest on the occasion of the Students' Union Day, and the Prime Minister Smt. Indira Gandhi paid a brief visit to the Karnal Institute in November 1970 and evinced keen interest in its activities.

The administrative control of the National Dairy Research Institute was transferred to the reorganised Indian Council of Agricultural Research in 1967. Dr. K. K. Iya, who was holding the post of Director since 1957 left the Institute in 1965 to become the Dairy Development Adviser, Government of India, and later Deputy Director General (Animal Sciences), ICAR. The post was subsequently held by Dr. S. N. Ray (1967–69) and Dr. Noshir N. Dastur (1969-70). Following the retirement of Dr. Dastur in November 1970 Dr. D. Sundaresan, Dean of postgraduate studies, Punjab Agricultural University, was appointed Directer of the Institute.

Present set-up and Activities

The National Dairy Reseach Institute at Karnal is situated on the Grand Trunk Road connecting Delhi to Amritsar. It covers an area of 600 hectares of which 400 hectares are under cultivation of fodder crops and perennial grasses and the rest used for roads, buildings, cattle yard, students' play ground and residential quarters.

The various activities of the Institute are carried on through 9 Research Divisions viz., Dairy Husbandry and Cattle Genetics, Dairy Cattle physiology and Nutrition, Dairy Bacteriology, Dairy Chemistry, Nutrition and Dietetics, Dairy Technology, Dairy Engineering, Dairy Economics and Statistics, Dairy Extension and Dairy Education with the attached Dairy Science College. There are 2 Students' Hostels and a modern Rest House as the estate.

The entire farm land is under mechanical cultivation and tube-well irrigation. The total amount of fodder produced per annum comes to about 25,000 tons which meets the green fodder requirements of the dairy herd. Several investigations are in progress to adapt new varieties of fodder, evaluation of cropping programmes, and relative nutritive values of different fodders.

The total herd strength is about 2500 including Red Sindhi, Sahiwal, Tharparkar Brown Swiss, Holstein-Friesian, Jersey and Brown Swiss-Sahiwal cross-bred cows, Murrah and Surti buffaloes and about 100 milch goats. About 4,500 litres of milk are produced daily and this milk is utilised for processing and manufacture of products in the Experimental Dairy. Farm bred pedigree bull calves are distributed to state farms for upgrading local cattle. A Key Village Development programme covering 10,000 rural cattle is in operation. Research work on cross-breeding and development of high milk yielding. Brown Swiss-Sahiwal crosses, physiology and nutrition of dairy animals and related aspects is being carried out. The Institute is maintaining 2 hectare and 5 hectare dairy farming units for demonstration to small and marginal farmers, and is conducting a project for obtaining better progeny from non-descript and useless cattle through cross-breeding. Annual Dairy Melas are also organised and the Institute also participates in All-India Cattle Shows and exhibitions. The Institute animals have been wining championships and other awards at the India cattle shows.

The Experimental Dairy, which is attached to the Division of Dairy Technology, is provided with modern plant and equipment to process and bottle milk and to manufacture all important milk products on a semi-commercial scale as well as to meet the training and research requirements. The dairy plant handles approximately

7,000 litres of milk a day. A bio-manufacturing unit has been set up for conducting pilot plant trials on production of dairy requisites like rennet, detergents, reagents for phosphatase test etc. based on processes developed at the Institute. Research work is in progress on standardisation of methods for manufacture of conventional as well as new dairy products and milk based food products. A milk parlour for the sale of dairy products to the public has been set up.

The Engineering Division has good workshop facilities for studies relating to designing and fabrication of dairy equipments. The Research Divisions have well-equipped laboratories and other facilities for carrying out fundamental as well as applied research work in different aspects of dairy science and for undertaking investigations on problems faced by the dairy industry in India. Several All-India Coordinated research projects are being organised by the Institute.

The Extension Division is responsible for the collection and dissemination of the result of research work carried out at the Institute, providing technical advice and guidance to farmers and publication of extension literature at the Institute press. The Economics and Statistics Division is helping other Research Divisions in the planning of research projects and interpretation of data, and conducting economic and cost surveys pertaining to milk production, dairy operation and marketing aspects.

The Institute Library has been organised and provided with latest books, reference works and periodicals on different branches of dairy science and technology and related subjects. Facilities have been created for operating documentation service. At present the Library has about 30,000 volumes of books and bound journals and is subscribing for some 600 periodicals from all over the world.

The Dairy Science College is running several instructional courses including B.Sc. (DT) and B.Sc. (DH), M.Sc. (Dairying), Ph.D., Dairy Engineering Diploma and short courses of practical training in different fields of dairying.

The Southern Regional Station is located on the Hosur Road in Adugodi village on the outskirts of Bangalore city. It has a total area of about 60 hectares of which about 40 hectares are used for cultivation of fodder crops. The total herd strength is about 400 including Jersey-Thari cross-bred cows and miscellaneous crosses, and Murrah and Surti buffaloes. The activities of the station are carried on through different units viz. Dairy Husbandry, Animal Nutrition, Chemistry, Bacteriology, Technology, Engineering and Education, Economics and Extension. The Central Artificial Insemination Centre located at Institute is supplying about 4 lakh ml of semen per annum from exotic and indigenous stock to over 100 centres in the Southern Region. The Key Village unit with 10 centres is providing A.I. Services and covers 24 village centres round about Bangalore. Under the All-India coordinated project a germ plasm Scheme is also in operation. The Southern Regional Animal Nutrition, research centre is functioning at this station.

The station has a new Dairy Technology building housing the dairy plant and Chemistry and Bacteriology laboratories used for students' training and research. The dairy plant has a capacity to handle about 4000 litres of milk a day and has

equipment to manufacture butter, cheese, condensed milk, milk powder, ice cream and casein. The Institute is actively assisting the Bangalore Dairy in many ways. The senior staff of the Institute have been giving technical advice to dairy plants/ farms in the Southern Region. Research work on various problems of the industry with particular reference to the Southern Region is being carried out. The Library is well stocked with books and reference volumes (about 7,000) and is subscribing for about 200 Journals. The station is giving training courses for the IDD (DH & DT) and short courses in various aspects of dairying.

The Western Regional Station at Bombay is at present housed in a farm unit at Aarey Milk Colony. It has a small dairy herd for experimental work. Several varieties of fodder crops are being grown on the available land with the exclusive use of farm yard manure and cattle yard washings. A Gobar gas plant is also being worked. A small laboratory has also been set up for chemical and bacteriological investgations.

The Eastern Regional Station is located on the premises of Kalyani University near Calcutta and is having a dairy herd for nutritional and other studies. Some work is being carried out on fodder production. A good laboratory for nutritional, chemical and bacteriological investigations is available. The Eastern Regional Nutritional Research Centre is located at this station.

Achievements

During the last 50 years the Institute has made valuable contributions in the fields of Dairy education and research. The highlights of the progress achieved in these directions are briefly reviewed in the succeeding pages.

ANIMAL BREEDING AND GENETICS

R. Nagarcenker and H. Kamalakar Bhat

The early work of the pioneers in the field of dairy cattle breeding was in defining the various breeds of Indian cattle [30,31,72,73,84,88,89,90]. They also tried to identify the problems facing the cattle–dairy industry in the country especially the contributions of Smith and Kothavalla need special mention [31,32,33,81,82,83,85,86,87]. Smith recommended formulation of pedigree herds of cattle to be bred for dual proposes i.e. milk and draft, encouragement for the cultivation of fodder crops and elimination of useless and unproductive cattle. Kothavalla stated that the introduction of the exotic animals may not be suitable for all regions of India and advocated the development of dual propose breeds for milch and draft proposes, and selective breeding to increase milk potential in the herds of Sahiwal, Red Sindhi, Hariana and Tharparkar. He stated that the buffaloes were adaptable to varying conditions and were even suitable for work in the regions of heavy rainfall and so they would remain premier milk producing animals in the tropical countries.

Selective breeding programme in Zebu cattle and Buffaloes

Davies stressed the importance of proper recording to evaluate the performance of male and female animals by the farmers and the necessity of the analysis of such records by independent bodies like milk recording societies, etc. The periodical recordings at an interval of 3, 7, 14 and 21 days as compared to daily recording gave an error in the estimation of lactation milk yield to an extent of 1.4, 1.8, 2.9 and 3.5% respectively in Red Sindhi, Gir and Ayrshire x Sindhi crosses[63].

The criteria in breeding of dairy cattle such as progeny performance, type appraisal, etc. have been described [27,53]. Though the selection is a time consuming method, it has to be depended upon since indirect methods such as skin studies, blood group types etc. had not yet been proved efficacious[53]. Various methods of selection and the role of progeny testing and artificial insemiation in making faster genetic progress in our dairy cattle by undertaking large scale progeny testing programmes in Key Village Schemes and Intensive Cattle Development projects have been discussed[40,43,46]. The data of Tnarparkar and Sahiwal herds at Karnal have been used to compare various methods of estimating breeding value of bulls and a Dairy Search Index was recommended for the purpose [95,98].

The history of the three herds of Zebu cattle i.e., Tharparkar, Sahiwal and Red Sindhi maintained at Karnal has been described[99]. The average age at first calving was 42 months among Tharparkar and Sahiwal and 41 months among Red Sindhi cows. The first lactation production and overall average lactation milk yield during the years 1956-60 in these three herds were: 1995 and 2211 kg. in Tharparkar, 2218 and 2417 kg. in Sahiwal and 1526 and 1753 kg. in Red Sindhi. The heritability estimates for age at maturity for Tharparkar, Sahiwal and Red Sindhi herd were reported to be 0.26 ± 0.18, 0.38 ± 0.26 and 0.44 ± 0.50 respectively[68]. Heritability estimates obtained by intrasire regression of daughters on dam for Tharparker herd were 0.32 ± 0.10 for age at first calving, 0.30 ± 0.26 for first lactation milk yield and 0.27 ± 0.15 for first calving interval[19]. Heritability estimate for 1st lactation milk yield by intrasire regression of daughters on dams was reported to be 0.22 ± 0.02 in Tharparkar and 0.44 ± 0.32 in Sahiwal[29]. The repeatabitity estimates for milk production were 0.49 ± 0.06, 0.52 ± 0.03 and 0.37 ± 0.12 for Tharparkar, Sahiwal and Red Sindhi breeds respectively[29]. Some workers[10] analysed the data of Tharparkar and Sahiwal herds at Karnal and found no outstanding bulls with an index of above 20% of the herd average. Analysis of breeding records of Red Sindhi and Gir herds maintained at Bangalore indicated that 5 out of the 36 Red Sindhi bulls had an index above 10%, of herd average, 2 of which had an index over 20% where as among 15 Gir none had index above 10%. The heritability and repeatability estimates for lactation milk yield in Red Sindhi were 0.37 ± 0.14 and 0.54 respectively. In case of the Gir herdthese estimates were 0.67 ± 0.40 and 0.66 respectively. The selection differential for milk yield per generation was found to be 192 lb for cows and 210 lb. for bulls in the Red Sindhi herd, the average generation interval being 7 and the % genetic gain per annum being 1.10. The selection indices for Tharparkar herd at Karnal evolved on the basis of 1st and 2nd lactation milk production, age at first calving and first calving interval have been reported[22].

Tha effect of restriction on first calving interval was found to affect the genetic gain in the total genotypic value much more than the restriction on age at first calving. The inbreeding coefficient in the same herd ranged from 2 to 30% with an average of 9.7%. However, no significant effect of this was found on the age at 1st calving, 1st lactation milk yield and 1st calving interval[24,]. Life time production from first lactation production was estimated for Tharparkar, Sahiwal, Red Sindhi and Ayrshire crossbreds[69]. Eighty % of the Tharparkar cows calved between November–May and 70% of Hariana cows calved between October-April at Karnal, and the average butter fat % was 4.553 and 4.595 respectively, the range being 3.8 to 5.2 in both the breeds.[34] A trend in the Hariana was seen that fat % reduced with increase in milk yield. With each month's advance in lactation the fat % increased by 0.062 in Tharparkar and by 0.079 in Hariana.

The influence of various factors affecting milk production in Red Sindhi, Gir and Ayrshire X Red Sindhi crosses at Bangalore has been studied[102,104,106]. Red Sindhi gave the highest milk production in the 3rd lactation (7.7 years) whereas

in crossbreds it was in the 4th lactation (6.0years). No effect of season of calving on milk yield was found in Red Sindhi. There was a positive and significant correlation (0.34) between body weight and milk yield in Red Sindhi and for every lb increase in body weight, the milk increased by 3.4 lb. The average service period was 156 days with 53.6% coefficient of variation in Red Sindhi and the order of lactation had no effect on service period. The average age at first calving (AFC) in Red Sindhi, Gir and Ayrshire X Sindhi cows was 42.9, 47.3 and 35.1 months respectively. The average first lactation milk yields were 3323, 3149 and 4458 lb. in a lactation period of 305, 301 and 327 days respectively in Red Sindhi, Gir and Ayreshire X Sindhi cows. Similarly the average calving interval was 461, 465 and 397 days respectively. The AFC was positively correlated with 1st lactation milk yield, 1st lactation length and 1st calving interval. All these correlations were significant except in case of AFC and 1st calving interval among Gir cows.

Tha average AFC in Tharparkar herd at Karnal was reported to be 31.49±0.29 months,[50,51,52]. The average number of lactations completed in life time was 3.1. No significant correlation of AFC with 1st lactation milk yield and life time production was found. The percentage of calving was lowest in November-January. Maximum yield was obtained from the cows calving in November and the lowest from those calving in September. The order of lactation and month of calving had significant effect on lactation yield. The average dry period in this herd was found to be 147.3 days with a C.V. of 67.8% The correlation between preceeding dry period and the subsequent lactation yield was 0.092 ($P<0.01$). It was concluded that a minimum dry period of 30 days was desirable. The heritability for age at AFC was reported to be 0.21±0.09 in Tharparkar[16]. The correlation between AFC and monthly gain in weight from birth to AFC was −058±0.10 and between AFC and weight at first calving was −0.48±0.11. The heritability estimate for breeding efficiency in the same herd was 0.30±0.12 on the basis of 1st 4 calving intervals[71]. The genetic correlation between breeding efficiency and AFC was—0.78± 0.19 and between breeding efficiency and 1st lactation production was—0.61±0.24. AFC affected milk production in Sahiwal breed upto 39.39 and 26% for the yield obtained upto 6, 8 and 10 years of age[21]. Similarly first lactation milk yield affected the milk produced in the first 5 lactations and upto 6, 8 and 10 years of age by 43, 22, 30 and 16% respectively. Inclusion of AFC along with 1st lactation yield increased the efficiency of prediction of life time production.

Various workers[2,3,5,35,36] investigated the causes affecting the gestation period and birth weight in cattle and buffaloes. They observed the average length of gestation period in days to be 283.00 in Sindhi, 285.09 in Gir, 279.98 in Ayrshire crosses, 277.77 in Ayrshire, 284.70 in Tharparkar, 288.38 in Sahiwal and 305.30 in Murrah. The breed of cattle, level of exotic inheritance among crossbreds, sex and sire of the calf were found to influence the gestation period significantly both in cattle and buffaloes. Weaning and month of freshening had no effect on gestation length. Order of lactation influenced gestation length in case of crossbreds and Murrah buffaloes.

The average birth weights in Red Sindhi, Gir and Ayrshire crosses were 45.6, 49.3 and 54.9 lb respectively. The birth weight was influenced by sex of the calf, calving sequence, sire, weight of the dam and gestation length. The birth weight in Murrah calves was reported as 81.4 and 70.2 lb for male and female calves respectively. No relationship was found between the increase in the dams' weight during gestation and the birth weight of the calf. The weight increase in dam was the highest during 3rd-6th month of gestation. In Murrah buffaloes the birth weight was not influenced by the month of freshening of the dam.

The heritability estimates were low for A.F.C. in Tharparkar, Sahiwal, Red Sindhi, Brown Swiss X Zebu crosses and Murrah buffaloes[73,77]. Culling of animals on the basis of performance alone had no effect on A.F.C. The correlation coefficient between growth rate upto 6 months of age and A.F.C, was found to be negative and significant in Sahiwal breed. The average productive life of Tharparkar, Sahiwal and Red Sindhi herds was 7.28, 7.65 and 7.66 years respectively[79]. Similarly the largest span observed in these 3 breeds was 18.5, 17.5 and 16.5 years, respectively. In case of Tharpakar it was found that the average productive life was 4 years and the average number of lactations completed in the herd were 3.5. About 40% of the animals were culled before the completion of three lactations.

The average A.F.C., the first lactation milk yield, Ist lactation length and Ist calving interval for the Murrah herd at Bangalore were 44.3 months, 3253 lb, 327 days and 490 days respectively.[103, 105, 107, 108]. The A.F.C. was significantly correlated with Ist lactation milk yield (0.39) and Ist lactation length (0.38). Nearly 70% of the buffaloes calved between July and December. Significant effect of the season was observed on the length of the service period. The overall lactation yield was 4052 lb, average service period was 202±8 days and significant correlation was found between service period and milk yield in that lactation (0.50). The March-May calvers had maximum length of service period (249 days) and June-Septmber calvers had a minimum length (138 days). Similarly significant correlations were found between weight at freshening and first lactation milk yield (0.45) and between weight at freshening and average yield in all lactations (0.20). The average dry period was 183 days and nearly 55% of the observations were in the range of 60-180 days. The correlation coefficient between preceeding dry period and subsequent lactational milk yield was not significant.

Similar information for the Murrah herd at Karnal has been reported[25]. The average A.F.C., average lactation production during the first 8 lactations, and average lactation length were 41.0 ± 0.7 months, 1495.0 ± 27.9 Kg and 269.0 days respectively. The average calving interval was 439.0 ± 7.3 days with a.c.v. of 31%. The relative afficiency of cow and buffalo as converters of feed on the basis of 2335 and 2007 lactations respectively has been compared.[67] The cost of feed for the production of 1 Kg of milk in cows and buffaloes was 43.77 and 52.41 paise respectively, for 1 Kg of F.C.M. (4% B.F.) it was 37.1 and 35.4 paise respectively and for 1 Kg of fat it was Rs. 8.47 and Rs. 7.28 respectively.

Buffaloes were reported to be better converters of fibrous feed and fodder than the cows[111]. The contribution of cattle and buffaloes in the countries economy has been discussed giving detailed statistics on the population, milk production, meat production and other by-products such as hides an skins, fat, bones, horns and hooves and slaughter house by-products[23].

Cross breeding with exotic breeds for milk production

Crossbreeding with Taurus breeds has been recommended in order to make the cow more economical in tracts where such cattle could be maintained and grading up with better Zebu milch breeds in other tracts[96]. Sterilising of poor yielding cows in order to reduce the gene frequency for low milk production in the further population was also suggested. Crossbred cows were profitable even in comparison with well defined indigenous dairy breeds[93]. A plan for increasing milk production by resorting to crossbreeding with exotic breeds in order to develop cows with an average production of 2000 litres per lactation within one generation has been outlined, indicating a strategy for producing 50 million tons of milk by the year 1980 by selection among buffaloes and by developing about 20 million crossbred cows[94]. Various breeding plans such as *interse* mating among F_1 hybrids, increasing exotic inheritance upto 3/4 level and use of more than 2 exotic breeds to have final level of inheritance upto 3/4 exotic have been stressed. Data on cost of production per litre of milk in Tharparkar, Sahiwal, Red Sindhi and cross-bred herds at Karnal have been presented to illustrate how the cost reduces as the production level of cow increases.

Another worker[48] elaborated a plan to produce 51 million tons of milk by the year 1980 by selection among buffoloes, by maintenance of nucleus of exotic Taurus cattle at various homoclimatic regions in the country and crossbred cattle of different exotic levels of inheritance in regions depending on the potentialies of the tracts. The results obtained on crossbreeding between exotic and Zebu cattle at various places in India have been reviewed[45,49]. The profitability of crossbred cattle has been indicated[56].

The results of cross crossbreeding work conducted at NDRI since its inception, with Ayrshire as exotic and Hariana, Sahiwal and Red Sindhi as foundation Zebu and similarly from 1938 with Friesian X Red Sindhi were summerised.[74] The crossbreds were found to yield more milk, had longer lactation length and productive life and shorter service and dry periods. The crossbreds matured early. It was seen that, the increase in exotic inheritance did not necessarily result in higher milk production. Half to five eighths Ayreshire crosses performed better than other rosses. There was an increased percentage of susceptibility to F & M disease among the crosses with higher exotic level. Abortion rate was higher among crossbreds when compared with indigenous cattle; It was 3% in Red Sindhi, 7% among half breds and 13% among 3/4 exotic crosses. The mortality rates were 23.6% in half breds 15.0% in quarter breds and 15.3% in the Red Sindhi.

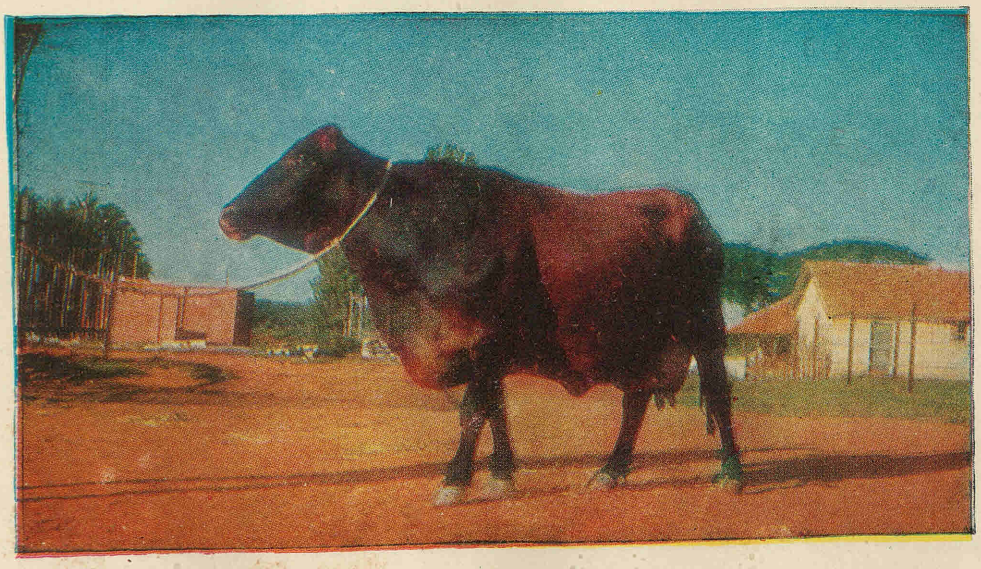
Summaries of the results obtained recently on the cross-breeding of Jersey with Tharparkar cows at Bangalore have been published periodically.[4,41,44] The A.F.C. among half-breds was 30.6 months as compared to 39.1 months in their dams. Tha lactation yield varied from 2078 Kg in the first lactation to nearly 2800 Kg in the 6th and 7th lactations. This was in comparison with range of 1000–1400 Kg production in the Thari dams. The average lactation length among the crossbreds was also higher and varied from 301 to 318 days depending on the order of lactation, whereas among their dams it was 254 to 286 days. The inter-calving period on average among F_1 cows was 12.9 months as compared to 15.5 months in their Zebu dams. By ten years of age the F_1 cows completed 7 lactations and produced 167 quintals of milk testing 5.0% butter fat, while very few of the Thari cows remained in the herd till 10 years of age by which time they completed only 5 lactations and produced 66 quintals of milk testing 4.6% butterfat. Percentage of abortions and still births were 7.2 and 1.9 respectively among the F_1 cows. Further studies are in progrers to compare the production of F_1 cows with their F_2 progeny born out of interse mating among F_1 and 3/4 Jersey x 1/4 Thari cows. The growth rate among F_1 calves was the best. The conception rate with frozen semen was 49.2% on the first insemination basis in crossbred animals.

Crossbreeding work at Karnal was started with the use of imported frozen semen of Brown Swiss bulls of proven merit. The results obtained have been periodically published[9,11,12,13,14,24]. The Red Sindhi and Sahiwal herds were used as foundation females for cross-breeding purposes. The birth weight in the F_1 calves was 26.27 Kg which was 25.30% more than that of the contemporary Zebu. The growth rate upto 6 months was 510 to 530 g in the crossbreds which was higher by 100 g than that of the contemporary Zebu calves. The average A.F.C. for F_1 cows was 30 months as compared to 40 months for their Zebu dams. The lactation production in 305 days was 3392 Kg in the F_1 as compared to 1986 Kg in Sahiwal and 1817 Kg in Red Sindhi dams. The average lactation length was 283 to 353 days in the crossbreeds as compared to 248 to 269 days in the Zebu in different lactations. The average intercalving period was 12 5 months in F_1 cows. The average cumulative yield of F_1 cows upto 6 lactations was 183 quintals whereas in case of Zebu the cumulative yield upto 4th lactation was 70 quintals. The average A F.C. for F_2 cows born of *interse* mating of F_1 was 36 months while the same was 30 months among 3/4 exotic. The milk production in the first two lactations was lower by 20-25 in% F_2 compared to the F_1 Brown Swiss X Sahiwal and Brown Swiss X Red Sindhi cows.

The environmental factors to be considered while introducing the exotic breeds and evolving new types for a particular region have been stressed[42,45] A revision of the P F.A. rules 1955 was suggested since the cross-bred cattle especially with Ayrshire and Friesian inheritance produced milk with low butterfat content and low S.N.F., in order not to discourage the farmer from resorting to crossbreeding with exotic cattle for augmenting milk production[15].



COWS ON PASTURE



CROSS BRED COW



FODDER MAIZE



FODDER DEMONSTRATION PLOT

Managemental Studies

By keeping equal intervals between milkings in crossbreds, equal yield in milk and fat could be obtained even though the evening milk had slightly higher butter fat percentage[17]. By keeping unequal intervals it was observed that the milk yield increased with longer intervals whereas, butter fat % increased with shorter intervals. The functional individuality of different quarters of udder in Red Sindhi and crossbred cows has been studied and right hind quarter was found to yield maximum milk and fat[20,39]. The hind quarters yielded 33% more milk than the fore quarters and right quarters yielded 12.2% percent more milk than the left quarters. There was no difference between butterfat % of milk from different quarters. Three times milking per day increased milk production by 6-8% on an average compared to twice a day milking in Red Sindhi, Sahiwal and Tharparkar cows[100].

The steps needed in raising calves successfully in health and sickness have been described[91,92]. Various operations e. g. forage and pasture management, feeding, labour management, housing, breeding, record maintenance and probhylactic measures in the management of a milking herd have been discussed[47]. No difference was found in milk and butter fat yields of cows of Tharparkar, Sahiwal and Brown Swiss crosses fed individually or in group lots[28] There was no appreciable difference in milk production between groups of cows fed *ad-lib.* and adequate green fodder as per their requirements[110]. The dry matter consumption was however higher in *ad-lib* fed group.

Maximum calf mortality among various breeds of cattle and Murrah buffaloes was between birth and one month of age (50–55% of the total mortality)[7,76]. The mortality rates were higher during winter. Pneumonia and diarrhoea ranked first and second among causes for mortality.

Trials conducted on machine milking of cows and buffaloes showed that machine milking was faster and yielded a little more milk compared to hand milking and the time taken for milking was reduced by 44 % by machine. Butterfat % was not affected by machine milking[97,101]. Temperamental causes especially in case of buffaloes increased time for let down during machine milking and also was responsible for drop in milk yield. The rate of milk flow differed significantly from animal to animal and it decreased with the advance of lactation[37]. The heritability estimate for milking rate was found to be high. According to some workers[70] a group of 10 milkers could handle 174 cows yielding on an average 6.12 Kg of milk per day in three milkings. In case of high yielders, the number of cows that could be handled was 145.

The incidence of mastitis was 45.5% among cows and 30.8% among buffaloes[64,65]. The incidence was observed to increase in later lactations Staphylococcal and Streptococcal infections were more frequent among cows and buffaloes respectively. On testing relative efficiency of various methods, Hotis reaction and microscopic

examination of incubated samples were found to be reliable methods for diagnosis of the streptococal infection. A rapid test (S. L. S. T. test) for diagnosing subclinical mastitis was developed[66].

Dipping of cattle in " Cooper cattle stock dip solution " helped in improving the coat of the animal and eradicating tick infestation and skin diseases[62]. A suitable technique for fixing canula to collect the abomasal juices for rennet isolation from live Zebu and buffalo calves was developed[60]. This rennet could replace imported Hansen's rennet for cheese making. The incidence of brucellosis in cattle and buffaloes in India, the various causative organisms and economic losses due to the disease have been reported[75]. An incidence as high as 20% has been reported from heavy rainfall tracts.

Genetical investigations

Studies on blood protein polymorphism on cattle and buffaloes revealed that fourteen cattle blood group reagents were produced by iso and heteroimmunisations[6,20]. The haemoglobin phenotypes and 5 transferrin phenotypes were found in Murrah buffaloes.

A quick serological test (Hansa test) for detection of cow milk adulterated with watered buffalo milk or with goat milk has been evolved[8,26,38,57,58,59,61]. The new test was based on antigen-antibody reactions Since there are differences in the milk proteins of different species, the antisera was prepared by immunising rabbits against the milk protein of a particular species. The agglutination reaction could easily be observed by naked eye within a short time and hence this was recommended as a quick platform test in dairy plants wherever the milk of each species is accepted separately and the rate of payment for milk differs depending on the species.

A spermogglutinating factor in normal cattle serum which arrested the motility of spermotozoa was observed.[65a] Seminal plasma was also seen to react immunologically with the spermasoagglutinin showing presence of common antigen between ejaculated spermatozoa and seminal plasma.

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ANIMAL NUTRITION

S. R. Sampath and S. P. Arora

Research on the nutrition of farm live stock has attained considerable importance due to intensification in the scale of live stock production. Systematic research in animal nutrition in India started in 1921, when Warth, the then physiological chemist initiated the work on composition and nutritive value of common feeds at the Imperial Agricultural Research Institute, Pusa, Bihar. In 1923, the section was transferred to the Imperial Institute of Animal Husbandry and Dairying, Bangalore. Later, the section was transferred to Indian Veterinary Research Institute, Izatnagar in 1936. However, the work on animal nutrition continued to be carried out at Bangalore. The nutritional laboratories have now considerably expanded in the country and many Agricultural Universities, Veterinary Institutions and Animal Husbandry departments of different States are all contributing by carrying out extensive investigations in this field.

In the year 1954, ICAR sponsored the establishment of Regional Animal Nutrition Centres. Southern Regional Station of National Dairy Research Institute became the centre of activity for the Southern Region. An account of the work carried out at the Institute is presented here under in brief.

Nutritive value of feeds

Chemical composition and nutritive value of para (*Braciaria mutica stapf*) grass was determined. The grass contained 8.11% DCP and 59.54% TDN[46]. The crude protein % in the strains of berseem varied from 17.2 to 19.37 while total dry matter yield varied from 152.52q to 162.4q/hectare. There was no effect of sowing tetraploid berseem on the fodder yields and the nutritive values were high for tetraploid than diploid[73].

Studies carried out on the nutritive value of different varieties of cow pea revealed that the varieties FOS-10, K-397 and FOS-1 produced the highest yields in terms of green yield as well as dry matter[75]. A varietal trial on oats for fodder, using different varieties, indicated that flaming Gold variety proved best in terms of highest dry matter yield for the 1st year while the Algerian variety proved to be better in the 2nd year. Flaming Gold produced the highest green yield of 509.9q/ha, but the highest dry matter yield of 108.38q/ha was recorded in the Algerian variety[77]. Teosinte (*Euchlaena mexicana schrad*) yielded better than maize but was less palatable when allowed to grow very tall and fibrous. If cut at

the proper stage, it can replace maize fodder and can be grown in low lying areas[72]. The approximate composition on dry matter basis of cow pea fodder at the flowering stage was 17.4% crude protein 2.5% ether extract 33.1% crude fibre and 2% Ca[74].

Nutritive value of Hybrid Napier was at its best with regard to total nutrients at about 6 weeks of growth but the oxalic acid content varied between 2.52 to 3.00% which was however below the toxicity level[71]. Supply of 40 to 60 kg N/ha increased yields of mustard fodder and the digestibility of cellulose also increased with increasing levels of nitrogen[92]. The Farm grown guinea grass contained 8.34% DCP and 53.90% TDN[1]. Fodder Jowar (90 days old) contained 4.40% DCP and 58.01% TDN. Feeding of Jowar to the animals resulted in daily retention of 29.17mg, 1.03g, 150.62mg and 1.16mg of Cu, Fe, Mn and Co respectively[16].

Paddy straw contained 46.94% TDN[101]. Ensiling of paddy straw with Berseem reduced the oxalic acid content of straw by 27.96%[43]. Mixing Berseem with wheat straw in silage making increased the cellulose digestibility of the straw[55]. Ragi straw contained 0.41% DCP and 58.42% TDN[39].

Tapioca contained 1.46% DCP and 83.34% TDN[60]. Ragi (*Eleusine Coracana*) grain grown as a millet was ground and fed to cattle. The digestibility trial revealed that ragi grain contained 3.87% DCP and 72.28% TDN, Ragi grain could well replace the other millets in the concentrate mixture[2].

The general microbial fermentation in the rumen with special reference to cellulose digestibility in coarse fodders along with the associated effect of feeding on their nutrient utilization of such roughages was described[104].

Agro-Industrial by-products as feed to cattle

In order to augment the resources of cattle feed, agro-industrial by-products were examined and assessed for their suitability as feed. Mulberry (*Morus indica*) leaf stalk remnants available after feeding the leaves to silk worms, were examined for their utility as cattle feed. The material contained 7.84% DCP and 48.35% TDN and the animals relished the same[98]. Adult bullocks fed with mulberry leaf stalk remnant retained 41.5% of carotene in the system and their blood carotene recorded an increase. The blood vitamin A level also increased. The balance per day of Fe was 0.31g, while those of Mn and Cu were 217.88 mg and 167.52 mg respectively[12]. Plenty of groundnut haulms (plant portion) are available. The cattle relish the same. The feeding trial conducted revealed that plant material contained 5.4% DCP and 50.9% TDN[15]. Spent tapioca pulp is a by-product obtained during the manufacture of starch from tapioca. The results of feeding trial indicated that the material has about 70% TDN[8]. The spent lemon grass, contained 6% crude protein. The DCP and TDN of this by-product worked out to be 0.64% and 49.76%, respectively, which shows that it compare well with the cereal straws in its nutritive value[31,48].

A feed compounded by mixing 70 kg spent lemon grass, 10 kg wheat bran, 2 kg groundnut cake, 15 kg molasses, 0.5 kg urea, 0.5 kg mineral mixture and

1 kg salt, was fed *ad-lib* to 5 adult dry and non-pregnant Tharparkar cows for a period of 30 days and during the last 10 days, a metabolism trial was conducted. The average dry matter intake was 2.11±0.15 kg/ 100 kg body weight and all the animals gained in their body weight. The nutritive value of the compounded feed was 4.37 kg DCP and 55.30 kg TDN respectively per 100 kg dry matter[79]. An investigation was conducted to assess the nutritive value of sal seed meal as well as the suitability of this material to be incorporated as an ingredient in concentrate mixture. It was observed that the material was highly astringent and unpalatable to cattle. The crude protein content of the meal was about 9% of which the digestible portion was nil and TDN content was also as low as 41%. The astringency as well as non–availability of protein in the ration was attributed to the high tannin content (7 to 8%) in sal seed meal[37]. Effect of feeding sal seed meal on the utilization of biuret in growing heifers was studied[42]. Significant differences in the digestibilities of dry matter, organic matter, CP, CF and NFE were observed. Feeding of sal seed meal in certain limits has no toxic effect, but long term trial is necessary specially in the case of milch animals if its feeding has to be continued for a longer period of time[63]. However, sal seed meal could be incorporated in the concentrate mixture up to 20% replacing the grain portion for feeding to cattle, provided the fat content of the mixture is kept high by incorporating ingredients such as whole cotton seed.

The composition of rain tree fruits were examined[25]. The fruits of rain tree can serve as a valuable concentrate in the ration of livestock especially during dry season[64].

Animal Nutrition survey

Animal Nutrition Surveys were carried out. The areas covered were : a low plane area in Nagarcoil (Tamil Nadu); Kangayam tract (Tamil Nadu); Tirupur tract (Tamil Nadu); Karimnagar (Andhra Pradesh); Ongole tract (Andhra Pradesh) and Malnad area of Karnataka State. The main object of this survey was to find out the qualities of animals. types and quantities of feeds available, methods of feeding in vogue, extent of shortage of feeds for livestock, methods adopted for the preservation of fodders and the approximate milk yield of buffaloes and cows. In Nagarcoil area, the mixture of grasses had 5 to 13% crude protein. Milk yield of cows ranged from 0.5 to 1.0 kg / cow / day. Late maturity was common in cows. The body weight of cows and buffaloes varied from 112 to 170 kg and 190 to 366 kg respectively. The calves had poor growth, rough skin, non–coordination of legs, staggering gait, lack of eye reflexes, opacity and in some cases, even complete blindness. In the Kangayam area, the survey revealed that the protein content of the grasses ranged from 5 to 12%. Rice bran, cotton seed and groundnut cake were used as concentrates for milch cows and working cattle. During monsoon, the animals obtained most of their requirement of nutrients from the pasture fields. Late maturity and long calving intervals were found to be common feature in the cattle. In Tirupur area, the cows were of non-descript type and buffaloes of local breeds or crosses of local with Murrah breed. The

protein content of grasses ranged from 2.6 to 5.5%. The body weights of cows and buffaloes ranged from 152 to 326 kg and 180 to 485 kg respectively.

In the Karimnagar area, cows (mainly Malvi) were reared with a view to get male calves and were owned in large numbers. Buffaloes were the only source of milk and their yield ranged from 1.0 to 1.5 kg / animal / day. There was acute scarcity of feeds and fodders in the area for the major part of the year. Grazing facilities were also very meagre and were limited to waste lands and Government lands. Occasionally, green maize and jowar were given to the cattle.

Ongole tract is famous for the Ongole breed of cattle. In the tract, various types of grasses and fodders were available. The grasses provided fairly adequate amount of nutrition during monsoon months. Pasture in the area comprised of many indigenous grasses, which contained 6.7 to 12.9% crude protein. The straw of rice and millets were the fodder available during winter and summer months. The average milk yield of cows ranged from 1.0 to 3.6 kg and that of buffaloes 2.0 to 4.0 kg/ day.

Malnad area of Karnataka State extends across the State from north to south with a range of elevation from 305 metres to 2,400 metres. The rain-fall is continuous and 380 to 500 cm of annual rain-fall has been recorded. Animals in the area are short in size and stunted in growth and locally termed as 'Malnad Gidda'. They are poor milkers and kept as a source for obtaining manure. The pasture in the area contained 2.67 to 12.72% crude protein. Bullocks of Hallikar breed were maintained in some of the villages mostly for ploughing work. Cases of nasal granuloma in bullocks were observed in some areas. Hypocalcemia cases were reported to occur in other areas. The animals recorded low level of Cu and Fe contents in their blood. The presence of eggs of liver fluke, parampistomum cervii, oocyst of coccidia and strongyle, were observed in the faeces samples, collected from some of the area of Malnad[60].

Effect of varying the level of nutrition on performance

Studies carried out revealed that the total protein N in milk was found to slightly lower on high protein ration and little higher with low protein feed. The total NPN, urea nitrogen and amino acid —N in milk increased when the level of protein in the ration was changed from the normal to high by 36.8%, 56.7% and 36.8% respectively, and decreased when high protein feed was replaced with a low protein ration by 31.2%, 51.6% and 28.3% respectively[103]. Sindhi cows were fed at 3 levels, i.e., normal, low and high levels of protein, with nutritive ratio of 1:6.7, 1:4.7, 1:7.8 for a period of 15 days. The % of NPN in the total N in milk of cows fed normal, high and low protein rations were 5.14, 7.06 and 4.70 respectively. Slight changes in other NPN constituents were observed. Effect of work done by cows on total N and NPN constituents of milk was studied with one group of 7 cows put to light ploughing work for 4.5 hours and the other group served as control. The additional energy requirement of the cows for work was met by feeding an additional 2 lb concentrate. Negligible differences in the total N and NPN constituents of milk of cows of 2 groups were noticed[102]. The

requirement of DCP for the Tharparkar cows both for maintenance and milk production was studied. The results indicated that lower level of DCP, i.e., 15% lower than that recommended[89] was satisfactory for maintenance. The production requirement was found to be 0.043kg DCP/kg milk at 5% fat[93]. Experiment was conducted on Tharparkar–Jersey bullocks, wherein body weight and balances of N were taken as the criterion of assessing the adequacy of the level of protein fed[38]. The maintenance requirement of protein for cross-bred animals was found to be 20% less than that recommended by Sen[89].

Effect of Various supplements in the ration of Cattle

Good growth was obtained on less protein suitably furnished than that recommended in Morrison feeding standard and providing the same levels of TDN in the diet[57]. All the calves showed positive N balance[56]. Further more it was observed that male calves grew at a significantly higher rate than female calves[58]. Colostrum fat at 3% level in skim milk was a good substitute for whole milk in raising of new born calves[67]. Effect of feeding milk substitute to calves on the growth rate was studied. Almost equal gain was observed in both the experimental and control groups. The cost of raising calves with milk substitute was about 1/2 of that of control.

Study on feeding vitamin A supplements to calves of indigenous breed revealed that the calves receiving the supplements recorded an increase in weight and height. Feeding of shark liver oil supplements to 4 day old calves resulted in a slight increase in the body weight and height as compared to calves of control group[33]. Feeding of refined groundnut oil and hydrogenated groundnut oil instead of milk fat to calves has been recommended on the basis of results obtained in experiments. The hydrogenated groundnut oil with melting point of 37°C at 4% level in skim milk with a small amount of shark liver oil concentrate was found to be satisfactory substitute for whole milk in the rearing of young calves. The use of this substitute reduced the cost of raising young calves and also saved milk fat for human consumption[20].

Ghee residue available from ghee refineries may be unfit for human consumption. The possibility of feeding this to growing heifers was examined. Each heifer was fed 0.5 kg of ghee residue replacing 0.25 kg concentrate mixture in the ration. Marked beneficial effect such as 60% higher growth in the ghee residue fed heifers was noticed.

Supplementing the ration of calves with 2 g iodinated casein per 100 lb live-weight resulted in the reduction of growth rate of approximately 43% and 55% in the groups of calves below and above 1 year respectively[91]. However, it was observed that feeding of iodinated casein to calves at low levels stimulated the growth. In another study[27], it was reported that calves receiving iodinated casein registered a higher growth rate initially, but at the end of 20 weeks, the difference in increase in growth rates of calves of two groups were not statistically significant. Metabolism study indicated that the animals getting iodinated casein were retaining

sufficiently less amount of N. No difference was found in the Ca and P balances of the calves of control and experimental groups. A retardation in growth, a slight rise in body temperature and pulse rate were noticed in the calves, administered iodinated casien. Administering 2 g of iodinated casein per 100 lb live weight to milch cows resulted in an increase in milk yield also. Even fat and SNF did show an increase during the period of treatment. Feeding of iodinated casein (0.75 and 1.24 g per 45 kg body weight) to young heifers improved in the absorption of P but no significant deviation took place in the metabolism of Ca and P when hyperthyroidism was indicated by supplementary feeding of iodinated casein[61]. Consequent to feeding iodinated casein to cows, the milk yield was found to increase and on withdrawal of the same milk yield was drastically lowered. Slight increase in fat content persisted even when iodinated casein was withdrawn from the ration. The increase in fat content varied from 8.0 to 21.3% over those of pre-treatment periods. The SNF increased from 3.7 to 9.3%[68].

Feeding 5 mg 'DES' daily for 24 weeks to 1 month old female calves resulted in an increase of nearly 7 kg in body weight over the controls. Feeding 10 mg of the same daily for 24 weeks to 1 year old heifer also showed some response in growth The effect due to feeding of 'DES' to one year old Sindhi and half-bred was more pronounced in male than in the female. Feeding upto 10 mg daily to lactating cross-bred cows for over a period of 16 weeks produced very little beneficial effect on the yield of milk or milk fat or solids-not-fat.

Hormonal injection hastened the occurence of oestrus in indigenous cows after parturition and early maturity in heifers and young bulls However, it could not stop the need for repeated service in cows. The administration of hormone rejuvenated the bulls about 12 years of age, which were slow at service[17].

Feeding of 2 g nicotinic acid mixed with jaggery or intravenous injection of 0.2 g of the same in 20 ml of normal saline every day to Sindhi cows continously for one week, did not affect the milk yield, fat, protein and lactose contents of milk.[111]

Supplementation of Cu and Co in the daily ration of heifers resulted in a significantly higher Cu and Co balances and increased blood Cu level. Liv-52, a herbal preparation and an anabolic agent, was found to contain 2.63% Ca, 0.18% P, 0.42 Mg, 116.2 ppm Cu, 427.5 mg% Fe, 234.5 ppm Mn and 0.9 ppm Co. Administration of 5 g Liv-52 / day animal was found to aid better retention of Ca, P, Mg, Fe and Co[14].

There was a general decline of tocopherol and carotene contents of fodder such as jowar, lucerne, guinea grass and napier grass with progressive growth[69].

A significant increase in the carotene and vitamin A of blood plasma was recorded when the green grass given to the animals was increased from 5kg to 10kg/animal/day. Supplementing the ration with 25,000 i.u., of vitamin A per day did not significantly increase the plasma vitamin A.

The effect of copper sulphate supplementation on the retention of Cu in the system and the reproductive performance of the heifers was investigated. When

the ration of the heifers, which had not come into oestrus even at the age of 27 to 39 months, was supplemented with 0.5 g copper sulphate per day per animal. 25% of the supplemented was retained in the system and the animals came into oestrus early and conceived [80]. The effect of copper sulphate supplementation at levels of 200, 300 and 400 mg/day/ milch animal was studied. The cows of supplemented groups had highest positive balance of Cu compared with those of control and also recorded higher level of blood Cu., P. C. V., Hb., and erythrocyte count. The supplementation of Cu at the rate of 200 mg/day was found to be beneficial. The effect of supplementation of 16, 24 and 32 mg cobalt chloride/cow day was also studied. The digestibility of nutrients were higher for the ration supplemented with 16 mg level. The supplementation of Co helped in bringing into oestrus the cows within 42.5 days as compared to cows of control group with post-parturition oestrus of an average 69 days[35].

Miscellaneous Studies

Feeding of 10 lb bago-molasses (*molasses 2 parts and bagase 1 part*) in a balanced ration had no adverse effect on growth and milk production. It can replace 3 lb of usual concentrate feed.

The vitamin A content of butter fat in buffalo milk showed an immediate increase when a carotene-low ration was replaced by carotene rich ration. Whereas the animals on high carotene ration were placed on a low-carotene ration, the vitamin A potency of milk went down, but the fall was found to be comparatively slow. The average vitamin A potency of butter fat was found to be 760 i.u per 450 ml on increased level of feeding of greens. The stored vitamin A in the system of the dairy cow was slowly used up when carotene supply was in deficit. The carotenoid feeding helped to build up reserve of vitamin A in the animal and slight increase was found in the milk also[45].

Silages were made out of sugarcane tops, sugarcane tops with molasses and sugarcane tops with a mixture of guinea grass and napier grasses. The molasses and mixed grasses produced more palatable silage compared with those made from sugarcane tops alone. Feeding 20 lb of silage daily/cow did not have any adverse effect on milk yield, fat output, general health and body weight of milking cows. Cows getting less silage consumed more ragi straw. Cows getting silage were found to record increase in the weight over those fed without silage. The quality and quantity of milk yield was not affected[34].

The anatomical and physiological developments of stomach of the ruminant (buffalo calf) fed different ratios of roughage to concentrates were studied. The study revealed that buffalo calf adapted during earlier age to dry feed and the rumen development was accelerated by restricted milk feeding and introducing dry feed in the diet from early age. The major changes from non-ruminant to ruminant type of metabolism took place at the age of 8 to 10 weeks and adult type of rumen function was achieved by restricted milk feeding and with access to dry feed/which resulted in maximum benefits to dairyman and saving milk for human consumption at the same time[105].

A study was carried out wherein the calves were fed reduced quantity of milk and the balance requirement of the nutrients was met by feeding calf starters (concentrates). The results of the study indicated that the total quantity of milk could be reduced from 450 litres to 150 litres, and the expenditure could be minimised [99]. Another study on the utility of calf starter revealed that the co-efficient of regression of growth rate/week in calves fed whole milk and one third and two thirds replaced by concentrate mixture were 3.14, 2.61 and 2.40 kg/week respectively. These differences were statistically significant[3]. This trend was confirmed in the studies carried out on Sindhi male calves subsequently[5].

Calves could be made to grow up to 12 weeks with as little as 165 litres of milk along with 44 kg of milk replacer costing about Rs 335. This is about half the cost of raising calves by the usual milk feed method. The calves in the milk replacer group (birth weight 35.0) and milk group (birth weight 31.0) grew to attain 72 kg and 74 kg weights respectively. The results showed that there was only 6 kg less body weight at 3 months in milk replacer group as compared to milk group, incurring only about 50% expenditure. The average cost of 1 kg gain in milk replacer group was Rs 9 relative to Rs 15 in the milk group[22].

In vitro studies were conducted to compare the quantity of release of volatile ammonia from ammonium salphate and urea using samples of cow and buffalo rumen liquor. The results indicated that the quantity of urea used in *in vitro* medium was hydolyzed in 75 min in sample of rumen liquors of cow and buffalo, indicating thereby that urease activity of SRL might be similar in both the species. Release of volatile ammonia was significantly less in case of ammonium sulphate as compared to urea. After incubation for 1½ hr, pH of the ammonium-sulphate based medium was closer to normal rumen pH than of urea-based medium. These studies further indicated less buffering capacity of samples of rumen liquor of cows than of buffalo when urea was used in the medium. It was further evident that release of volatile ammonia was incremental as the pH in the medium was made to increase when these two non-protein nitrogenous sources were used[21]. The effect of substituting partially the total N in the ration by urea at 1 and 2% level was studied. A reduction in the cost of feeding was accomplished by the inclusion of urea in the ration of calves without any adverse effect on the calves fed urea at 1 and 2% level[9].

Possibility of bringing down the cost of milk production by replacing a portion of concentrate and feeding guinea or para grass *ad lib* to milch animals was examined. The animals were found to receive their requirement of DCP for maintenance and further for the production of 4.5 kg of milk while they were fed *ad lib* green grass[94].

The possibility of feeding a concentrate mixture consisting of only by-products such as cakes, brans and husk excluding grains for feeding to milch animals was investigated. The milch animals were found to continue to do well in their performance on such a ration for over a lactation period[95]. To effect economy in

feeding and to bring down the cost of milk production, 25% of the concentrate mixture (production ration) was replaced with an appropriate quantity of para grass to provide the equivalent amount of DCP. Neither the dry matter nor the TDN intake was affected by this. It was also observed that the milk yield, fat %, fat-corrected milk yield, total and protein in milk were not affected[47].

Compounded cattle feed manufactured by a local cattle feed factory was found to contain 16.42% of DCP and 77.46% TDN and 73.70% S. E.[6].

Examination of the semen of the bulls fed a ration adequate in protein and minerals but devoid of carotene / vitamin A for a period of 80 weeks was undertaken. The semen obtained was poor and did not store well consequent to feeding carotene / vitamin A free ration for 3 months even. This was also reflected by a significant fall in the serum akaline phosphatase activity of blood. Continued feeding of the carotene-free ration for a period of 80 weeks resulted in very poor quality of semen, the primary abmormality reaching as high as 42%. Supplementing vitamin A in the daily ration of bulls in the absence of adequate green grass, has been emphasised[82].

Crop residues such as straws of ragi and paddy are not palatable and less nutritive. Efforts were made to enrich the same with 2% urea and 10% molasses to improve the palatability and nutritive value. The investigation carried out revealed that the enriched material was highly palatable and the animals left less residue. The dry matter consumption also increased. Enriched paddy and ragi straws contained 7.0% and 4.88% DCP respectively. This method of incorporation of urea in the ration of cattle is safe[100].

In order to assess the nutritional status of cattle, the blood of different breeds of cattle of both sexes maintained in different farms was examined for various haematological and biochemical constituents. Hallikar breed of cattle had the highest haemoglobin, Fe, Cu, carotene and vitamin A. Murrah breed of buffaloes recorded the highest Ca and Mg contents in blood serum. Gir breed of cattle had the highest inorganic P, Cu, and haematological constituents such as RBC, WBC and packed cell volume in blood and non-protein nitrogen in blood serum. The average values obtained in the blood of different breeds of animals serve as a guide for laying down the norms for the various blood constituents[60].

Information on the blood carotene and vitamin A level of cows under green fodder regime as well as when green fodder was withdrawn completely from the ration was examined. When the green fodder was withdrawn for about 30 days, a fall of about 70% of the blood carotene was observed. The study also indicated that supply of vitamin A to the animals may be furnished by oral supplements of vitamin A when the scarcity of green fodder is acute [80].

The inclusion of tapioca in the ration in place of oats or barley for feeding to working bullocks[19] and growing calves has been found to be satisfactory[4]. Studies carried out indicated the cereal portion of the concentrate ration of milch animals can be replaced by less costly tapioca chips without any adverse effect[50].

Nutritional status of the cattle in an organised farm was reported. The animals given 6 g of Liv-52 supplement/day/animal recorded higher Ca and Mg in their blood. A significantly higher inorganic P in blood of the animals was also observed consequent to Cu and Co supplementation of the ration. The supplementation of Cu at the rate of 0.5 g copper sulphate/animal/day for a period of 6 months helped in bringing 75.2% of the heifers into oestrus and subsequently, settling on artificial insemination[19].

General

The role of Animal Nutrition Research in India has been mentioned. Investigations into the chemical composition of fodders and grasses, digestibility and nutritive values of some of the Indian feeding stuffs have been suggested for experimental purposes[88] Details of feeding of animals are given[86]. The salient features of research and survey made on fodder production and conditions of grazing in India have been stated. Composition, oxalate and protein contents of cultivated fodder grasses are also given[90]. Importance of trace elements in the nutrition of animals has been mentioned[23]. The importance of berseeem as a fodder for animals is detailed[65]. The role of cattle in Indian Agriculture and Nutrition has been discussed[24]. The microbial synthesis of livestock feed, choice of microorganisms thereof, raw materials for growing yeast, role of fodder yeast in cattle nutrition, use of NPN compounds for stock feeding have been exhaustively reported[29]. The use of molasses as a feed along with roughages, grains, seed, bran, oil cakes in the ration has been recommended[30]. The importance of providing adequate ration to cattle has been emphasised[53]. Agriculture and livestock targets for dairy development in the State of Bihar was discussed. The requirements, availability resources as well as balance sheet of oil cakes, green fodder, and dry roughages have been worked out[107].

The relative merits and limitations of either buffalo or cow as dairy animal are plenty. The available literature has been reviewed with respect to various aspects of buffalo husbandry including the role of buffalo, number and distribution, breeds, systems of husbandry, nutrition, productivity, reproductive efficiency, environmental physiology and planning and future trends[109]. The concentrate availability for dairy and poultry industries was evaluated. It was suggested that by up-grading the milch animals, the efficiency of conversion of edible concentrate into better animal product such as milk might be increased by many folds[106]. The availability of concentrates, green and dry fodders in the country were 10.32, 23.13 and 16.36% respectively, of the requirements[108]. Para grass, a quick growing perennial with wide creeping stem, thrives best in moist areas. It can supply 1,100 lb crude protein and 7,700 lb of TDN/acre per year[49]. The inter-relationship between mineral make up of the soils, plants and milk produced by cows was reviewed[96]. The necessity of properly balancing the protein to energy ratio in poultry feed was discussed. The actual levels of protein and energy and also optimum ratio between the two for egg production and growth have been reviewed[97]. The effect of introducing tannic acid either directly or through materials such as sal seed meal in the poultry ration has been reviewed[11]. In order to obtain quality

milk for processing and manufacturing of milk products, the important points to be observed, have been mentioned. The need for the various ingredients in the feed or the concentrates such as oil cakes etc. to be balanced suitably has been stressed.

To predict the nutritive value of feed, many formulae have been suggested for application on the basis of chemical composition. The formula established earlier, has been found to be good in predicting the nutritive value of grass, hay etc. as evidenced by application of the same to various feeds[13,87]. The various aspects of processing the by-products available for rendering them suitable to feed livestock were mentioned[10]. It was emphasised that prior to feeding, processing of the by-products will result in better utilization. Different sources of by-products that could be used for augmenting the cattle feed have been discussed. A systematic study and judicious use of these by-products have been emphasised[83]. Instances of poisoning amongst livestock as a result of ingesting mould infested feeds have been reported frequently. Among the mycotoxins elaborated by the moulds, aflatoxin, which is a secondary metabolite of A flavus is of great concern to both poultry and cattle. In order to emphasise the salient features regarding this toxin, the subject has been reviewed exhaustively with special reference to chemical nature and biological effects of aflatoxin[40]. It has been emphasised that certain parameters such as acidity, and freezing point of milk and R.M. and iodine values of milk fat, which are used as indices in quality control, are influenced by the feed ingested by the cows[36]. The importance of dairy farming in rural areas, feed requirement, deficiencies in Indian fodders, scope of improvement, conservation and storage of feeds, improving the palatability and nutritive value has been described[85]. Various avenues to meet the feed needs of livestock were discussed[84]. Various aspects regarding the planninn of milk production in India has been discussed[110]. Milk prodcution function and optimum feeding schedules were reported[32]. Urea as a source of protein in the ration of ruminants has been mentioned[59]. The use of mulberry leaves as livestock feed has been advocated[81]. The role of antibiotics in livestock ration was reviewed[41].

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MICROBIOLOGY OF MILK AND MILK PRODUCTS

S. N. Anantharamaiah and B. Ranganathan

Investigations in fields of fundamental and applied aspects of dairy microbiology, prior to the establisment of research departments at NDRI., Bangalore were very scanty and isolated. Planned and project oriented research activities had their start only since 1943–44.

Quality of market milk

Bacteriological quality of over 1340 samples of milk produced under different conditions in and around Bangalore, were assessed by the application of methylene blue reduction test and plate count[1]. Dairy Institute farm samples from individual animals showed counts below 50,000 per ml and MBR time of over 5½ to 7 hr while the herd samples showed figures below 100,000 and 4 to 5½ hr. Milk from the Institute dairy and travelling cows showed counts below 500,000 and MBR time of above 4 hr. The corresponding value for other categories of milk were: town stables 0.5 to 5 millions and 2 to 5½ hr; village, 0.5 to 10 millions and less than 4 hr; milk hawkers, 0.5 to 5 million and below 3 hr; town dairies, over one million (maximum over 90 millions) and less than 2 hr. The need for a properly organised and vigorous campaign of clean milk production and effective bacteriological control of market milk was emphasized.

Extensive bacteriological survey of market milk were carried around Bangalore, Bombay, Anand, Delhi, Mathura, Karnal, Lucknow and Allahabad under coordinated research projects; MBR time varied from 15 min to 5 hr. Coliforms sometimes exceeded, 10,000 / ml when total counts reached one million. The investigation provided useful data for the proper design, construction and working of various city dairies established under the Five year plans (NDRI Annual reports 1947–1953 and 1959).

Quality Control tests

A modified standard for 1 hr resazurin test was suggested based on comparison with a methylene blue reduction of 4 hr for good quality milk. Reduction to the stages of blue, lilac or mauve indicated good samples. Pink mauve or purple pink was average quality. Pink stage indicated poor quality, while samples which became colourless were poor[6].

Ten min resazurin tests was found to be the most reliable platform test[126]. Reduction up to lilac stage indicated satisfactory milk. Reduction below pink was

unsatisfactory. An accelerated resazurin reduction test, by adding 0.001% xanthine to the standard resazurin solution, was found to be valuable in screening very poor quality samples in 2 min., when reduction reached stage 1/2 to 0 of resazurin disc. Hypoxanthine was twice as active[7,8].

Triphenyl Tetrazolium Chloride was shown to be useful as a new dye reduction test, particularly for demonstration purposes by extension workers. The end of reduction was indicated by the formation of cherry red colour in milk.[9]

It has been shown that agar can be re-used by dilution, washing and neutralisation[116]. Coconunt water has been found to be effective in retaining the viability and activity of high acid producing lactics for about month at room temperature and coconunt water agar has been found to be a good substitute for potato dextrose agar for yeasts and moulds[117,118]. A new and low cost whey agar media suitable for the growth of a variety of lactic acid bacteria, by incorporating agar to whey obtained from a short time hydrolysis of milk by a cell free system from *B, Subtilis*, and a low cost whey desoxycholate agar for enumeration of coliforms, have been standardised[119].

Microflora of Milk

Several investigators carried out detailed studies on individual species of organism occuring in milk with respect to the incidence, seasonal distribution, metabolic activities and taxanomic classification of isolates. The studies included Streptococci[10,11] Lactobacilli[11,12], Microbacteria[13], Staphylocooci[14], Coliforms[15], Micrococci[16], Enterococci[17], Mycobacteria[18],, Sporforming bacteria[19,20], Psychrophiles[21], Lipolytic bacteria and heat resistant flora[23]. Detailed investigations of microflora of buffalo milk has also been carried out[24].

Incidence of Salmonella and shigella in raw buffalo milk was found to be low[110]. Many pathogens were able to survive in dahi for a long time[111].

Pasteurised Milk

Coordinated research projects were carried out at Bangalore, Karnal, Bombay and Anand on the bacteriology of pasteurised milk. Samples were also examined under actual processing conditions at the large dairies at Aarey and Amul. The question was also examined whether pasteurisation temperature could be enhanced in view of the general unhygienic conditions of milk production in India. The keeping quality of raw milk in organised dairies was about 10 hr and it varied from 17 to 22 hr for pasteursied milk. Commercial dairies showed 4 to 6 hr and 10 to 15 hr respectively. An important finding was that the keeping quality of pasteurised milk did not improve by raising the temperature of pasteurisation beyond 165°F. On the other hand keeping quality decreased, inspite of lower counts due to the unchecked metabolic activity of sporeformers, apart from the consideration of severe strain on the plants due to enhanced temperatures. The effect of storage temperature on keeping quality of pasteurised milk has also been studied. Studies on thermal destruction of several dairy microorganisms suspended in different media showed higher heat resistance in ice cream than in milk and greater destruction in holder than in HTST (Annual Reports, NDRI, 1960-62).

Experiments were carried out in collaboration with the Pharmacology department of Indian Institute of Science, to find out whether the time-temperature combination of pasteurisation followed in India was adequate for the destruction of pathogens in milk[25]. *Salmonella typhosa and Shigella sonnei* did not survive pasteurisation. However, it was pointed out that virulent organisms like *Microbacterium tuberculosis* H-37-rv require adequate control of pasteurisation procedures, and every care and precaution should be taken to see that every particle of milk is adequately heat treated.

Detergents and Sanitisers

Bentonite, a naturally occurring alkaline earth available in many parts of India, was found to be comparable in cleaning action to washing soda, and much better than wood ash based indigenous cleaning subtances[2].

A detailed study was carried out regarding the mode of cleaning and sanitising practices of the country and materials used and their properties. Suitable cleaning mixtures and detergent-cum-sanitisers for use in modern dairies and village conditions have been standardised[128,129]. (NDRI report 1952 to 1954). Evaluation of some common dairy sanitisers have been carried out and use of detergents and sanitisers in the efficient cleaning of bulk milk tankers and road tankers demonstrated[27]. Indophores of comparable costs and efficiency to imported ones have been formulated from indigenous surface active agents and iodine, and found to be much more efficient than chlorine[28].

Improving the keeping quality of Milk

Use of about 200-300 ppm hydrogen peroxide, free from toxic materials has been found to increase the keeping quality of milk[29]. Personal interest by way of following cleaning and sanitising of utensils enhanced the keeping quality of farm raw milk. MBR time of over 9 hr. could be obtained[35]. Studies on germination of spores have brought out some factors for increasing the keeping quality of raw, and boiled milk for 4 and 7 days respectively when stored at 37°C. This method has also been found to be applicable for the preservation of concentrated milk and to lower the temperature of its heat treatment for microbial destruction[30].

Starter Cultures

L. plantaram–89 was found to be a better substitute for the assay of riboflavin than the conventional *L. casei*[31]. A rapid method for estimating riboflavin based on the ability of *S. faecalis*-190 to reduce triphenyl tetrazolium bromide has been standardised[32]. Methods have also been suggested for estimating thiamine, citric acid, and acetoindiaecetyl[34], using strain of *S. citrophilus*[33]. Studies on the vitamin[86] and amino acid[39] requirements of a number of strains of lactic acid bacteria have been made and, nutritional requirements for acetoin and diacetyl production[38] have been determined. High diacetyl yielding mutants have been obtained[39]. Other important aspects include studies useful in the preparation of starter distillates and selection of good cultures[40,41] for diacetyl production,

influence of colony variation and role of phospholipids on diacetyl formation[42], screening lactic acid bacteria for proteolytic activities[43], quantitative studies on progressive amino acids release during incubation and relationship between active lactic cultures[44,45]. Many essential amino acids have been found to be released in milk cultures.

Several diverse aspects [55-69] of starter cultures have been studied which include growth of starters in cow and buffalo milk[55], factors affecting growth of starters, associative action, mechanism of diacetyl production, genetic variants, defects, evaluation of starter activity tests, proteolytic activity in cow and buffalo milk, freeze drying of starter cultures, and starter distillates. A simple mode of transport of active starter cultures in agar, very useful to the public, and easy to handle, has been devised[70]. Cells of *S. lactis*-57 antigen has been found to be useful to distinguish between cow and buffalo milk in a simple ring test[127].

Dahi and fermented Milks

Over 2000 samples of dahi [3,4,5] were collected from different parts of India and analysed for their chemical constitutents and types of lactic acid bacteria. Detailed studies were carried out on the morphological, and biochemical characteristics of isolates and the organisms taxonomically classified. Selected cultures constituted the nucleus of starter culture collection of India, for distribution to the public and organised industries, for the preparation of dahi, lassi, yoghurt, acidophilus milk, butter and cheese. Since then the maintenance and distribution of starter cultures has been a very important function of the Bacteriological Division of the NDRI Complex.

A method has been standardised for the manufacture of *yoghurt*. A suitable equipment has also been designed[46]. Detailed studies have been carried out regarding the required metabolic activities of yoghurt organisms, prior to spray drying of yoghurt, suited to give an acidity of 0.8% on reconstitution at 13% total solids[47]. A satisfactory and simplified method of preparing *Acidophilus* milk has been evolved using carbonated milk.

A simple procedure for preparation of good quality carbonated dahi which could be stored at room temperatures for more than a fortnight has been found out. Whole milk, skim milk and milk standardised to various levels of fat could be used. Samples have been transported over long distances and good reports received even 20 days storage. Extension and large scale trials have proved the economic importance of the method for the industrial production of hygienic quality dahi[49,50,51,52,53].

Almost all the samples of dahi examined were found to be contaminated with yeasts and moulds while coliforms and micrococci also were found in many. A very simple method for over coming this defect, which can be universally applied has been found out[54]. Dilution of a portion from the middle stratum of a freshly coagulated dahi to about 1000 times with good quality water and use of 2% of this suspension for inoculum results in good quality product. Field trials have confirmed the results.

Butter

Detailed investigations on the microbiology of butter have been carried by various workers [71-76]. A procedure for obtaining coliform free butter, by using 10 to 20 ppm chlorine water for washing butter, by use of selected starters, and by use of starter distillates have been described. Keeping quality increased by adopting the above procedures.

Cheese

A method has been developed for shortening the time of preparation of cheddar cheese, by use of selected strains of cultures after proper screening procedures. Studies on acceleration of cheese ripening have also been carried out with good results by selection of strains, addition of suitable enzymes, orientation of starters, and ripening in an atmosphere of carbondioxide at room temperatures[78]. Selection of strains and use of dlacetyl rich starter distillates enabled preparation of good quality surti cheese which kept well for 4-6 days at room temperatures[79]. Detailed studies on the biochemical changes during ripening has been studied[80].

Bacterial rennet substitutes for cheese have been prepared from spore formers[81,82,83] from mould species [84,85,86] and acido-proteolytic bacteria[86,87]. Cheese prepared by using microbial rennet gave excellent grades.

Ice Cream, Khoa and Evaporated milks

Bacteriological quality of market ice cream around some cities, like, Delhi, Karnal, Bangalore and Bombay have been carried out[88,89]. Presence of coagulate positive staphylococci as well as coliforms were reported in considerable number of samples.

Microbiology of market Khoa has been studied and method for improved keeping quality suggested[90,91,92]. Market Khoa had a poor keeping quality or less than 3 days at 30°. The keeping quality increased to about 30 days on storing at 5 to 7°c packed in sorbate coated wrapping papers.

Bacteriology of buffalo evaporated milk has been studied[93]. Microbial control was found to be essential for successful preparation. Improvements for the successful preparation of buffalo evaporated milk based on studies on microbial metabolism in buffalo milk have also been suggested[94]. Studies on the microbiology of market samples of sweetened condensed milk showed the presence of a number of species of ba acteri and moulds. A gradual increase in counts for some time followed by decline was noticed[94,95].

Enzymes

The relation between xanthine oxidase activity in cow and buffalo milk and the dye reduction test was demonstrated. Pesteurisation increased xanthine oxidase activity[96]. The antogonistic effect of bacterial enzyme system responsible for diacetyl production and those in the reduction of tetrazolium bromide has been found out[97]. Other enzyme systems studied include the proteinase system in Fusarium cultures[86] and bacterial phosphatase[98]. Proteolytic and lipolytic activities and a dipeptidase in pseudomones and Achromobacter species have also been studied[99]. Alkaline phophatase activity was observed in stored pasteurised millk[21].

Inhibitory substances and antibiotics

The presence and activity of Lactenins, the naturally occuring inhibitory substances in cow and buffalo milk has been studied. Lactenins affected all streptococci except *Str. thermophilus*, coliforms and typhoid organisms which were not inhibited, while *Str. pyogenes* was most sensitive. Lactenin content was more in Red Sindhi and Tharparker than in Sahiwal cow milk, more in early and late lactation than in mid lactation milk[100,101]. Antibiotic sensitivity and resistance of certain micrococcic and staphylococci isolated from milk was demonstrted[14],

Evaluation of some antifungal agents has been carried out[102]. Antogonistic effect of *Streptococcus diaectyl lactis* against other lactics has been observed[45]. The inhibitory effect of starter distillates on microbial growth has been reported[103]. *L. bulgaricus* and *L. acidophilus* exhibited antibacterial activity against *E. Coli staph. aureous* and *B. subtlis*[104].

Studies on isolation of nisin producing *S. Lactis* strains, and development of mutants giving higher yields have been carried out[105,108]. Nisin decreased heat resistance of aerobic sporeformers. It increased the shelf life of processed cheese up to 90 days at 30°C[109].

Mastitis Control

Studies carried out on rapid identification of mastitis organisms have shown that detection of free amino acids and changes observed on protein patterns in infected samples gave good indications[112].

The incidence of mastitis in farm herd and the relative efficiencies of different antibiotic preparations for treatment have been studied[113]. Periodical mass screening of the entire farm in 2–3 days and prompt treatment have been found to reduce the incidence to almost zero levels[114]. A very effective BTB paper test for rapid detection of mastitis has been standardised using indigenous papers[115].

Microflora of rumen and silage

Studies on cow and buffalo rumen microflora and their metabolic activities in the rumen under different feeding regimes have been carried out[120,121]. Studies on microbiology of silage have been initiated and total counts and differential counts of lactic and clostridium species recorded.

Utilisation of whey, colostrum and dairy effluents

Studies on the utilisation on colostrum[77], waste whey from cheese vats, and dairy effluents have shown that good crops of *Saccharomyces fragilis* and *Torulopsis candida* can be obtained using the waste fluid with supplements[123,124]. It has also been shown that high yields of riboflavin (760 umg/ml) and vitamin B_{12} (9 umg/ml) could be obtained by suitable fermentations. A process for the manufacture of palatable and nourishing soft drinks has been standardised by yeast fermentation of whey[125].

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DAIRY BIO-CHEMISTRY

R. Venkateswara Rao

Earlier research in Dairy Bio-Chemistry dealt with the general composition of milk in relation to the effect of breed, feed, season, stage of lactation and species. Later, with the establishment of a good animal house, feeding experiments were conducted to evaluate the nutritive value of milk and milk products, the effect of feeding various nutrients on the composition of milk, biochemical changes in miik and milk products, and characteristics of individual constituents of milk like proteins, lipids, vitamins and enzymes.

Proteins

Studies on the total proteins of milk of cows, buffaloes, and other species such as sheep, goat, ass and human, were made [1,2a,3,4,5,15]. The NPN content of milk was estimated[6]. Detailed studies have been made on the partition of casein of different milks into various components[7-11], technique for the preparation of alpha and beta caseins[20], the whey proteins of milk[12,13] and sialic acid content of casein under various conditions [11,14,15,16]. Some attempts were made to study the biosynthesis of milk proteins by incorporation of labelled amino acids[17]. Casein from ass milk was isolated in a fairly pure state and found to contain a higher amount of P than milk casein of other mammalian species[18]. Serological studies for differentiating cow and buffalo milk proteins were made [21,22]. Antisera for casein and non-micellular proteins of cow and buffalo milk were produced using rabbits and their characteristics studied by Ouchterloni's technique and paper electrophoresis[19,a,b]. Skim milk from goat and cow was reported to contain a potent stimulant for protein synthesis[17]. The amino acid composition of milk proteins of different species was studied[7,28]. Human and ass milk appeared to contain lower amounts of essential amino acids than the milk of other species. Sheep milk was richer in all amino acids by virtue of its high protein content. The composition of goat milk approached that of buffalo milk. The valine content was lowest in the milk of Tharparkar cows and highest in the milk of Red Sindhi cows. There were no significant differences in the concentration of essential amino acids in the milk of different breeds of sheep except for tryptophan, methionine, valine and threonine. The concentration of tryptophan, valine and methionine decreased with the progress of lactation in Red Sindhi and Murrah buffaloes. Cow milk proteins were richer in iso-leucine and valine than buffalo milk proteins[8]. A simple and specific method using N-ethylmaleimide was evolved

for the estimation of free sulphydryl and disulphides in milk[23]. Variations in sulphydryl content of milk due to breed, species, and season was reported[23]. Significant variations due to feed and season were observed[24]. The sulphydryl content increased after 5-6 months and continued to increase till the end of the lactation. Goat Milk had lower reducing capacity as compared to that of cow and buffalo milk. The hydrogen sulphide content in cow and buffalo milk under different conditions of processing was observed to be a function of time and temperature. Cow milk had a higher hydrogen sulphide content than buffalo milk. Milk from Brown Swiss crossbred cows had higher total reducing capacity and hydrogen sulphide content as compared to the milk from cross-breds. Free sulphydryl and disulphides increased 2 fold when milk was sterilised. Cooked flavour was predominant in sterilized milk. There was an increase in the thio barbutric acid values of milk powders accompanied by deterioration of the organoleptic quality of the product. During Khoa manufacture the free sulphydryl content, total reducing capacity and disulphides were on an increase for the first 15 min of heating with simultaneous appearance of cooked flavours[24].

Lipids

Fishiness in butter was due to oxidation of lecithin to trimethylamine and the reaction was accelerated by the presence of heavy metals and high acidity[29]. The ass milk fat had a penetrating odour and was yellow in colour[26]. The effect of feeding hydrogenated groundnut and coconut oils on the composition of milk fat of Sindhi cows and Murrah buffaloes was studied[27]. Palmitic acid showed a sharp increase in buffalo colostrum fat. Ingestion of coconut oil and hydrogenated coconut oil in feed increased the % of lauric and myristic acids. The amonut of oleic acid increased with coconut oil feeding. Feeding of groundnut oil and hydrogenated coconut oil increased oleic and stearic acids. Sesame oil feeding had similar effect except that the butyric acid showed a slight increase. Cottonseed feeding markedly raised the stearic acid content. It was observed that a high % of linoleic acid in the diet did not increase the amount of palmitic acid in the fat secreted. Cow ghee contained the largest amount of C_4 acid. Buffalo ghee was very similar to cow ghee in general composition. Goat and sheep ghee differed from cow and buffalo ghee in containing larger amount C_8 and C_{10} acids. The presence of C_{10} unsaturated acids was confirmed in all the four butter fats[30]. Butter fat from Indian cows had more unsaturated fatty acids than that of their counter parts in England[31]. Feeding Sindhi cows and Murrah buffaloes with cottonseed, sesame and groundnut oils resulted in a decline in the Reichert value and an increase in the iodine value and butyro-refractometer reading. The changes in composition of milk fat were more pronounced in buffalo milk than that of the cow[32].

The peroxide value of the samples increased rapidly on heating ghee to 175°C[33]. The component fatty acids of cow and buffalo colostrum fat has been studied[30,31,34,35,36]. Butter fat from cows fed on sufficient green fodder was richer in butyric, caproic, caprylic and capric acids and had a higher growth promoting value in

rats[37]. Relative proportion of different fatty acids in high acid ghee was studied[38]. The phsopholipid content of cream increased with the fat content and desi ghee contained much less phospholipid than creamery butter[39,40]. When C_{14} acid was added to rumen fluid, it was noticed that 80% of total radio-activity was recovered in the volatile fatty acid fraction, of which 98% was in acetic acid[41].

Flavour And Other Aspects

A few investigations relating to the microbiology and biochemistry of dahi have been reported[41-45]. Some strains of streptococci and lactobacilli synthesised flavour compounds like diacetyl in dahi. The growth of starter organisms was significantly inhibited in fresh raw milk and the inhibitory factors were eliminated to some extent by pasteurisation and almost completely by boiling[46]. Mastitis and end lactation milk samples showed the highest inhibition in Dahi of good texture and flavour could be prepared from samples of colostrum after heating them at a temperature below the (coagulation) point[47]. The production of volatile acids and flavour compounds like acetyl methylcarbinal and diacetyl in milk has been studied[48]. During curdling of milk by micro-organisms a mild greenish yellow colour developed in buffalo ghee which was not due to carotene[49]. Further work showed that the pigment has several fractions[50]. Analysis by GLC of the methyl esters of free fatty acids of ghee indicated that the FFA content, was broadly similar in both cow and buffalo ghee[51]. Copper was less potent in causing oxidative deterioration of buffalo milk, even though no appreciable differences could be seen in the Cu content of cow and buffalo milk[52].

Enzymes

The possibility of using the extract from the berries of Withania coagulans for coagulation of milk in the manufacture of cheddar cheese and soft (Surti) cheese was investigated[53]. The phoaphatase content of milk showed a tendency to decrease soon after parturition and then to rise again[54,55]. The phosphatase was higher in the milk of goat than in the milk of buffalo, cow and sheep. The tributyrinase activity of the milk of different species was studied[55]. A marked increase in the xanthine-oxidase activity of buffalo and cow milk as a result of pasteurisation was reported. Pasteurisation of cream, caused decrease in the enzyme activity[56]. Alkaline phosphatase and xanthine oxidase were observed to be the most prominent enzymes in buffalo milk fat globule membrane protein[58]. Some properties of fistulated goat rennet were investigated in radio isotopic studies on the mechanism of synthesis and secretion of rennin in the abomasum[57]. The proteolytic activity and release of glyco peptide by the action of fistulated calf rennet was reported. The buffalo casein micelles showed a higher level of Ca and P with a lower content of Sialic acid, compared to cow casein micelles.

Vitamins

The effect of different levels of carotene ingestion on the vitamin A potency of milk and butter fat of stall fed Murrah buffaloes was studied[58]. The addition

of cotton seed in the diet was found to affect adversely the amount, of carotene and vitamin A in milk and feeding of shark liver oil to Sindhi cows and Murrah buffaloes on low carotene diet caused high increase in the vitamin A content of butter fat[60,61]. Significant variation in the Vitamin A and carotene contents of butter fat secreted by cows before and after parturition was reported[36,62,63]. The loss of vitamin A in ghee on storage could be greatly reduced by careful control of the desi method of preparing butter[64]. Antioxidants incorporated into ghee were effective in checking oxidative spoilage but not the loss of vitamin A[65-67]. Synthetic vitamin A was found to be as stable as natural vitamin A in ghee[68]. A study of the relative stability of synthetic vitamin A in ghee, oils, and butterfat during storage indicated that vitamin A was more stable in ghee. Tocopherol was also more stable in ghee than in groundnut and sesame oils and antioxidant had no effect in reducing the loss[70,71]. Some workers have found that added vitamin A, unlike in vanaspathi and some oils, was more stable in ghee in the presence of anti-oxidants during heating[79,73]. Tocopherol was fairly stable in ghee, less stable in coconut oil and hydrogenated oils and least stable in sesame and groundnut oils. Antioxidants had no effect in suppressing the loss during deep frying although they did protect vitamin A to some extent[73]. Heifers secreted more vitamin A in colostrum than cows, and cows on pasture produced, more vitamin A on winter rations[74,75]. The vitamin A content was independant of the number of lactations. The presence of carotene in goat colostrum was demonstrated and vitamin A alcohol was found to be present in both cow and goat colostrum. The tocopherol and vitamin A content of the buffalo colostral fat was found to be lower than that of cow colostral fat. Other factors investigated were breed, dry period before calving and individuality. The tocopherol content of buffalo milk was higher than that of cow and the vitamin contents were related to the ingestion of green grass in feed[76]. Supplementary feeding of a small quantity of tocopherol acetate increased the tocopherol content of milk. The influence of intermitent supplementation of small as well as massive daily doses of vitamin A concentrate resulted in giving favourable results[78]. The vitamin A potency of market milk of cow and buffalo also indicated seasonal trends[77 79]. Fat soluble and water miscible forms of synthetic vitamin A added to milk were stable to pasteurisation and boiling. The loss of synthetic vitamin A, when fortified milk was drastically heated as in Khoa making, was similar to that of natural vitamin A in unfortified whole milk[72,80]. Vitamin A was more stable in milk fat than in colostral fat and in buffalo milk fat than in cow milk fat. The addition of hydroquinone reduced the destruction of carotene and vitamin A in the colostral fats[71].

The thiamine, riboflavin and nicotinic acid contents of the milk of Indian cow, buffalo, goat and sheep have been reported[81]. Riboflavin and cobalamine activity in the milk of different species of mammals was studied[82 84]. Folic acid activity in milk during production of Dahi increased. The feeding of nicotinic acid to Sindhi cows had no influence on the amino acid content of milk but caused significant increase in the riboflavin and nicotinic acid contents of milk. Biotin,

pantothenic acid and folic acid of the milk of different breeds of cow and Murrah buffalo was reported[87]. The Murrah buffalo milk had the lowest biotin and pantothenic acid and highest folic acid content. Human and sheep milk had the highest pantothenic acid as compared with the milk of other species. The ascorbic acid content of milk from Indian cows and buffaloes was studied[85]. Compared to the chemical methods for the estimation of choline in milk microbiological method was found to be advantageous[88]. Human and ass milk contained comparatively greater quantities of choline than cow or buffalo milk, while buffalo milk was superior to cow milk in its choline content.

During souring of milk by pure cultures of *Streptococus cremoris* and *Streptococus lactis*. a slight synthesis of thiamine was reported[90]. The destruction of riboflavin was most when milk was exposed to direct sun light for 2 hr and when exposed to ultraviolet rays. Cow milk retained 90% of riboflavin and buffalo milk only 84%[89]. The effect of heat treatment on thiamine, vitamin B_6 and vitamin B_{12} of cow and buffalo milk was studied. Sterilization caused maximum destruction of thiamine and vitamin B_6 in both types of milk. When milk was boiled twice the loss of all the 3 vitamins in both the types of milk were approximately double that of the boiled milk[91]. Destruction of vitamin C in milk under different conditions such as pasteurisation, boiling, storing at various temperatures, exposure to sunlight and contact with various metals was reported. The destruction was highest when heated in naked copper vessels and least in the case of nickel[92].

Nutrition

Boiling of milk caused on an average 5% loss of valuable nutrients[92]. It was found that Kadoo, almond and Mahuwa oils which showed high rate of digestibility by ricinus lipase, were poorly digested by pancreatic lipase. Cow and buffalo ghee were hydrolysed almost at the same rate[98]. Two hr after administration, olive oil and cow butter fat were most readily absorbed while mustard oil was found to be least absorbed using rats as experimental animals[94]. Calcium ingested in the process of chewing 6 betal leaves with lime was the same as supplied by 10 ozs of cow's milk[94]. The vitamins A, B Complex, C, D, the heat stable factors of the vitamin B-complex and riboflavin helped in the utilisation of Ca, P and Mg[96]. The addition of butterfat, supplemented with vitamins A, D and B complex, to poor rice diet accelerated the growth of rats to some extent but the addition of milk had a very significant influence in promoting growth and maintaining normal reproduction and lactation[96]. No appreciable difference was observed between raw and heat treated (Pasteurised, boiled or simmered for 5 min) milks in promoting the growth of male rats[97]. Milk had a better growth promoting effect on rats than dahi, even after supplementation with lactose and vitamins. The comparative nutritive value of cow and buffalo ghee, vegetable fats and hydrogenated fats was studied[99–101]. The changes during processing in vitamins, proteins etc and in the nutritive value of several indigenous products like dahi, khoa, kheer and channa when

fed as such or as supplement to a poor rice diet was reported[102,104,105]. The biological value and protein efficiency ratio of the milk proteins of cow, buffalo and goat was studied[105]. On storage of spray dried skim milk of cow and buffalo there was a loss of 20-25% of lysine and loss was 50% when glucose was added to milk before spraying[105]. The effect of repeated boiling on the nutritive value of milk has been studied[106]. The haematological picture of the rats fed on Acidophilus milk was good[107].

Biochemical studies on semen

The antigenic relationship of blood group substances to homologus spermatozoa antigens was studied in rabbits and cattle. In cattle 2 specific antigens I and II were discovered[108–112]. Normal semen of both rabbits and cattle possessed a factor that agglutinated their own spermotozoa and the factor was identified as gamma globulin portion of the sera. Seminal plasma of cattle possessed antigens which reacted with sperm agglutinin of normal serum as in the case of rabbits. These results afforded an immunological method for control of conception in cattle. Paper electrophoretic studies of semen indicated that the Zebu, Cross bred and buffalo bull semen contained 8 protein components, whereas the semen from the bulls of Bos Taurus type contained 2 additional protein components. Lecithin and chalesterol were present along with other semen constituents in seminal plasma and spermotozoa[113]. Various factors concerned with deep freezing of buffalo semen were studied[114]. Freezing in liquid nitrogen vapour gave better results. A factor which is present in buffalo bull semen and is non-protein in nature was found to be the cause of comparatively low keeping quality of buffalo bull semen[115]. The presence of adenyl cyclase in spermatozoa of goat and buffalo bulls was reported using labelled ATP[116]. About 10% of the total carbohydrates were found in the bound form in spermatozoa[117]. Extenders which could keep the semen for long period, without refrigeration, was developed[118]. The characteristics of lipids in spermatozoa and seminal plasma were studied[119]. Different methods were found suitable for studying the abnormalities of spermatozoa of Indian Cattle[120]. The current knowledge of biometrics of spermatozoa, morphology, structural abnormalities, genetic dimorphism and morphology, morphology and fertility was reviewed[121]. Freshly ejaculated semen samples from 3 Tharparkar bulls and 3 Sahiwal bulls were studied by staining with periodic acid and silver nitrate separately. Four types of acrosomal abnormalities viz; swollen, large, deformed and negative acrosomes were observed. The incidence of defects was 4% in Sahiwal and 5.5% in Tharparkar cattle. The mechanism of formation of spermatozoa, genetic dimorphism and fertilisation and different methods available for separating the spermatozoa bearing X and Y chromosomes were described[123]. The mechanism of somatic cell hybridisation and its application in the field of basic genetics was discussed[124]. The maximum absorbance of cervical mucus of cows in dioestrus, oestrus and pregnancy was found to be 265.4, 261.1 and 275.7 millimicron respectively, The changes in the absorption values of cervical mucus of cows could be used in the pregnancy diagnosis as early as a fortnight after conception[124].

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DAIRY CHEMISTRY

M. Bhimasena Rao and M. K. Rama Murthy

The research section in Dairy Chemistry was opened along with Dairy Bacteriology in 1941. Fundamental and applied research was given substantial encouragement in 1945 by the institution of the scheme of Honorary Research Workers; these along with the staff were given facilities to submit their findings in the form of theses for higher degrees of M.Sc. and Ph.D of different Universities.

General Composition

Earliest reference to the investigation on the composition of milk at this Institute dates back to the early twenties, when the effect of milking interval on the yield and composition was studied; the fat content in different portions of the same milking was also studied[1,2,3,4,5].

Considerable amount of work has been done to study the influence of different species (cow, buffalo, goat, sheep, ass and human), different breeds of cows and buffaloes, feed, season, stage of lactation and interval of milking on the composition of milk and correlation between various constituents[6-11]

Goat milk resembled cow milk while the milk of sheep and buffalo resembled each other in many respects. The average values of different constituents of milk in the decreasing order are as follows:–

Specific gravity : Sheep (1.0338), goat (1.0307), buffalo (1.0306), different breeds of cows (1.0293), Human (1.0290)

Fat (per cent) : Buffalo (6.56), sheep (6.04), different breeds of cows (4.65), goat (4.50) human (3.50)

Protein (per cent) : Sheep (4.85), buffalo (3.89) goat (3.80), different breeds of cows (3.38), human (1.98)

Lactose (per cent) : Human (6.50), buffalo (5.23), sheep (4.99), different breeds of cows (4.91), goat (4.68)

Minerals (per cent) : buffaloes (0.839), different breed of cows (0.774), goat (0.52), sheep (0.52) human (0.150)

Total solids (per cent) : Sheep (16.3), buffalo (15.75), goat (13.50), different breeds of cows (13.34), human (12.13)

Solids-not-fat (per cent) : Sheep (10.26), buffalo (9.19), goats (9.00),cows (8.71), pH : Cow (6.63), buffalo (6.74), goat (6.54), sheep (6.54), ass (6.97) human (7.27)[14,15]

There was no significant influence on milk composition when carbohydrate rich materials as sugar cane and molasses were fed. However, the non-protein nitrogen (NPN) of milk was in proportion to the protein fed[12]. The effect of feeding iodinated casein to cows along with the normal ration was an increase in fat content and the increase persisted even after the feeding was stopped[13].

A comparative study of cow and buffalo colostrum indicated that buffalo colostrum was higher in sp. gr., acidity, sodium chloride, total protein, casein, albumin and globulin and ash than cow colostrum, while the lactose content was lower than that of cow colostrum[16]. A similar study was made on the composition of prepartum milk and colostrum[17].

Effect of Heat On Milk

When milk was allowed to simmer for long periods, the skin formed contained a high concentration of minerals, 21.7% P, 43.2% Ca and 46.7% Mg[18]. In another study the effect of different processes of heating on the composition of skin of boiled milk was found to be 49.3% fat, 28.1% protein and 4.4% ash[19]. In another study of a similar nature, a decrease in protein nitrogen and NPN was found[20]. But some other workers found that there was no change in NPN and amino acid N but a decrease in urea and uric acid N and an increase in ammonia N[21]. The loss of total solids in milk due to skin and residue formation as a result of boiling was greater in buffalo milk than in cow milk[22]. Heating milk brought certain changes in proteose-peptone level of milk[25,24].

Milk Proteins

Earlier research indicated that buffalo milk contained a higher proportion of protein than cow milk[25,14]. The elementary composition of cow and buffalo milk casein was studied[26]. The casein, albumin, globulin and NPN contents of Murrah buffalo milk were estimated[27]. Human milk had a lower protein content. The casein, albumin and globulin contents of Indian buffalo milk were estimated and compared with those of cow milk. A study of the effect of lactation and season on these showed that the latter was more marked in cow milk than in buffalo milk[19].

The NPN contents of milk of cow, buffalo and goat was estimated. There was no effect of season and lactation. Goat milk was richer in urea than cow milk, the latter had a higher uric acid content than other milks. Creatinine in sheep and buffalo milk was higher than in other milks. Colostrum contained higher NPN than normal milk except creatinine[28].

The non-micellular proteins of buffalo and cow milks obtained by high-speed centrifugation were studied by paper electrophoresis. The alpha-lactalbumin of buffalo milk showed greater mobility than that of cow milk and these mobilities indicated a definite ratio, whereas the B-lactoglobulin (B) of both the milks had the same mobility[29]. A similar study on the milk of goat, sheep, ass, and human species was made, and distinct differences were reported[30] Electrophoretic mobilities on buffalo

milk casein, the effect of trypsin digestion, rennet action, sialic acid content, effect of buffers on casein proteose-peptone of colostrum and normal milk, use of gel filtration technique for its assay were studied in detail[31,40,42,43]. A method for the preparation of alpha-S_1, beta A casein released during the preparation of Kappa casein has been reported[41].

Lipids

The size and number of fat globules per unit volume of milk of different milch breeds of cows and buffaloes were studied. Buffalo milk had larger globules and the total globules were fewer in number. The milk of milch breeds of cows had large fat globules compared to those of draught breeds[44]. Several workers studied the influence of stage of lactation on the composition of cow and buffalo milk fats[45-48]. With the progress of lactation, the general trend in changes observed was: a gradual rise in Reichert and saponification values, gradual fall in iodine value, and B.R. index, a decrease in oleic acid and an increase in low molecular fatty acids; but this trend was reversed at the end of lactation and the composition of butter-fat approached that of body fat. The influence of dietary fats, especially hydrogenated, on the composition and yield of butterfat of cow and buffalo was studied in great detail[49,50]. Glyceride structure and fatty acid composition of cow and buffalo milk fats were studied in detail[51-55].

The cholesterol content of milk of cow, buffalo and goat was studied by several workers in relation to individuality, breed, stage of lactation, free and bound cholesterol. The following results are reported for total cholesterol: Cow milk: 17.6 mg/100 ml milk and 396.2 mg/100 g milk fat, Buffalo milk: 24.2 mg/100 ml milk and 334.4 mg/100 g milk fat and Goat milk: 21.4 mg/100 ml milk and 510.0 mg/100 g milk fat[56]. The cholesterol value increased towards the end of lactation. In herd milk, cholesterol per 100 ml milk showed 2 peak periods during February and August; also the cholesterol content of crossbred cow milk was higher than that of indigenous cow milk[57]. The free cholesterol content of cow milk and buffalo milk was 0.245% and 0.220% and that of bound cholesterol was 0.060% and 0.045% respectively[58]. The variation in phospho-lipid content of colostrum and milk of buffalo, four breeds of cows, goat and sheep with reference to lactation, season and species were studied in detail; also the phospholipid content of cream, butter and ghee was estimated[59-61]. The fatty acid composition of phospholipids of cow and buffalo milk was determined and the presence of C_{22}, C_{23} and C_{24} saturated fatty acids in appreciable quantities were found in cerebrosides and sphingomyelins[62,63]. The fatty acid composition of cholesteryl esters of ghee prepared from cow and buffalo milks was determined and certain differences were found[64].

Lactose

The lactose content of herd and individual samples of milk from different breeds of cows varied from 4.87 to 5.25% while in buffalo milk samples, it varied from 5.46 to 5.73[65-68].

Minerals

Study of the minerals, in particular Ca, Mg, phosphate and citrate and the salt balance is of importance especially in determining the heat stability of milk and its relation to the manufacture of evaporated milk. The average values for ash content of milk reported are : 0.71 to 0.75% in cow milk and 0.72 to 0.86% in buffalo milk[69]. A study of Ca partition in milk gave the following values per cent : Cow milk : total Ca 0.153, coll. Ca 0.142, rennet whey Ca 0.050 ; Buffalo milk : total Ca 0.191, Coll. Ca 0.148, rennet whey Ca 0.043. Collodial Ca as% of total Ca was 77.49 in buffalo milk and 67.09 in cow milk[70]. However, some other workers found a higher value for Ca (CaO 0 245) and P (P_2O_5 0.267) in buffalo milk[71]. The average values for Ca in cow, buffalo and goat milks were 135.5 mg, 137.0 mg and 139.2 mg per 100 ml of samples respectively. The average values for Mg in cow, buffalo and goat milks were 9.88 mg, 12.70 mg and 10.49 mg per 100 ml samples respectively[72,73].

The average citric acid content of cow and buffalo milk was 0.225 and 0.193% respectively as against 0.180% reported for the milk of foreign cows[69,71]. Goat milk was the poorest containing 0.078% while sheep milk showed an average of 0.154%. Colostrum was rich in citric acid reaching normal value in 7-8 days; the values decreased towards the end of lactation[74].

The effect of breed, season and stage of lactation on Cu, Fe, Na, K, Cl and lactose of milk was found to be significant[75,76].

Physico-Chemical Properties

Detailed studies on the freezing point of Indian cows and buffaloes have been made. The average freezing point of milk of Cross-bred, Gir, Sahiwal, Sindhi and Tharparkar was –0.548°C and that of Murrah and Dharwar breeds of buffaloes was –0.549°C. There was no significant difference in the values of different breeds of cows. Average values for goat and sheep milks were –0.575°C and –0.588°C respectively. Over 97% of the samples examined showed freezing point greater than –0.530°C, and therefore this limit has been suggested as the minimum for prescribing legal standards. The method was useful in detecting upto 3% adulteration with water. The effect of heat treatment, addition of extraneous materials, development of acidity and other factors on freezing point of milk has also been studied[66-68].

The relative viscosity of raw buffalo milk at 40°C ranged from 1.39 to 1.47 while the value for evaporated milk of 25.9% total solids ranged from 3.06 to 7.50; the value for evaporated milk of 31% total solids ranged from 8.65 to 14.9; raw cow milk showed a relative viscosity of 1.36 and evaporated milk of 31% total solids prepared from the sample showed a value of 12.75[73].

The average value for surface tension of buffalo milk was 50.4 dynes/cm at 20° and 49.64 dynes/cm at 27°C. The average values for milk of cows of four different breeds at these respective temperatures were 51.84 to 51.93 dynes/cm and 51.09 to 51.19 dynes/cm.[77]

The average electrical conductivity at 37± 0.01°C of cow milk was 40.61×10^{-4} mhos at 50 Hz and 44.75×10^{-4} mhos at 3KHz. The corresponding values for buffalo milk were 29.60×10^{-4} mhos and 33.21×10^{-4} mhos respectively. The electrical conductivity of buffalo milk was significantly less than that of cow milk. The electrical conductivity increased with frequency[78,79].

A study of the relationship between relative viscosity and electrical conductivity of skim milk indicated that the relative viscosity was dependent on electrical conductance only for morning cross-bred cow milk at 35°C and for morning Tharparkar milk at 40°C. This correlation was significant at the higher frequency. The anamolous behaviour can be interpreted in terms of variations in casein structure and its hydration[80].

The average values for acidity in terms of % lactic acid as found out by different workers are: cow milk 0.14[71], milk of cross-bred, Gir, Sindhi cows: 0.12, 0.13 and 0 14 respectively[81], buffalo milk 0.14[74], Murrah buffalo milk 0.10 to 0.12[81], Dharwar buffalo milk 0.15[86]. Colostrum showed a higher acidity of 0.30[81].

The buffer value of milk was higher in the acid range at a pH range of 4.8–5.2; at pH 6.6 the buffer value of milk was 0.0155 and when the peak was reached the average values for cow and buffalo milk samples were 0.0359 and 0 0417 respectively. Thus the buffalo milk showed a higher buffer value than cow milk whilst the reverse was the case in the alkaline range. There was a significant difference in the buffer value of milk of different breeds of cows[82]. The effect of some factors on the pH of milk was studied[83].

A large number of samples of milk, cream and butter were examined for flavour. It was found St. citrovorus when used produced diacetyl from citric acid in milk; it also produced lactic acid which curdled milk at 20 - 21°C[84]. The sulphydryl compounds of milk and milk products were studied in their relation to cooked flavour[85]. The factors for the flavour of ghee were separated and found to be a number of carbonyl compounds[86,87].

Buffalo ghee prepared by Desi method acquired a greenish yellow colour which was not found in cow ghee similarly prepared[88,89].

Analytical Techniques and Quality Control

The importance of analytical techniques and standardisation of methods cannot be over-emphasised. With the progress in analytical science, newer techniques have been developed at the Institute which combine simplicity, rapidity and accuracy in the analysis of milk and dairy products.

A simple rapid electrometric method for the estimation of solids-not-fat by ceric-sulphate titration with as small a quantity of milk as 0.5 ml has been developed[90]. A similar method combined with EDTA titration for the successive estimation of total proteins, chlorides and lactose in milk was developed[91]. A method using formaldehyde titration for the estimation of SNF in milk has been suggested[92]. A semimicro method for the estimation of chloride by mercurimetric titration was evolved[93]. A constant potential amperometric technique for the successive complexometric determination of Ca and Mg was evolved[94]. The

same method was adapted to estimate Ca and Mg in milk[95], and for the estimation of Fe and Cu in milk[96].

A simple method for the estimation of cholesterol in milk by the application of Lieberman and Burchard action was satisfactorily evolved[97].

Investigations on the use of 'Zeal' type lactometers under tropical conditions, statistical evaluation of different types of lactometers and statistical evaluation of the volume of milk pipette for high fat milk in Gerber test were made[98-101]. Modifications for the Richmond formula for milk under Indian conditions have been suggested[98-102]. A detergent "Ramko" Test avoiding the use of concentrated sulphuric acid in Gerber fat test has been evolved and a patent was taken[103]. A similar 'Brisk' test has also been reported at a later date[104].

A turbido-metric for the estimation of proteose-peptone in milk[105] and a simple petri-dish method for resolving milk proteins by starch gel electrophoresis[106] have been evolved.

A modified method for the estimation of total carbonyls in milk fat has been suggested[107]. A method for the estimation of phospholipids in milk and milk products has been standardised[61].

The Hansa Test is a specific serological test for detection of buffalo milk in cow milk and several modifications in the test have been suggested[108-112]. Paper electrophoresis of non-micellular proteins of cow and buffalo milk showed characteristic differences[29]. Starch gel electrophoresis of cow and buffalo milk proteins indicated certain differences[113]. A strain of S. lactis was found to contain an antigen to some antibodies in cow milk but not in the case of buffalo milk[114]. The ultra violet and visible absorption spectra of diethyl ether extraction of milk has been used as a criterion for distinguishing cow and buffalo milk[116,116].

Milk Products

Based on the analysis of large number of samples of ghee and butter analytical standards for ghee were prepared[117]. The chemical constants of ghee were studied by several workers[118,119]. Ghee prepared by desi method rapidly developed peroxide compared to creamery ghee[120]. A simple method for the removal of free fatty acids of ghee was suggested[121]. The free fatty acid content of high acid ghee was determined[122]. The keeping quality of ghee prepared and stored under different conditions was investigated[123-125]. The development of taints in butter during storage was investigated; the fishiness in butter was due to oxidation of lecithin to yield trimethylamine and this reaction was favoured by traces of heavy metals and high acidity[126]. Adding citric acid and sodium citrate, although improved the aroma of butter, adversely affected the keeping quality but ghee prepared from such butter had both an improved flavour and better keeping quality[127]. The role of milk phospholipids in the auto-oxidation of ghee was studied [128-131]. The addition of ethyl gallate 0.02% was effective in checking oxidative spoilage in ghee[125]. The effect of addition of different antioxidants on the oxidative stability of ghee was investigated[132].

Copper, an important catalyst in the development of oxidised flavour in cow milk was less potent in bringing about oxidative deterioration in buffalo milk. A comparative study of the distribution of copper, both natural and added, and its role in oxidation has been investigated[133].

Some aspects of detection of adulteration of ghee with vanaspati by the addition of 5–10% sesame oil to the latter was investigated[134]. Colouring vanaspati to light red with Ratanjot (Onasma echoides, Linn) was explored[135]. Both paper and thin layer chromatography techniques were developed for detection of adulteration in ghee with vegetable and animal body fats[136-140]. A method was evolved for the separation and detection of annato and other food colours[141]

During the ripening of cheese made from cow and buffalo milk certain distinct differences between the two cheeses in regard to lipid[142,143] proteose–peptone[144], carbonyls, and free fatty acids[145] were observed. Hydrolysis of cheese proteins during ripening of cheeses made from Hansen's rennet and fistulated rennet was studied[146]. Studies on sulphydrils and disulphides of cheddar cheese made from cow and buffalo milks, both at the time of manufacture and ripening showed that the free sulphydrils were more in cow milk than in buffalo milk; during ripening there was a steady increase in sulphydrils and disulphides in both cheeses; in old cheese the difference narrowed down considerably[85]. A study of the ripening of Egyptian (Domiatti) soft cheese by using whey protein hydrolysates was made[147].

A detailed method was formulated for pilot plant production of evaporated milk having 26% and 31% total solids content from buffalo milk[73]. Some studies on the incorporation of cow milk casein for stabilising evaporated milk during its preparation has been reported[148].

The sulphydril content of various milk products, made from milk of exotic and indigenous cows and buffaloes was estimated and its effect on the keeping quality of the products under various conditions was studied[85].

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DAIRY ECONOMICS

Y. V. R. Reddy, K. C. Sastri and Jayashankar

The importance of economics in any field of activity cannot be over emphasized. In short the main aim is to secure maximum output with minimum inputs and at the same time to bring down the cost of goods and services as far as possible without risking the efficiency. Therefore in a field like dairy industry economics play a vital role at every stage of activity.

With this end in view a separate wing for Dairy Economics and Statistics was started at the N.D.R.I. Karnal in the year 1960 and this wing has been working on various economic problems pertaining to dairying. Subsequently a full fledged Division of Economics and Statistics was started. The work accomplished at Karnal has induced the authorities to create a separate wing at the S. R. S. of N.D.R.I. in 1972.

The present review deals with the work done at N.D.R.I. Karnal and Bangalore on several aspects of dairying such as survey work, cost of cultivation of fodder crops, cost of feeding dairy cows, pricing policy of milk and a host of other subjects pertaining to dairying in the country.

Survey Work

The necessary pre-requisities for consideration in starting milk supply schemes so as to make them viable units of business enterprise have been discussed[9]. A survey on the consumption pattern of bovine milk in Bangalore city has been made to find out the influence of increased income on the consumption pattern of milk among different income groups of people[26,27]. Such studies enable the entrepreneurs to adjust or modify their business. The advantages of maintaining crossbred cows in and around metropolitan cities have been stressed[7].

Dairy Farming

From an economic appraisal of dairy farming and arable farming it has been shown that dairy farming under the present agro-economic studies is more profitable than arable farming[5]. In a study of milk production and dairying practices in rural areas the average daily milk yield has been reported to be 5.6 Kg for crossbred, 1.2 Kg for Hallikar and 2.1 Kg for buffaloes[23]. From a study of the economic viability of maintaining cows for milk production it has been reported that a cow giving more than 2292.44 litres of milk within an inter-calving period of 446 days could be considered as an economic unit for maintenance[19].

Calf Rearing

Statistical studies have been made on the economic aspect of calf rearing for three different breeds viz, Tharparkar, Sahiwal and Red Sindhi and the cost has been arrived at as Rs 1581.38, 1491.04 and 1638.07 respectively. This study has also revealed that feed alone is the major cost taking away 80% of total gross cost and that the cost was also influenced by the age at maturity[10]. In another study the cost of rearing heifers was reported to be Rs 2956 07 for miscellaneous crosses, Rs 3944.10 for Jerthar breed and Rs 4778.26 for buffaloes and the age at calving was found to be 920, 1204 and 1548 days respectively[24]. The cost of rearing calves has been found to be Rs 1715.16 for cross breds and Rs 2053.24 for Thari[11].

Fodder Crops

Among the various items of expenditure in the cost of milk production the expenditure involved in raising fodder crops forms an important item. Investigations have shown that the expenditure on human labour, fertilizers and tractors can be considerably reduced if rotation of crops was practiced. The cost of production of fodders like Maize, Cowpea, Berseem, Oats and Lucerne for the years 1964–65 to 1966-67 has been worked out[18]. Studies on the input-output relationship of Rabi fodder with reference to Oats and Berseem have revealed that input factors like irrigation and fertilizers are equally important and any variation in them would either increase or decrease the out–turn[4]. Efficient transport of fodders was found to reduce the cost of ultimate product[13].

Feeding of Dairy Cows

Feed cost was found to account for 60% of the total cost of milk production[14]. The least cost combination of para grass and concentrate mixture without affecting the milk yield has been worked out[1].

From a Time and Motion Study for the work of hand milking of Cows it has been shown that scientific methods of milking would increase the productivity[20].

Cost of Milk Production

A number of studies have been made on the cost of milk production from time to time both at Karnal and Bangalore to help fixing up the cost of producing an unit of milk. It has been pointed out that the cost of production decreased with the increased level of milk production and that the variation in the seasons would also affect the cost structure. Remedial measures have been indicated to bring down the cost[25].

The net cost of producing one kg of milk for individual breeds has been found to be 59.9, 59.7 and 68.1 paise for Tharparkar, Sahiwal and Red Sindhi breeds respectively with an average daily milk yield of 5.1, 5 3, and 4.4 Kg respectively. It was also observed that more than two-thirds of the total cost was on feed and that feed cost was highly correlated with the total lactation yield, number of days in milk and dry days[11]. Similar studies have been made to find out the trends in the cost of milk production for the years 1961 and 1966 [16].

The cost of producing a litre of milk worked out to 72 paise for crossbreds and 117 paise for the pure breds and the daily average milk yield was calculated to be 7.48 litres for crossbreds and 4.18 litres for pure breds. Feed cost came to 55 % for crossbreds and 43% for pure breds[22]. In another study it was found that cost of milk production from crossbred cows was less than from pure breds[21].

The cost of milk production at Bangalore Institute farm was reported to be 52.4 paise for 1 kg of milk for cross breds and 97.6 paise for Thari when the average milk yield was 5.9 kg. and 3.2 kg. respectively for the two breeds[15].

In another study it has been found that miscellaneous crosses are more economical than Jerthar crosses and that the cost of milk production could be considerably reduced by replacing concentrates with green fodders[2].

The application of methylene blue reduction test for fixing the price of milk in order to bring about improvement in the quality of milk has been suggested[12].

Utilization Of Milk

A pilot survey has been conducted to fiind out marketed surplus of milk and it was observed that the per-capita consumption of milk increased with an increase in size of holding where as the marketed surplus of milk decreased with an increase in the size of the farm[6]. Economic methods of utilizing surplus butterfat profitably have been suggested[17].

Employment Potential

While discussing the employment potential in dairying it has been pointed out that an increase in the employment potential would result in under-employment among marginal and the landless farmers and the need for superior employment potential of dairy farming over mixed and arable farming was emphasized[8].

Fat and SNF Losses

Studies on fat and SNF losses have been conducted and the relationship of fat and solids-not-fat-for different patterns of milk utilization as well as the reasons for losses have been indicated[3].

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DAIRY ENGINEERING

S. S. Sharma

There are many indigenous dairy products like khoa, ghee, dahi etc. for which no equipment was available for their manufacture continuously. The earlier methods of their manufacture were all batch processes and quite often unhygienic and laborious. Similarly, no machine was available for chilling milk under conditions which should be simple, easy to operate, repair and maintain, of low initial and operational cost and which could be operated even without electricity. No tractor driven equipment was available for harvesting berseem. An urgent need was, therefore, felt to develop new dairy equipments for the manufacture of indigenous dairy products like dahi, khoa and ghee, chilling equipments to operate under rural conditions, equipments for harvesting berseem, feed mixing plant, milk tankers etc. Some proto-types have been developed in the Dairy Engineering Division at Karnal during the last few years and trials have been conducted. The results have been very encouraging.

Continuous Khoa Making Equipment

The conventional method of preparing khoa in mild steel karahi is slow and laborious and there are chances of burning if the scrapping is not effective. To overcome these draw-backs, first a prototype equipment, consisting of a pan with steam jacket and mechanical scraper and with a capacity of 50 litres of milk at a time, was designed and tried out[1]. Subsequently, a continuous khoa making equipment was designed where milk could be fed at one end and the khoa could be taken out from the other end continuously. The equipment included a steam jacketed drum heater, open steam jacketed pans, scrapers and power drive for scrapers. Steam supply (50 kg/hr under 3.5 kg/cm^2 pressure for heating milk and electric supply (4 KW/hr) will be required for operating the equipment. Pilot plant trials indicated that 400 litres of milk could be converted continuously into khoa of good quality in an 8 hour shift. The loss of khoa during the operation was about $\frac{1}{4}$ Kg. The equipment is being used regularly at the National Dairy Research Institute, Karnal [2].

Dahi Making Equipment

This equipment was designed for the preparation and storage of dahi in batches of 6 crates, each crate containing 20 half litre-bottles. The main purpose was to provide suitable equipment for small dairies where dahi could be prepared and stored at low temperature. The equipment is thermostatically controlled [3].

Design of a sterilizer for sterilization of milk

An equipment for sterilization of milk in bottles was fabricated. About 200 bottles ($\frac{1}{4}$ litre capacity) of milk can be sterilized at a time. Trial runs have given satisfactory results[4].

Planning and layout of milk collection and chilling centres

A study was made of 1408 milk collection and chilling centres in the country with the object of suggesting guide lines for planning and layout. It was observed that there were 488 milk collection centres receiving 400–500 litres of milk. The distance of the collection centres was in the range of 50–80 Kms and generally milk took 7-9 hr to reach the dairy plant [5]. A study of the relative efficiency of the plate cooler, surface cooler and vat cooler for use at chilling centres was made. The effectiveness of plate cooler was found to be around 80%, the surface cooler 70% and the vat cooler around 43%. Amongst the refrigeration equipments, it was observed that ice bank system was more suitable to our conditions since it can handle varying loads. Moreover, ice bank system was able to store refrigeration and supply cooling effect, if there were a small break down. In the refrigeration system, equipment used for storage was insulated cans, ice chamber cans, insulated bank, refrigerated tank and can in cold storage. The transportation was usually done by insulated van or truck and road tankers. Layout plans were prepared for units of the following capacities : Upto 2,000 litres/day, 2,000-5,000 litres/day and 5,000-10,000 litres/day. The cost of chilling milk was also estimated for different capacities at different centres. It varied from 3 paise per litre to 6.5 paise per litre [6].

Modifications in sealed compressors

Hermetically sealed compressors, which are used in the dairy in in-can coolers and other small refrigeration equipments are difficult to repair because of welded construction. The effect of over-charging and undercharging of the refrigerant, evaporator temperature, condenser tempereture and voltage variations on the working of the compressor has been studied with a view to modify the design of the compressor to minimise failures. Hermetically sealed system has been suitably modified by providing flanged units. The evaporator and the condenser have been modified to suit the requirements of experimentation. An insulated room has been constructed for conducting experiments on cooling performance. Arrangements for measurement of temperture have been finalised and calibration of the thermocouple has been done. Temperature of the motor windings will be directly measured by means of thermocouples. Further trials are in progress [7].

Equipment for chilling milk

A refrigeration equipment based on vapour absorption system with ammonia and water as working fluids with a capacity of 500 litres/hr was designed and fabricated. The equipment can be used with or without electricity, simple in operation and easy to repair and maintain. Moreover, the initial cost and cost of operation is likely to be low. The equipment was tested for leaks. Safety devices and

measuring instruments for temperature, pressure and level have also been installed on the system[8]. Collaborative work at different institutes for extensive testing of the equipment for different refrigerant-absorbant combinations is being taken up.

Design of bulk milk cooler

The conventional bulk milk coolers used for chilling milk are very costly. A suitable equipment involving low initial cost has been designed for 1,000 litres capacity with fibre glass reinforced plastic (food grade) used as tank material in place of stainless steel[9].

Studies on road milk tankers

Work on the design and fabrication of milk tankers was started by using an aluminium tanker of 1,000 litres capacity, mounted on mild steel frame and having minimum joints. The tanker was tried under actual operating conditions[10]. Standardisation of type and thickness of thermal insulation in bulk milk transportation and storage equipment is in progress[11].

Designing and fabrication of Milk Dispenser

A simple milk dispensing equipment, which can deliver desired quantity of milk in consumer's containers, and is of low initial cost has been designed. The unit consisted of a stainless steel over flow tank alongwith valve and fittings, and an electric time delay relay system to control the time and opening of the stainless steel valve and deliver desired quantity of milk into containers. Three different quantities of milk can be obtained by pressing the corresponding push button switching system. The equipment was extensively tested for different quantities of milk and different types of time delay relays. It was observed that for 85% observations, the electronic timer relay gave results within the permissible limits of 1%[12].

Development of berseem harvester

In order to minimise labour involved in harvesting berseem a mower with a reciprocating knife bar was used but it did not give satisfactory performance because of the succulent plants of berseem. A suitable berseem harvester was designed, whose essential features were cutting by impact force, side mounting, cutting machanism drives by power-take off (PTO) shaft of the tractor, height of cut 40 to 50 mm, harvested crop in a windrow, ease of fabrication, minimum vibrations of the machine and other advantages. It consisted of a main frame power transmission system and cutting unit. The main frame was fabricated from M. S. angles (30x30x6mm) with requisite bracing. It supported the power transmission unit and the cutting unit. The power transmission system consisted of a gear box connected to the PTO shaft of a tractor through a telescopic universal shaft. The power was transmitted from the gear box to the cutting unit through v-pulleys and belts. The cutting was done by four sharpened blades of swinging type made of high carbon steel. The cutting unit operated at 2,000 rpm to give a peripheral speed of 3600 meter/minute. The width of cut was 1150 mm.

The first prototype berseem harvester was tested in the month of November and December, 1972 at the Institute farm with a Ford 3,000 tractor. The area covered in one hour was 1.75 hectares. A gauge wheel had to be provided to protect the blades from digging into the irrigation bunds. The machine is under testing for further modifications[13].

Design and development of pilot feed mixing plant

A feed plant of 4–5 tons capacity per day (8 hr. operation) was designed. The feed mile of the matching capacity has been procured. Four bins have been designed and fabricated for storage of various ingredients of cattle feed mixture. Experiments have been conducted to evaluate the performance characteristics of screw conveyors. The screw conveyor system was evaluated with barley and ground-nut-oil-cakes. The pin was required to be vibrated by installing an electric surface vibrator. Some bridging was observed in handling oil cakes in the bin. Experiments have been undertaken to analyse the effect of the moisture, nature of material, pitch, diameter and speed of screw augers on the rate of discharge of the material. Other accessories required for bins are under fabrication [14].

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DAIRY EXTENSION

S. R. Jayashankar and T. S. Sohal

One of the primary objects of establishing the Dairy Institute at Bangalore in 1923 was to provide technical advise, and guidance to Central and State Government Organizations, Cooperative institutions and private entrepreneurs in the development of cattle and dairy industry in India. In the early years there was no separate Extension Unit attached to the Institute. Extension and advisory work was being rendered through personal discussion and correspondence by the former Imperial Dairy Expert upto 1939 and subsequently by the Director of Dairy Research with the help of the scientific and technical staff of the Institute. At the request of State Governments, private individuals and other parties they visited various centres in the country to study local conditions and collect necessary data and prepared schemes and lay-out plans with financial and technical working details for the establishment of cattle breeding farms, dairies etc. A large number of such farms, goshalas, dairies, milk products factories and milk supply organisations were set up in different parts of the country with the active help of the Dairy Institute which gave advice and assistance in the day to day activities of these concerns and in the solution of their problems. Several of these farms and dairy organisations are still functioning in various parts of the country. Special efforts were made to assist State Governments in organising cooperative dairies and milk unions and in introducing scientific methods of milk production, collection and processing in these institutions.

The Institute was also participating in All India and Regional Cattle shows where besides exhibiting the Institute animals dairy exhibition stall were also put up in several industrial fairs, congress exhibitions and Mysore Dasara Exhibitions.

Under the Key Village Cattle development programme initiated in 1952 the Institute built up a close *liaison* with the farmers in villages and gave them guidance and assistance in the improvement of village cattle through A.I. Services, Veterinary aid and personal advice. Calf rallies were held periodically to demonstrate the results of cattle improvement work in the villages and encourage progressive breeders. The cattle breeders round about Bangalore were particularly benefitted by the A.I. Services and other forms of assistance provided by the Institute in the development of cross bred cattle with high milk potential.

The Institute was also distributing to different centres in the country pedigree animals and semen of farm bred bulls for grading up local cattle, root slips for improved fodder production and starter cultures for preparation of dahi, butter and cheese.

Publication of technical articles and notes in a popular language on various topics bearing on scientific methods of cattle management, milk handling and milk utilisation, and the results of research work done at the Institute was another important aspect of extension work carried out by the Institute.

With the establishment of the National Dairy Research Institute at Karnal and the consequent redesignation of the Indian Dairy Research Institute at Bangalore as the Southern Regional Station extension work was given greater priority and also carried out on a more systematic basis. A separate Extension Division with necessary staff and extension equipment together with a printing press was created at the Karnal Institute and an Extension Section was also started at the Bangalore Institute, The Western Regional Station at Bombay and the Eastern Regional Station at Kalyani (near Calcutta) were provided with a nucleus of extension staff to take up extension work on a regional basis.

The NDRI took a prominent part in the world Agricultural Fair held at New Delhi in 1959 and put up charts, models and posters supported by demonstrations to present the various developments in the dairy industry and to focus attention on the importance of quality control, scientific methods of milk handling, economic utilisation of milk etc.

The NDRI at Karnal and the Southern Regional Station at Bangalore have continued to carry out extension work vigorously in various ways for building up a closer *liaison* between the Institute, the farmers and the organised dairy industry. The main activities pursued at the two centres in the above direction are briefly indicated below :—

(I) Participation in cattle shows, exhibitions and Industrial fairs and the all India Dairy Industry Conferences held in different parts of the country every year and preparation of suitable panels depicting different themes, posters, charts and other exhibition materials for the purpose.

(ii) Organisation of field extension work including field demonstration farms for cultivation of exotic varieties of grasses, clean milk production, community milking byres etc.

(iii) Establishment of a model two hectare and five-hectare dairy farms at the Karnal Institute to demonstrate the economics of dairy farming.

(IV) Holding of exhibition, film shows and demonstrations in villages to educate the farmers on modern dairy practices, management of cattle etc.

(V) Organisation of dairy melas, calf rallies, seminars and symposia at the Institutes involving scientific workers, farmers and representatives of the industry.

(vi) Participation in A.I.R. broadcasting programmes on topics of interest to dairy farmers.

(vii) Preparation of schemes, Lay-out plans and other details for starting of dairy farms and general advisory work.

(viii) periodical visits by the Technical Staff to dairy plants for discussing the problems of the industry.

(ix) Supply of germ plasm of exotic bulls and indigenous breeds for improvement of milch cattle.

(x) Distribution of starter cultures for preparation of dahi, butter, cheese etc. and root slips for propagation of fodder crops.

(xi) Organisation of special training courses in dairy extension.

(xii) Preparation and distribution of extension literature in English and some regional languages based on the results of research work at the Institutes.

(xiii) Publication of a monthly "Dairy Extension" journal at the NDRI from 1961 (which work was later transferred to the Extension Directorate of the Ministry of Agriculture Government of India).

(xiv) Publication of a monthly NDRI News letter and preparation of a "Dairy Hand Book" for the benefit of dairyman.

(xv) Demonstration of the working of Gobar gas plant (installed at the Western Regional Station of NDRI, Bombay) for the effective utilisation of farm yard manure and agricultural wastes as compost for fodder production and use of the gas for laboratory lighting and heating purposes and as motive power in sprinkler irrigation. At this station the possibilities of growing various fodder crops on rocky soil have been demonstrated.

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DAIRY TECHNOLOGY

N. R. Sundararajan and M. R. Srinivasan

This review covers the research work done in the field of Dairy Technology both in Bangalore (1923-1973) and in Karnal (1958–1973). The review is classified on the basis of products.

Pasteurization of milk by the batch method in a Wizard spiral coil vat of 200 gallons capacity was found to result in a loss of 0.74 to 1.69% of the milk in the pipe connections, outlet valve, pumps, etc., and the average loss was 1.12%[1] The suitability of cooling milk heated to 172° F, by passing it over a revolving drum filled with ice cubes and common salt was studied and the cost worked out[2]. A study of storing milk in sterilized glass containers[3] at elevated temperatures showed that at storage temperatures of 133° F and below, both cows' and buffaloes' milk curdled within 24 hr whereas at 131 and 143°F the milk kept well for 48 hr.[3] A process of storing boiled milk in mud pots insulated with hay was developed. By this process the milk could be stored for 17-18 hr without spoilage thus enabling the villagers to market the morning milk in the evening or the evening milk in the next morning[4]. Farm-produced milk was processed at 150°F and stored at the same temperature for 16 hr. There was no change in the acidity of the milk and there was a definite decrease in the number of organisms as compared to the milk stored in the cold subsequent to pasteurization[5]. Eighty five % of buffalo milk samples and 70 % of cow milk samples processed and stored at 145± 4° F curdled within 48 hr whereas similar samples processed and stored at 130± 4° F gave very promising results[6]. Milk processed at 170° F was as effective as at 180° F/190° F or boiling. The keeping quality of the milk judged by the alcohol positive index was an average of 27 hr. The acidity did not increase appreciably upto 18 hr of storage The MBR time (37° F) at the end of 6 hr storage served as an indication for the comparison of the efficiency of the heat treatment. The rate of growth of organisms surviving the heat treatment indicated the possibility of prolonging the shelf life of the milk further by suitable reprocessing at the maximum proliferative stage[7,8,9]

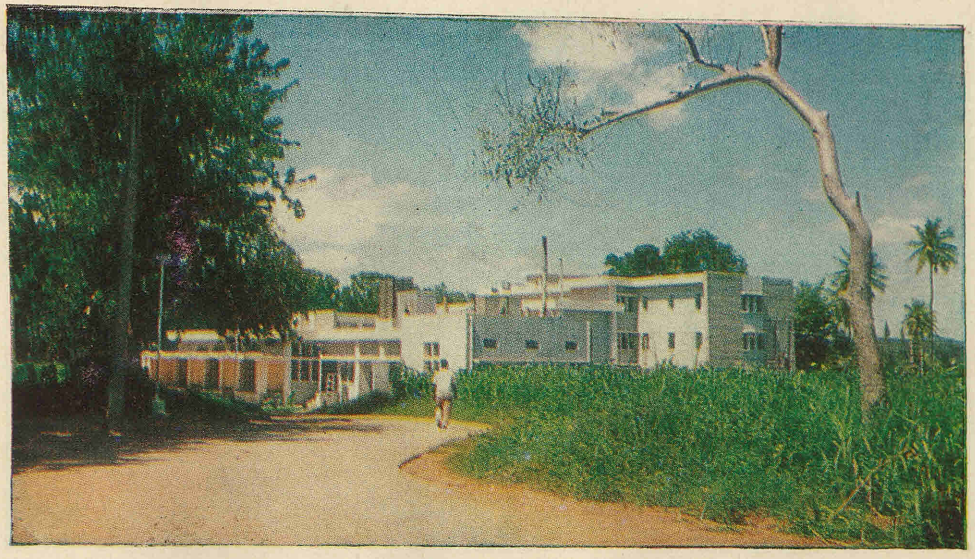
Reheating of pasteurised milk after storage for 8 hr at room temperature affected the nitrogen distribution by 7% and 17% respectively for cow and buffalo milk and an increase in the non–protein nitrogen by 25 % and 11% respectively for cow and buffalo milk, when such milk was stored for 24 hr. About 0.7% of the

original total solids in the cows milk and about 3%of the total solids in the buffalo milk were deposited at the bottom of the vessels[10]. A tamper-proof milk delivery can was designed and fabricated with the collaboration of the Hindustan Aircraft Ltd[11]. Marketable life of milk cooled to low temperatures of 40, 50, and 60° F and stored in insulated containers was compared to that of milk heated at 170° F/ 10 minutes and water-cooled to 72±2° F. The latter was found to be more effective[12]. Processing milk (80±5° F) enabled the transport of milk from rural producing centres to the dairy without spoilage. Processing at higher temperatures had an advantage[13]. The effects of pasteurization and homogenization (single and double stage) on the Gerber test for fat, surface tension and viscosity of buffalo milk were studied[14]. Double effect homogenization at 140° F reduced the curd tension of raw buffalo milk by 55%. Boiling or sterilization caused greater reduction in curd tension than pasteurization. Boiling and sterilisation increased viscosity of buffalo milk, the increase being higher when homogenization preceded heat treatment. Fat test by Gerber method was 2 % lower when homogenized milk was boiled or sterilized[15]. Absence of protein destablization and cream layer formation was observed in recombined milk prepared from butteroil emulsion containing 18% fat and 8.5% SNF when added to reconstituted milk to give 3.2% fat and pasteurized[16].

Analysis of 10 years' data on the daily handling of milk at the NDRI Dairy showed that on an average 0.67% of milk was lost in handling while in terms of fat and SNF the losses were 0.792% and 0.725% respectively. A decrease in the loss of milk and milk solids was observed with increased quantity of milk handled[17]. A method was standardized for the detection of sodium bicarbonate in milk at 0.4% and above by methylene Blue reduction method as 0.3% and higher levels of bicarbonate by finding titratable acidity after boiling and at levels above 0.15% by observing the development of chocolate colour on autoclaving both milk using chocolate colour standards[18].Preconcentration of milk for long distance (1000 km) transport was shown to be an economic proposition[19,20].

Butter and Ghee

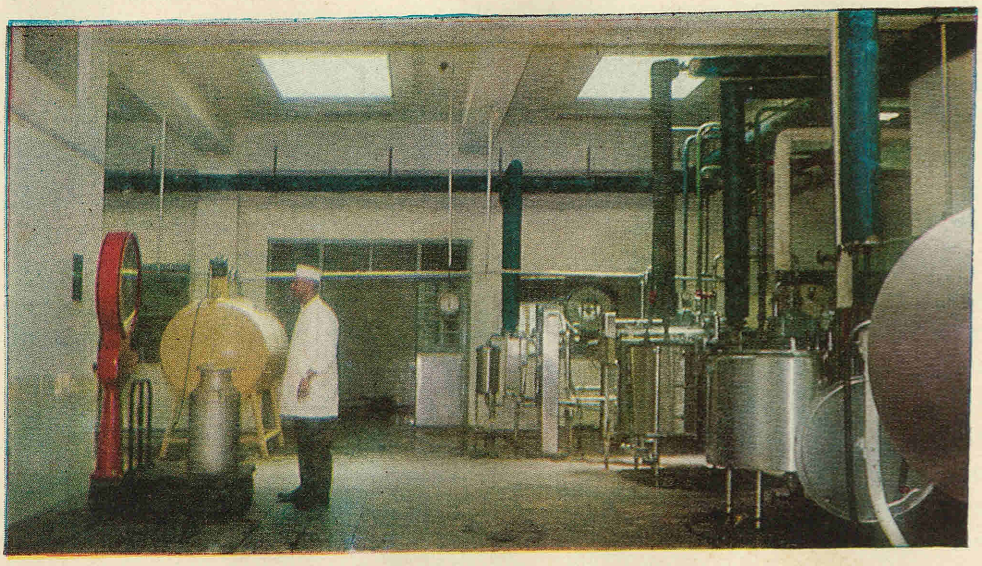
By means of a comparison, it was established that ghee making by cream seperator method gave 18% more yield than the desi method.[21] It was shown that sour cream could be neutralized, pasteurized and converted into butter even after 12 months' storage in tins was of good quality[22]. Adjusting the fat in the cream to 30% for churning minimised the loss of fat in the butter-milk. The optimum temperature of ageing was found to be 48 – 52°F and that of churning at 54 - 56°F Addition of sodium citrate to the cream improved the flavour and keeping quality of the butter.[23] Butter prepared from high acid cream (0.5 to 1.3%) neutralized by Sodium carbonate and pasteurized at 172°F was found to be satisfactory[24]. Annatto butter colour, which compared with the imported butter and cheese colours, was prepared by extracting the colouring material from the seeds of a plant called *Bixa-orelana*, which is also locally grown[25]. A comparison of the shelf life of butter samples having 16, 18 and 20% moisture showed that samples having 20% moisture was poorer in aroma, taste and body after storage and also registered greater increase in their peroxide values[26].



AN APPROACH TO SOUTHERN REGIONAL STATION



A SECTION OF LIBRARY



A SECTION OF DAIRY



A SECTION OF RESEARCH LABORATORY

An insulated box for storage and transport of butter under atmospheric temperatures of 90 to 120°F was designed. Butter stored for 6 days in the box remained fairly hard and the quality of the butter was unchanged[27]. A comparison of the improved desi churn and barrel churn for churning cream was made. By virtue of the special arrangements in the improved desi churn for regulating speed, it could be used for cream containing 53% for yielding 93–95% recovery. By carefully regulating the speed of the churn, the temperature of churning and the number of times of working the butter, it was possible to obtain table butter of average quality[28]. Chas or Matha in ghee was found to increase the keeping quality of ghee. Ghee samples in which Matha is present to the extent of 1% showed the lowest peroxide and acid values[29]. It was observed that direct clarification of washed cream with a lactic acidity of 0.15—0.20% (by ripening or acidification) effected 92-93% of fat recovery with the minimum loss of fat in ghee residue. Peroxide values of ghee samples indicated that an acidity of this order in the cream prior to its clarification did markedly affect the keeping quality[30]. It was possible to get 93-94% yield by the desi curd process of ghee manufacture when the improved churn was used. The butter and ghee thus obtained were also of high grade and longer life[31].

Ghee heated to between 60 and 100°C and maintained at 29°C in the case of cow ghee and 31°C in the case of buffalo ghee formed the largest number of big grain. The maximum grain size was 0 34 mm in cow ghee and 0.54 mm in buffalo ghee[32]. A procedure for the preparation of ghee by induced stratification of butter at 80°C for 30 minutes in the case of desi butter and for 15 minutes in the case of creamery butter followed by heating the top 2 layers to near about 120°C was developed[33]. By diluting cream with water to the original volume of milk and reseparating, the weight of ghee residue and hence the fat loss in the residue was considerably reduced when the cream was directly converted into ghee. Ghee of the best quality was obtained from cream washed once and ripened to 0.16% lactic acid[34]. Comparison between direct heating of cream into ghee and pre-stratification of cream followed by heating indicated that the latter method was far superior to the former in many respects, although the yield was the same in both the cases. Aroma and storage stability of the ghee were shown to be influenced by the temperature of clarification. Cream having 40%fat gave the highest yield by this method. Neutralizing acid cream prior to washing had no advantage in this method of ghee preparation. Also addition of lactose to the washed cream before ripening had no desirable effect on the flavour of ghee[35,56,37].

Studies on the efficiency of the 'Blanche-Electrix' churn for the preparation of butter from curd showed that maximum out-turn was obtained by diluting the curd with an equal quantity of water, adjusting the acidity to 0.9-1.0% (lactic) and maintaining a churning temperature of 85° F or below. The butter thus obtained had lower moisture, but more curd than the desi butter. Similar studies on cream indicated that this butter also had more curd than the butter made in the 'end-

over-end' wooden barrel churn[38]. Heating butter fat with lactose or with casein did not produce the characteristic flavour of ghee. Use of lactic curd containing acid casein and traces of lactose produced the desired flavour in butter fat. Creamery butter ghee retained the flavour for a longer period than direct cream ghee or desi ghee[39]. A laboratory outfit was designed to ascertain the shelf-life of ghee on the basis of induced oxidisability[40]. Re-working of desi cow and buffalo butter having 18-30% moisture several times brought down the moisture to 16% or below. A starter culture containing *S. lactis*, *L. helveticum*, and *L. Plantarum* yielded very good butter. Dahi held and churned at room temperature showed more loss of fat and the churning time was 15-20 minutes. Desi butter stored in chilled water (5–10° C) for a week showed 1 to 2% further decrease in moisture[41]. Washing butter with water having 20-25 p.p.m. chlorine prior to working minimized the coli, yeast and mould counts. Higher concentration of chlorine left a residual smell in the butter[42].

Investigations on the standardization of the method of production, packaging, storage and utilisation of dehydrated butter fat showed that reseparation of cream at 140° F increased its fat content by about 10 to 15%. The use of oil separator brought about a similar increase to the fat but with less loss of fat during handling. The treatment of butter at 140° F using ordinary mechanical cream separator and oil separator maintained the moisture levels below 2%. Cream samples with high SNF did not lend themselves to satisfactory dehydration. Shock cooling was helpful for obtaining a butter substitute; but, for the development of packed grainy texture gradual cooling aided by seeding with grain from previous loss was suggested. The dehydrated butter fat developed perceptible oxidized flavour during the first month of storage. Addition of ethyl gallate in a concentration of 0.05% increased the shelf life upto 3 months. Alternatively packing the product under 20" vacuum prior to sealing considerably increased the shelf life[43].

The washing of butter from buffalo cream collected under commercial condition was found to cause early deterioration of the organoleptic quality[44]. Low water-insoluble acid values were found to correspond with high table quality of butter and low yeast and mould count[45]. Limited rheological studies (hardness, oiling off and slip point) revealed that although rapid cooling of cream resulted in apparantly harder butter, considerable amount of liquid fat was left in the butter which was liberated at higher temperature. Use of additives was found to increase the hardness. Use of Tween 80 was found to decrease the oiling-off in butter. Buffalo butter was harder than cow butter (1.929 : 1.000)[45a]. Increase in the hardness of butter was accompanied with decreased BR values, high melting points and low solidifying points. Pasteurization did not affect hardness but ageing temperatures significantly affected the hardness and BR value. Ripening was responsible for lowering the hardness[45b].

Maximum fat recoveriets were obtained from fat levels of 35% in buffalo cream and 40% in cow cream. Fat losses from sweet cream were more than the

neutralized acid cream. Addition of breakwater was responsible for reduction in the fat losses in neutralized cream only[46].

A technique for the manufacture of sterilised buffalo cream of an acceptable quality was standardised. The process consisted of standardizing the cream to 20% fat with skim milk preheating to 80°C and holding for 10 minutes, two stage homogenization at 175 kg/sq cm and 50 kg/sq cm, addition of trisodium citrate at 0.2% and trisodium orthophosphate at 0.1% level and canning and sterilization at 144 ± 1°C for 15 minutes. A product of more than nine months' life at room temperature was obtained[47].

Cheese

Milk having 3.5 to 5.0% fat was shown to be most economical with minimum fat loss for conversion into cheese[48]. Maximum yield of good quality surti cheese (Panir) was obtained when (i) the milk had 6% fat, (ii) pure lactic starter (0.7 – 0.8% lactic acid) was added at the rate of 0.5 oz for every 100 lb of milk, (iii) rennet at the rate of 1 ml for 16 lb of milk was added to prepasteurized milk maintained at 95°F (iv) 4.75% salt was added to the 'green cheese' and (v) the cheese was ripened for 12-36 hours steeped in the whey[49]. A casein/fat ratio of 0.7 : 1 was found to be satisfactory for cheese making in Bangalore. Pre-ripening of milk with 0.1% cheese culture at 50°F for 12–16 hours prior to its conversion into chaddar cheese reduced the time of curd production by about 25%[50]. Cheese prepared with bacterial rennet produced in the Bacteriology laboratory of the Institute was comparable in quality to that made by using Hansens rennet[51]. Chaddar cheese having desirable flavour and texture was manufactured from buffalo milk with slight modifications in procedure for cows milk[52]. Removal of two lactic streptococci that were susceptible for agglutination from cheese cultures resulted in the reduction of cheese preparation time to 3 1/2 hours. Two different combinations of fast acting cheese starters were standardized[53].

Storage of cheese blocks at room temperature in an atmosphere of carbon-di-oxide hastened the rate of ripening of the cheese as judged organoleptically and by chemical analysis[54]. Surti cheese (Panir) steeped in whey containing 50% starter distillate (5 ppm diacetyl) could be stored at room temperature upto four days without spoilage. Inclusion of flavour producing organism along with an acid producer in the starter enhanced the flavour and keeping quality of the cheese.[55]

A process for manufacture of cheese of satisfactory quality from buffalo milk has been standardised. The procedures included the addition of starter when about 3/4th of milk was received into the vat to ensure thorough incorporation of starter, use of diluted rennet, cutting a short while earlier, cooking the curd upto 38.7°C within 30 minutes and maintaining it at this temperature for another half an hour, draining at the end of 60 minutes, piling high, filling and pressing into 20 kg hoops, and curing at 10°C[56]. Techniques for the production of quick ripening 'Karnal Cheese' have also been developed[57]. Swiss cheese was made with cow and buffalo milks. The rate of acid development during manufacture was

higher in cow than buffalo milk. Matured cow milk cheese was found to contain higher levels of moisture, NPN and water soluble nitrogen than buffalo milk cheese. Cow milk cheese had characteristic eye formation and flavour[58]. Conditions for the spray drying of cheese spread were standardized. The technique consisted of spray drying the spread obtained from 5 months old cheese at an air inlet temperature of 160-170°C and outlet temperature of 99-100°C. The product was gass-packed in containers. A shelf-life of over two months at 5°C and 15 days at 30°C was reported for the freshly made cheese spread while dried product remained marketable for over 6 months[59]. Buttermilk cottage cheese was manufactured from a mixture of buttermilk and skim milk (1:1) using long and short setting times. After coagulation the curd was cut into cubes of 5–6 cm., and heated at 80°C. After draining the cheese was pressed for 3–4 hours in cloth lined hoops[60]. High heat treatment of milk and curd, addition of lactic and phosphoric acid to cream, cooling of curd and wash water treatment with Aureomycin were found to retard the growth of *coliforms* and *psychrophiles* in creamed cottage cheese. Sorbic acid and myprozine were effective against yeasts and moulds[61]. Processed cheese was spray dried at 170°C inlet temperature and 98-100°C outlet temperature. A loss of 5 to 7% volatile fatty acids was observed. Free fat was found to increase during first 30 days of storage. The shelf life at 30°C of the product was predicted to be 10 months using regression equation[66].

Concentrated and Dried products

Investigations on the preparation of evaporated buffaloes milk showed that preheating of 4% fat–adjusted milk at 95°C for 5 minutes prior to condensing at 115-120°F (25'' Vacuum) followed by sterilization at 12.5 lb pressure for 15 minutes yielded a product which stored well for 2–1/2 months. The alcohol and phosphate tests were found to be unreliable for determining the heat stability of evaporated buffalo milk[62]. A process for the small scale preparation of evaporated/sweetened condensed milk under village conditions was developed[63]. It was found that fore-warming at 203°F for 5 minutes was the most suitable treatment for buffalo milk. The alcohol test was more reliable than the phosphate test in predicting the heat stability of evaporated buffalo milk. Stabilizers like disodium hydrogen phosphate and sodium citrate increased the heat stability of evaporoted buffalo miik[64]. A process for the preparation of evaporated buffalo milk conforming to British and Indian standards has been developed. The product had a shelf life upto one year[65].

Comparative studies on the production of instantised and normal spray-dried non-fat buffalo milk powder from different levels of total solids in the concentrate showed that moisture, solubility index, average particle size, bulk density and dispersibility increased with increased total solids in the concentrate[68]. Factors influencing the solubility of double-drum-dried buffalo milk were studied using whole and skimmed milks[69]. Addition of 0.01% BHA to standardized milk was shown to extend the shelf life of full cream spray dried buffalo milk[70]. A study on the production and shelf life of spray-dried fruit milk powder was carried

out. Shelf-life of 6 months or more was reported when gas-packed. The banana milk powder had shelf-life of 3 months[71]. The physical characteristics of skim and whole buffalo milk powder made by different processes corresponded to those of cow milk powder. The solubility index of buffalo milk powder was slightly higher than cow milk powder. It was possible to produce near-instant milk powder from buffalo skim milk by single pass process using 50% total solids in the concentrate, holding it at 5°C for 12 to 14 hours and then atomizing it at 7000 rpm. This treatment permitted adequate lactose crystallization to alpha non-hydrate form producing easily wettable and dispersible powders. The size of casein micelle of buffalo milk was found to be bigger than casein micelle of cow milk. The effect of heat on casein micelle in reconstituted milk from buffalo skim milk powder and instant milk powder was greater than that in reconstituted cow milk powder. The clustering of casein micelles in reconstituted milk from buffalo milk powder was also greater[72].

Techniques for the production of full cream recombined sweetened condensed full cream buffalo milk were standardized[73,74]. The shelf-life of selected brands of sweetened condensed full cream buffalo milk were studied[75]. At storage temperatures around 37°C, the viscosity of sweetened condensed full cream buffalo milk showed an initial drop and then a progressive rise when the product was stored upto 135 days. Below 25°C all the samples had acceptable viscosity[76]. The rate of evaporation in batch and continuous evaporators was higher with higher inlet temperatures of the feed.[77] Skim milk evaporated faster than water but the rate was similar for skim milk and standardized milk. Energy consumption was found to be independent of the three process variables. Incorporating acid precipitated casein in milk before evaporation was studied and storage properties of the product for six months at 37°C were reported as satisfactory[78]. Physicochemical properties of electrodialysed buffalo milk (passed through an electrometathesis equipment for ion-exchange) were recorded The removal of calcium from buffalo milk increased with decrease in the flow rate through the membrane. The curd tension of milk dropped after electrometathesis, but the rennet coagulation time and heat stability increased with increased removal of calcium (upto 45% removal)[79].

Casein

White coloured good quality rennet casein was obtained by washing the curd three times with warm water and once with cold water and drying in the sun. Lactic casein of fair quality and light ivory colour could not be further improved by washing the soft green curd[80]. Cow and buffalo skim milk of low acidity and low fat content gave, on rennetting, casein of good colour keeping quality and high ash content. Pasteurised and boiled milks yielded an inferior product. However, addition of saturated lime solution and constant stirring during rennetting and cooking improved the quality of the product to some degree[81]. Optimum conditions for the precipitation of casein with hydrochloric acid were established. A sanatogen like food product was made by the incorporation of sodium glycero-phosphate into the soluble ammoniated casein[82]. A process for the preparation of lactic casein

was standardized. Addition of 3% lactic starter by volume gave firm and smooth curd. Addition of water upto 10% of original milk had no appreciable effect on the quality of casein. A fat level of less than 0.05% in the skim milk and uniform regulation of hot air circulation in the drying cabinet were found to be necessary for getting a good quality product[83]. A standard technique for the manufacture of casein under Indian village conditions was developed[84]. Alkali treatment of skim milk to decrease the fat content to less than 0.05% markedly affected the rennet activity for precipitating casein. However, acidification of this treated milk with dilute lactic acid to pH 6.0 restored the rennet activity. This process did not affect the yield or the quality of casein[85]. Precipitation of casein from desi-butter-milk by direct heating gave 90% recovery but the product had 6% fat. By repeated dissolving in alkali solution followed by passage through a cream separator and acid precipitation 69% of the casein in the butter-milk could be recovered and the fat content of the product was within the specifications[86]. The detailed procedure, equipment required and manufacturing cost of casein under Indian conditions were discussed[87]. Trials on the manufacture of edible casein and sodium caseinate were conducted for the conversion of surplus, substandard and sour buffalo skim milk. The wet or dry casein was dispersed in 2.5 N alkali keeping pH at 7.0 to form Sodium caseinate followed by spray or roller drying[88].

Khoa

Good quality khoa was obtained by boiling milk having 4.5% fat until a pasty consistency, followed by desiccation at 180 to 190°C to 25±2% moisture level[89]. Although neutralization of 'high-acid' milk improved the body and texture of khoa obtained therefrom, the flavour and keeping quality of the product was still poor. Sweetening of normal milk prior to dehydration improved the keeping quality of khoa remarkably[90]. Initial moisture content of 20-25% in khoa and a temperature of 90°C at the time of packing in the tins ensured a minimum shelf-life of 14 days at 37±1°C. There was no advantage of incorporating pottassium sorbate and butylated hydroxyanisole in khoa[91] It was shown that the surplus concentrated milk of the dried and evaporated milk industries could be profitably converted into khoa[92]. Smooth texture khoa was produced from aged roller dried skim milk powder and ghee[93]. A continuous khoa making plant was developed to overcome the drawbacks of batch process[94]. With improvements in the design and operation of the continuous khoa making plant, a storage life of 10 days at 38°C has been reported for canned khoa[95]. Physico chemical changes during storage of khoa were mostly proteolytic, lipolytic and 'sugar-fermented' type[96]. Many biochemical and physicochemical changes have been observed during khoa manufacture in respect of lactose destruction and browning, redox potential, pH, formal titre, free fat, peroxide value, acidity and detailed chemical composition[97].

Other Products

A technique for the processing of ghee residue by washing with 50% alcohol followed by cooking in a 10% solution of bicarbonate was evolved. The processed residue was subsequently used for the preparation of chocolate toffees and edible

pastes[98]. Chocolate milk having 2 to 3% fat, 6 to 9% sugar and 1.5 to 2% chocolate was found to have the most suitable marketable quality[99]. Carbonation of heat treated milk prior to inoculation with a mixed starter consisting of *S. lactis* and *S. cremoris* and bottling yielded dahi with satisfactory keeping quality at room temperature[100].

Ice Cream

A method for the production of ice cream with cultured flavour was standardized. A mix containing 14% fat, 15% m.s.n.f., 14% sugar, 0.3-0-7% gelatin and 0.05% lactic acid gave most desirable product. Data on the viscosity, surface tension and time required to obtain 100% over-run were also recorded[101]. Trials were conduted on the spray drying of ice cream mix using a T. S. content of 27.36 and 39% and outlet temperature of 100 and 108°C. Inlet air temperature of 160°C was found most suitable. The bulk density averaged 0.5 gm/ml during the trials. The solubility of powder decreased at faster rate during storage when packed in air than in nitrogen packed samples. Low viscosity of reconstituted mixes produced icy and coarse textured ice cream[102]. The best judged soft serve ice cream was prepared from 7%fat, 12% m.s.n.f., 15% sugar (derived from 35:65 parts of 50 DE corn syrup and sucrose), 0.3% sodium alginate, 0.2% glycerol monostearate. An overrun of 50–60% and serving temperature of 20 to 23°F were considered desirable[103]. A technique was standardized for the production of spray-dried Srikhand. The product on storage beyond 90 days showed progressive loss of flavour. The volatile fatty acids also showed an increase during storage[67].

A method was developed for the large scale manufacture and storage of Srikhand and Srikhand powder by spray drying with an air inlet temperature of 100° C and air outlet temperature of 100° C.[104] Chhana production from buffalo milk has been standardised.[105] Rasagolla was prepared from cow and recombined milk and canned in 55° bricks sugar syrup. Addition of sodium metabisulfite and sorbic acid were found to increase the shelf-life. The highest recovery of milk solids was obtained by heating milk to 60° C followed by coagulation.[106] A ready-to-reconstitute coffee complete containing milk, sugar and coffee has been developed and this had a shelf-life of 6 months at room temperature.[107] A technique was also standardized for the production of spray dried tea complete. The product had a shelf-life of 9 months when gas packed in hermetically sealed containers.[108] Methods for the industrial production of yoghurt and other fermented milk drinks have been developed. A continuous process for the manufacture of fermented milks has also been suggested.[109] A comparison of the lactose contents of chhana whey and desi buttermilk indicated that the former contained 4.1 to 4.8% while the latter 1.5 to 1.75% of lactose.[109] Crude lactose having 6.1 % moisture and 3.62% of ash on purification by boiling with activated charcoal and recrystallization gave a product having only 1.88% moisture and less than 0.16 % ash.[110] A colorimetric method was standardised for measuring the extent of caramelization (intensity of browning) in dairy products such as heated milks, khoa, ghee residue, etc.[111]

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DAIRY EDUCATION

S. R. Jayashankar and P. G. Nair

It is a well known fact that any industry can thrive only on the skill of the persons engaged in the trade. So is the case in the dairy industry. Prior to the starting of this Institute in 1923, it can be stated that there was no systematic training given to the persons engaged in Dairy Farming.

In the year 1923 the Government of India sanctioned the opening of two years' training course for the award of Indian Dairy Diploma in Dairying on the lines of National Dairy Diploma in Dairying given by the Royal Agricultural Society in England at the Imperial Institute of Animal Husbandry and Dairying (later designated as Indian Dairy Research Institute), Bangalore. In the very first year of the commencement of the course, about 200 applications from all over India were received but only 15 candidates could be admitted due to limited training facilities. Two other courses viz (i) a Post-graduate Course for imparting higher instruction in the science and practice of dairying and (ii) Short Practical course in dairy farming for benefit of the men in the field were initiated at the Institute from January 1924. A little later, special courses of instruction for co-operative inspectors and vocational training courses for soldiers were also introduced.

The two years' diploma course included training in subjects like elements of agriculture, farming, cattle management, dairy chemistry, dairy bacteriology, manufacture of milk products, dairy book keeping and cooperative dairying. Year after year there was increased demand from the States and private candidates for admission. In addition to the diploma course, the Institute for some years admitted students for 15 months post-graduate course in dairying (Associateship of IDI) for which Indian Dairy Diploma holders as well as graduates in pure science, agriculture and veterinary science were eligible. This course was discontinued in 1948. In the year 1945, the necessity for training candidates in fundamental and applied research was felt and with this end in view Honorary Research Workers course of 2 years' duration was started. These workers afetr undergoing a course in general dairying took up research work on dairy problems and also submitted Theses embodying the results for getting M.Sc. and Ph.D. degree of various Indian Universities (Bombay, Poona, Madras, Gujarat, Nagpur, Agra and Punjab). In addition, the Institute continued to offer the short period training (3 months duration) for men in the trade. With the introduction of accelerated training programme to provide trained

man power to the industry in 1945–46, larger number of students were admitted to the IDD courses. The admission to the Honorary Research Workers course was also increased.

With the establishment of the National Dairy Research Institute at Karnal in 1955, the Institute at Bangalore was designated as the Southern Regional Station and all its educational programmes were continued as before.

In the year 1957, for the first time in the country a Dairy Science College offering a three and a half years B.Sc. (Dairying) degree course was started at the newly established NDRI at Karnal. The college was affiliated to the Punjab University. From the year 1961 onwards the course was reorganised into two branches for specialization in 'Dairy Husbandry' and in 'Dairy Technology'. It was also felt that there was need and scope for the bifurcation of the diploma course into Dairy Husbandry and Dairy technology streams and this was effected in the year 1961.

With the coming out of the first batch of graduates in Dairy Science a post-graduate degree programme was also started at Dairy Science College, Karnal, in the year 1961 offering M.Sc. degree in Dairying. A post-graduate diploma course in dairy engineering was initiated subsequently. The B.Sc. (Dairying) degree as well as the M.Sc. (Dairying) courses were changed to semester system in 1970 and then to trimester system in 1972.

The Institute in collaboration with Indian Institute of Management conducted multi level management programmes in 1966. This included an apex seminar, a rural level and a plant level management programme. Another management seminar was held in collaboration with FAO, Royal Danish Government and Government of India. A third "Dairy Executive Management" programme was held in 1969 in collaboration with the Indian Institute of Management, Ahmedabad, where dairy managers and intensive cattle Development Project officers participated.

Number of students have also been trained for short periods in various branches such as analytical techniques, artificial insemination, quality control, manufacture of dairy products, etc. The Institute has also arranged several short duration training programmes to housewives in the preparation of dairy products and to farmers in dairy farming, forage production etc.

The NDRI at Karnal and the Southern Regional Station at Bangalore have developed facilities for doing advanced research and have admitted a number of candidates to do research work for the doctorate degrees of various Universities. These two Institutions have been recognised by many Indian Universities as centres for post-graduate research work and the staff have been recognised for guiding the students. With the starting of the regular M.Sc. degree courses at Dairy Science College, NDRI, Karnal, admission of candidates for this course at Bangalore was discontinued and candidates were taken only for Ph, D. degree. The Institute has maintained a broad based view in all its training activities and has kept open the admissions to the post-graduate studies to graduates in Veterinary

Science, Agriculture, Medicine, Economics, Extension and also pure sciences. Those without dairy background are required to undergo some pre-requisite courses so as to make them fit to take up specialized post-graduate courses at the Institute.

Summer Institutes

The Institute organised two summer Institutes one in 1969 on Milk production at Bangalore and another on Dairy Technology in 1970 at Karnal. Manuals containing various articles articles by specialists were released to the participants. A workshop on All India Coordinated Research Projects was held in 1971 at Karnal, to discuss on transportation of milk, technoiogical and economic progress of liquid milk plants, and utilization of surplus-sub-standard milk. A third summer Institute on quality contorl measures was conducted at Karnal in 1973.

Besides these the staff of the Institute have participated in seminars and workshops organised at other Institutes/Universities from time to time.

In order to make the information on facilities and courses available to all the persons, the first 'Hand Book of Dairy Training in India' was published by the Institute in the year 1961. The book gave all the information on the courses offered at the institute Including the syllabi for the then existing courses.

Staff training activities

The Institute has realised the importance of offering facilities and incentives for the higher training of its staff. These have included deputation of staff to foreign countries under various aid programmes such as TCM, FAO and Colombo Plan. At the lower level staff have been given study leave to complete Masters degree courses. Staff have also been allowed to attend many refresher courses conducted with the assistance and collaboration of international bodies like FAO/ UNICEF both inside the country as well as in foreign countries. Staff members have been encouraged to undertake short duration observation-cum-study tours in foreign countries so as to incorporate the latest knowledge and techniques in the training and research programmes of the Institute.

Board of Dairy Education

With a view to maintain a uniform standard of training of the diploma students at various centres, the Government of India constituted a Board for Dairy Education in the year 1961. With the reorganisation of ICAR the name of this Board was changed to ICAR Sub-Committee on Dairy Education. This Committee has since then regularly met 2 or 3 times in each year and supervised the training activities and examinations for the IDD courses at different centres viz., Bangalore, Bombay, Anand, Allahabad and Haringhatta.

Centre of Exellence in Dairy Production

A "Centre of excellence in Dairy Production" has been established at the Institute through a project of the United Nations Development Programme. Under this programme the Institute has obtained a Mini Computer. The Principal of the

Dairy Science College visited foreign countries to find avenues for advanced training in dairying for Indian scientists.

Scholarships and Medals

In order to encourage young men and women to take up dairying as a career, the Institute has arranged to obtain a number of scholarships and fellowships to its students. A total of 28 NDRI Scholarships, 12 private and a number of I C.M.R., I.C.A.R., C.S.I.R., scholarships are awarded each year. In addition to the above many students are given State Government scholarships/stipends. A number of medals are given to meritorious students who secure ranks in the final IDD, B.Sc., (Dairying) and M.Sc. (Dairying) examinations. Details of the scholarships, fellowships and awards available for the students are shown below :—

NDRI Scholarships

Course	No. of scholarships	Value (Rs/month)
IDD (Dairy Technology)	4	100
IDD (Dairy Husbandry)	4	100
B.Sc. in Dairying (Dairy Technology)	8	150
B.Sc. in Dairying (Dairy Husbandry)	8	150
M.Sc. (Dairying)	4	200
	28	

These scholarships are given to students on merit cum means basis every year.

Other Scholarships

These scholarships have been instituted by the industry in order to encourage young men to study the courses at the Institute.

Donor	Course	No. of Scholarships	Value (Rs/month)
Sir Dorabji Tata Trust	B.Sc., in Dairying (DT)	3	75
Amul	,,	1	50
Larsen & Tubro Ltd	,,	1	50
Polson Ltd	,,	1	50
A. P. V. Engineering Co. Ltd.	B.Sc. in Dairying (DH)	1	50
Food Speciatities Ltd	,,	1	50
Glaxo Labs India Ltd	,,	2	50
Hindustan Milk Food Mfrs. (P) Ltd.	M.Sc. Dairying	1	200
Amul	IDD (DT)	1	75
		12	

ICAR and CSIR Fellowships

A limited number of followships from ICAR and CSIR are awarded every year for the M.Sc. and Ph D. students.

Besides the above scholarships and fellowships a number of State Governments offer stipends/scholarships to the students studying in the Institute.

Medals

The following medals are awarded :

Punjab University Gold medal	....	M.Sc. (Dairying) B.Sc. (Dairying) DT B.Sc. (Dairying) DH
Amul Gold medal	....	B.Sc. (Dairying) DT
Venus Training Co. Gold medal	....	IDD (DT) and (DH)
,, ,, Silver medal	....	IDD (DT) and (DH) for individual Centres
Indian Dairy Science Association Gold medal		IDD (DH) and (DT)

Foreign Scientists and Experts

The Institute has had the benefit of having Foreign Scientists as experts in the Institute for a number of years under various aid programmes. They included, H. R. Whitehead (New Zealand), O. Samlik (Poland), Prof. Carl W Hall (U.S.A.), Mr. Newcomer (U.S.A.), Prof. J. D. Sargent (New Zealand), Dr. W. L. Slatter (U.S.A.), Dr. G. H. Wilster (U.S.A.), Dr. G. Godberson (Germany), Dr. D. L. Gibson (Canada), Dr. A. W. Farrall (U.S.A.), Mr. R. E. Stout (U.S.A.), Mr. J. H. Hensen (New Zealand) and Dr. A. Dunlop (New Zealand) These experts have helped the Institute in the training programmes.

Organization of seminar/workshops/symposia at the Institute

With a view to encourage the persons in dairy trade, Government employees working on dairy schemes and teachers in the field to meet, discuss and enlarge their vision, the Institute has organized several symposia, seminars and work–shops under its own finances or through collaboration with other organizations.

The first of the series of workshops was organised under the joint auspices of FAO/UNICEF/Government of India at Karnal in the year 1961. This was followed by similar workshops in 1962, 1963, 1964 and 1965. Teachers from all the Dairy Training Institutes took part in these workshops. Foreign experts and scientists acted as advisers/directors. These workshops covered various topics eg. technique of teaching and educational methods, preparation of lecture outlines and laboratory manuals, in different subjects, effective teaching and communication techniques, preparation of time tables, assessment of students, equipment and services needed for dairy training, examination system, inplant training programmes and manual in English to improve the vocabulary of students and revision of IDD syllabi with consequent modifications in lecture outlines and laboratory manuals.

Students' Union and Extra Curricular activities

The Institute has placed great importance on the physical and cultural developments of its students. For encouraging the students to take part in such activities, Students' Unions have been created. All the extra curricular activities such as games, sports, debate, drama etc. of the students are organized by the Unions. The students at Karnal have participated in state tournaments and won laurels. The students both at Karnal and Bangalore have taken part in the cattle judging competitions in the All India and Regional Cattle shows and won prizes. The Unions at Karnal and Bangalore have brought out students' magazines.

Number of students trained at Bangalore and Karnal

Courses	DSC NDRI Karnal	SRS NDRI Bangalore
Ph.D. (dairying)	20	16
M.Sc. (,,)	176	44
B.Sc., (,,)		
B.Sc., (dairying) (DT)	223	...
B.Sc., (dairying) (DH)		
A. I. D. I.	...	149
I. D. D.	78	1316
Short courses Milk Production and Market Milk plant Operations	....	1120
Diploma in Dairying (Engg)	57	...
Extension Courses	77	56
Other short courses	278	15

Names of IDD students obtaining first rank

BANGALORE

Year	Name		Year	Name	
1925	Sri Khurody D. N		1962	Sri Kanai Chakraborty	
1927	Singhal C. B.		1963	Abhi Bhushana Chowdary	(DT)
1929	Raghubir Singh			Narendra Nathan P. K	(DH)
1933	Francisco J		1964	Ish Kumar Narang	(DT)
1935	Mohammed Y. K.			Banare R. O	(DH)
1937	Mehta G. H		1965	Murugappan V. T	(DT)
1939	Iya K. K			Kumbar R. M.	(DH)
1941	Krishnaswamy M. A		1966	Ghate P, K.	(DT)
1943	Ranjit Singh			Srinivasan S	(DH)

1945	Saraswat D. S	1967	Narayan Nair N	(DT)
1947	Wilfred Abeywarna		Mardur Y. V	(DH)
1948	Waidyaratna	1968	Ashok Kumar Gupta	(DT)
1949	Shanmugam N		Nafe Singh Dabas	(DH)
1950	Thanaye U	1969	Srinivasa Murthy S	(DT)
1951	Seetharaman C. R		Radhakrishnan S	(DH)
1953	Desai H. B	1970	Vinod Kumar Goel	(DT)
1954	Basudev Narain		Abhaynath Thakur	(DH)
1955	Ghose D	1971	Narasimhan M	(DT)
1956	Chakraborthy B. K		Sohrab E Chinoy	(DH)
1957	Satish Verma	1972	Ramalingam M. P	(DT)
1958	Chaterjee		Anil Kumar Sinha	(DH)
1959	Saini R		Rayappa Reddy	(DH)
1960	Gopalan Nair K. C	1973	Patanjali N	(DT)
1961	Chandran R		Joseph Manuel	(DH)

KARNAL

1963	Sawhney S. S	1967	Harbhajan Singh
1964	Banwarilal Khattar	1968	Gupta D. K
1965	Gurdial Singh	1969	Om Prakash
1966	Chhinna, M. S	1970	Chadda, J. M

Names of B.Sc. (Dairying) Students Obtaining First Rank

Year	Name		Year	Name	
1960	Avadesh Prasad		1968	Rizvi, S. S. H.	(DT)
1961	Inder Krishan Vijay			Arun Srivastava	(DH)
1962	Sati Kant Mishra		1969	Arun Kilara	(DT)
1963	Kadan, J. S.			Vijay Shankar	(DH)
1965	Amrik Singh	(DT)	1970	Jolly, R. C	(DT)
	Tarlok Singh Riar	(DH)		Rajinder Singh	(DH)
1966	Sood, V. C.	(DT)	1971	Sachdev, V. K	(DT)
	Juneja, R. K.	(DH)		Onward Taw	(DH)
1967	Thakura, K. K.	(DT)	1972	Agashe, C. D	(DT)
	Gupta, A. N.	(DH)		Mohinder Singh	(DH)

Names of M.Sc. (Dairying) Students Obtaining First Rank

Year	Name	Year	Name
1964	Pramod Lokre	1969	Sood, V. C
1965	Motilal Madan	1970	Rizvi, S. S. A
1966	Thomas, C. K.	1971	Sankarasetty, P. A
1967	Kulshrestha, V. V	1972	Gajri, V.K
1968	Thomas, K. C.		

Staff members winning University Awards

1950	Dr. Zal R. Kothavalla	Gold Medal (D.Sc), Bombay Uuiversity
1952	Dr. H. Laxminarayana	Gold Medal (Ph.D.) Bombay University
1945	Dr. C. P. Anantakrishnan	Maharaja of Travancore, Lord Curzon award, Madras University
1948	Dr. T. M. Paul	Maharaja of Travancore, Lord Curzon award Madras University

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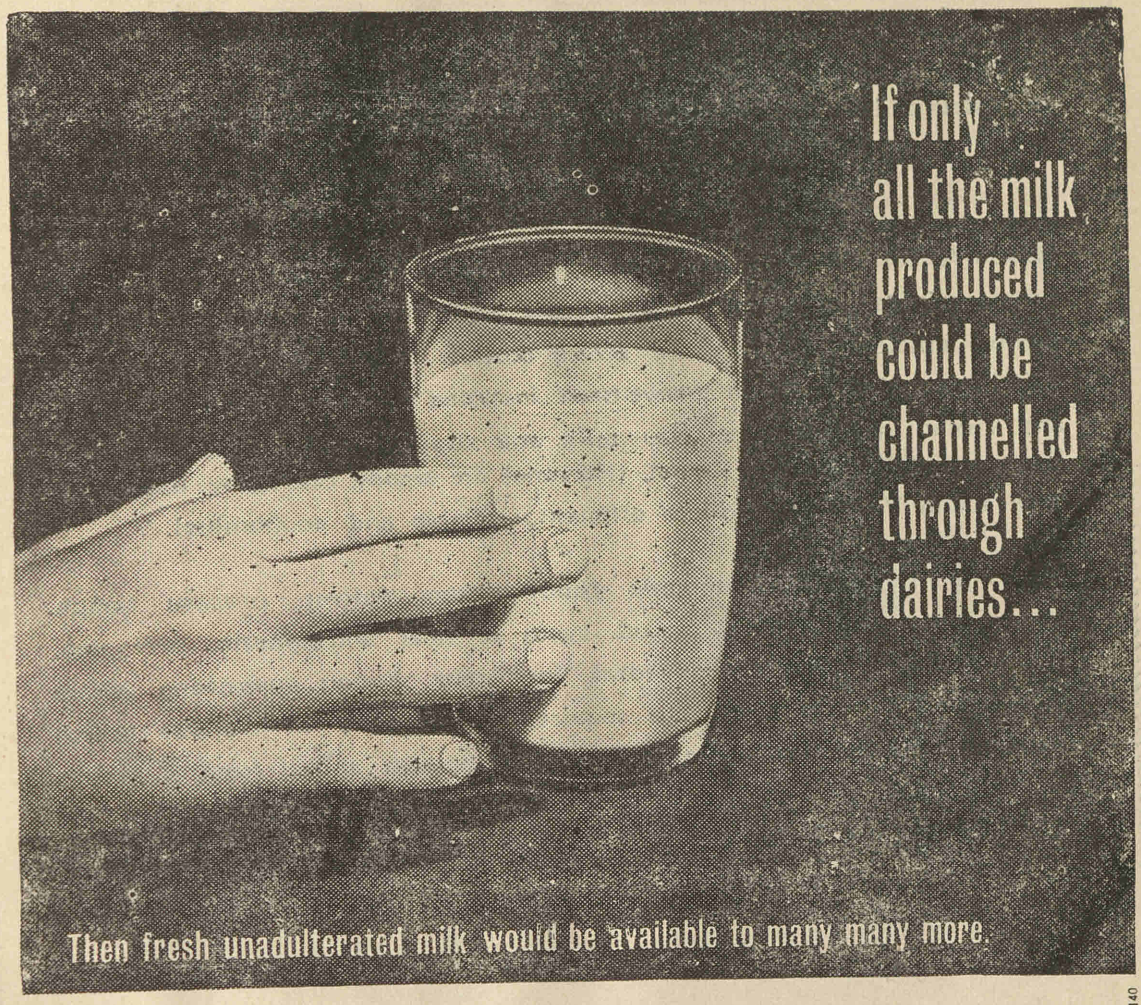
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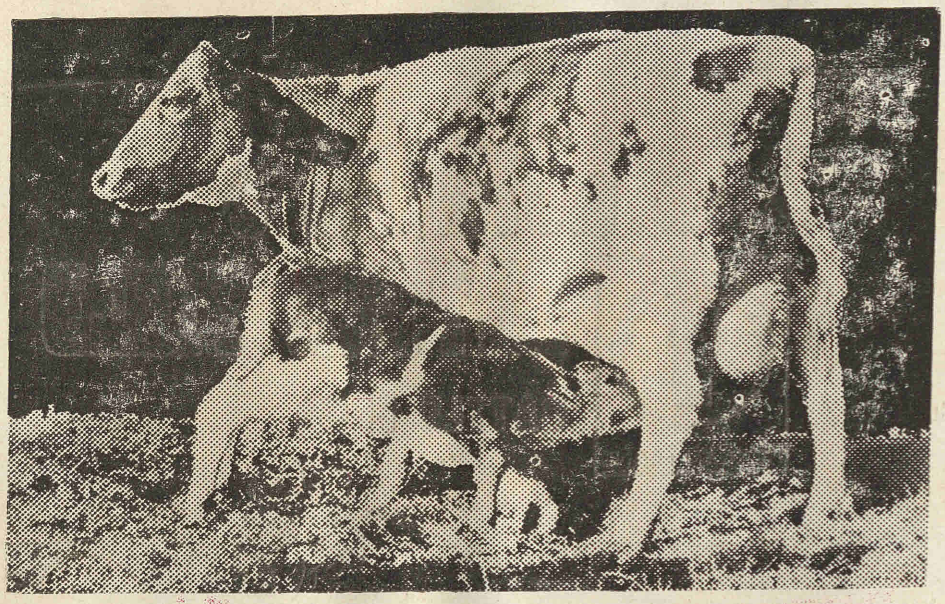


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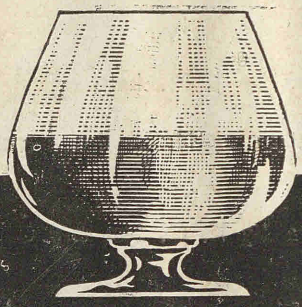
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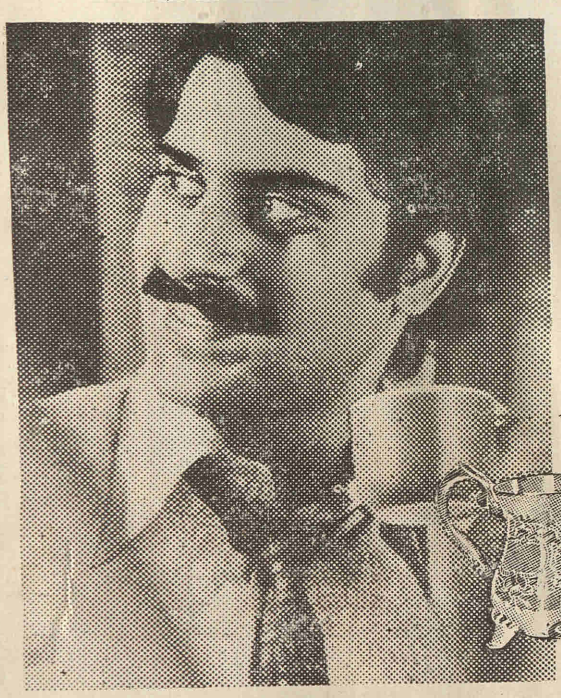
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