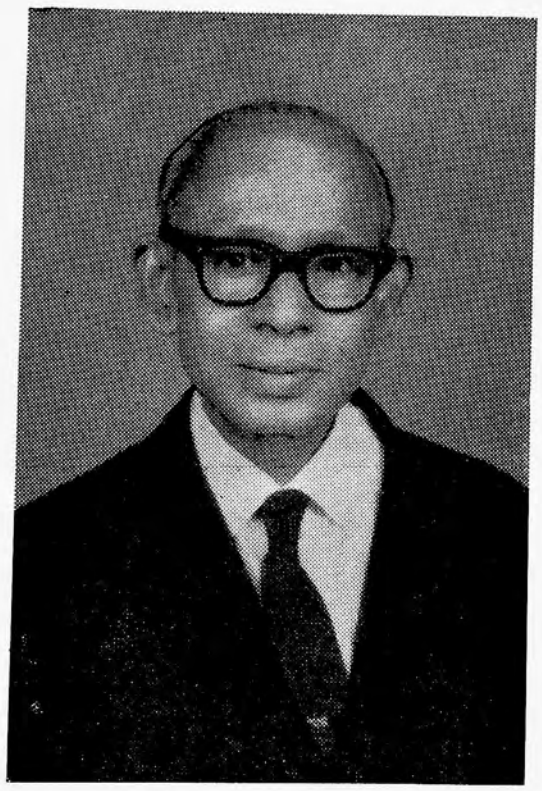

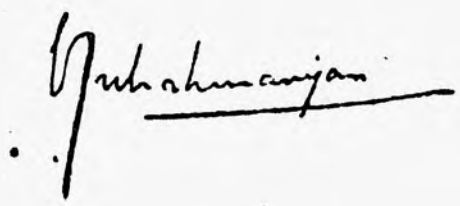

VAIDYANATHA SUBRAHMANYAN

(1902–1979)

Foundation Fellow

Early Life, Education, Scientific Career

Vaidyanatha Subrahmanyan was born on September 16, 1902 in Sirkazhi, Thanjavur District, Tamil Nadu and had his school education also in Sirkazhi. For his Intermediate and collegiate education, he went to St Joseph's College, Tiruchirapalli. He came out with distinction in the BA degree final examination securing the highest marks in Chemistry for the entire Madras Presidency for 1922. Immediateiy after obtaining his BA degree he joined the Department of Biochemistry, Indian Institute of Science, Bangalore. With a loan scholarship offered by the JN Tata Endowment, he proceeded to England in 1925 for higher studies. He was fortunate to come under the direct tutelage of the late Sir John Russel at the Agricultural Research Station, Rothemstead. The problem assigned to him there was related to the nutrition of the rice plant in water-logged soils. The studies formed the subject matter of his doctoral dissertation for which he earned the DSc degree of the London University in 1927.

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* The author had the privilege of being a graduate student of Professor Vaidyanatha Subrahmanyan during 1943-1948 in the Department of Biochemistry, Indian Institute Science, Bangalore. Not only was Professor Subrahmanyan the mentor of his doctoral dissertation but also a source of wise counsel to whom he turned till his last day. With his direct involvement under his supervision in the multi-institutional evaluation of the safety of hydrogenated vegetable oils during 1945-1948 envisaging growth experiments on three generations of the abino rat, studies on nitrogen, calcium and phosphorous balance in human volunteers and adult rats, and most significantly institutional feeding trials on orphanage children in Mysore, the author was very much part of the 'inner circle' around Professor Subrahmanyan at the time he was on his move to Mysore from Bangalore. However, he was not among those who accompanied him to Mysore in building the Central Food Technological Research Institute. Instead in migrated to Lucknow in July 1950 to join the nucleus of another CSIR national laboratory, the Central Drug Research Institute.

Faraway from Dr. Subrahmanyan and his sphere of activities in the Cheluvamba Mansions, Mysore and yet deeply interested in the growth of food science and applied nutrition and what is more, having been exposed to him during a critical and formative phase of the author's own research career he claims the advantage of being an 'outsider' and hence to possess a certain degree of freedom from subjectivity in presenting this biographical memoir of a scientist for whom 'food science was not a profession but a life's passion'.

Returning to India he was appointed a Lecturer in the Department of Biochemistry, Indian Institute of Science, Bangalore. Within two years came the elevation to the rank of Professor and Head of the Department when he was just approaching his twenty seventh year. It must be mentioned here that in pre-partition India there were only four centres for biochemical research; the Indian Institute of Science, Bangalore, the University of Panjab, Lahore, the University Biochemical Laboratories, Madras and the University of Dacca, Dacca. From 1929 to 1948, for 19 years, Professor Subrahmanyan occupied with distinction the chair of Biochemistry in the Indian Institute of Science and attracted a large number of research scholars from all over the Indian subcontinent.

Deputed in 1939 for refresher-training in the United Kingdom, he visited a number of research laboratories during his two year subbatical in England but spent most of the time in the Biochemical Laboratories in Cambridge.

Returning to India in 1941 Professor Subrahmanyan found the country deeply involved in World War II. There was an inevitable policy shift in the management of IISc necessitating the diversion of all R & D activities towards defence needs. Professor Subrahmanyan plunged into this effort wholeheartedly and guided a number of application-oriented research programmes. These include the supply of glandular products for therapeutic use, conservation of food grains and preparation of biochemicals. He bade goodbye to his work on enzymes and carbohydrate metabolism and totally identified himself with problems related to their nutritional evaluation food processing and preservation and their evaluation.

His appointment in 1948 as the Planning Officer for a Food Technology Laboratory by the Council of Scientific and Industrial Research, Government of India marked the end of one phase of his career and the beginning of yet another at Mysore.

After two years of intense spade work including the acquisition of Cheluvamba Mansions and its conversion, with minimum architectural changes, to a modern research laboratory, Professor Subrahmanyan was able to organize the formal opening on October 21, 1950 of the Central Food Technological Research Institute by the late C Rajagopalachari, the then Home Minister, Government of India. The same day he took charge as Director of the newly established Institute and served it for thirteen years till his superannuation in 1963. 'With vision and widsom, drive and dynamism, energy and enthusaiam, he helped to convert a Maharaja's Palace into a modern temple and build a transdisciplinary scientific team...' writes Professor Nayudamma in his Foreward to the Professor V Subrahmanyan commemmoration volume of the Journal of Food Science and Technology. No other words are needed to encapsulate, as it were, the illustrious career of Professor V Subrahmanyan the prime architect and the first executive of one of our premier national laboratories.

Retirement from the Directorship of CFTRI did not mean for him cessation of scientific activities. As an expert consultant on behalf of the Food and Agriculture Organization of the United Nations, he spent three fruitful years in Philippines and helped the National Institute of Science and Technology in Manila to organize a Food Technology Laboratory. On returning home he became an Emertitus Scientist of CSIR and advised the Ministry of Food, Government of India on subsidiary foods and mass nutrition programmes. In 1969, he acceded to the request of the Tamil Nadu Government and founded the Paddy Processing Research Centre at Tiruvarur. He continued to serve this new Centre and developed many areas of work on pre-harvest and post harvest technology till he breathed his last on January 30, 1979 a few months short of reaching his seventy seventh year.

Scientific Work And Some Major Contributions

Professor Subrahmanyan's scientific career can be considered as an unending list of activities not confined to one single area but truly of a transdisciplinary nature. The best tribute one can pay him is to recall that in days when it was the vogue for eminent scientists to pursue their research within the narrow boundaries of their own special interest totally unconcerned with what was happening in the neighbouring room, he was perhaps one of the earliest in the country to appreciate the need for multi-disciplinary approach in solving major problems in biological research.

He began his scientific career with a piece of research on acetone fermentation in 1923 but soon found that his major interest was in the study of soils, the interaction of nutrients, crop yields and recycling of agricultural wastes and residues. After an interlude of work on enzymes related to carbohydrate metabolism, the World War II period and the few following years saw his deep involvement in a number of application-oriented development projects giving him the strategic background and preparedness for launching into areas of food processing and preservation which literally kept him on his toes for the remaining forty years of his life. An attempt is made here to outline the highlights of these studies and indicate their overall impact on the development of science in our country.

Soil Science and Environmental Biochemistry

Problems related to soil nutrition attracted Professor Subrahmanyan throughout his life. In the early phase of his work, attention was mostly devoted to the role of manure, soil microflora, microfauna and the close interrelationship between soil structure, plant growth and crop yield. Among the trace elements manganese was shown to play a catalytic role in crop yields—a discovery which Soviet agroscientists exploited profitably a decade later.

The nature of oxidation of carbon in soil and its influence on nitrogen metabolism in the rice plant were hotly pursued by this group. Dr A Srinivasan,

FNA investigated the characteristics of rice starch and its breakdown. He adduced evidence for the phosphorylytic cleavage of starch besides the amylolytic mechanism but missed discovering phosphorylase, the related enzyme which was accomplished a few years later by CS Hanes in Cambridge.

Even a casual perusal of the titles of the papers published during this phase indicate that the Bangalore School was aware of the frontier areas of research on nitrogen and carbon cycling in soils. These problems have today assumed vital significance to us with mounting evidence for what appears to be an irreversible degradation of our soils by intensive cultivation and indiscriminate application of chemical fertilizers. Retrospectively, one cannot help noting with regret that interest in this vital area of research viz the biogeochemical cycles of the primary elements, dwindled in the Department of Biochemistry after the fifties. The work of pioneers like Professor Subrahmanyan and Professor GN Acharya in composting and recycling of nutrients was presumably dismissed as dreams of Gandhian utopians. How amusing that, today in the mid-eighties, composting, biogas production and recycling of human wastes have all been assigned the status of 'thrust areas' in the National Biotechnology Programme.

In this context it is worth mentioning the studies initiated in Bangalore in the last part of the twenties and early thirties on the treatment and disposal of municipal wastes. Sewage with a high BOD could be converted by a simple aerobic process, later christened as the Activated Sludge Process into a relatively safe effluent which could be used for raising farm crops and vegetables. The residual sludge which was enriched with nutrients could in turn be applied to infertile soils. The municipalities of Ahmedabad and Madurai promptly adopted the process and the transfer of technology was effected without any fan-fare. The treated effluent could also be used for aqua culture. With financial assistance from the Indian Council of Agricultural Research, Drs R Rajagopalan and SC Pillai carried out extensive studies spread over a period of thirteen years on the utilization of sewage for crop production. It was shown that the soil mostly suited to sewage irrigation was the sandy soil and the crops most suited to sewage farming were fodder crops and sugarcane. It was advisable not to grow vegetables and salad crops on sewage in the interest of the health of the consumers. Again it is interesting to mention that the Biotechnology Board has of late massively supported studies on algal culture for biomass production based on waste water utilization. Furthermore, standardization of farming conditions for the use of municipal waste water has become the preoccupation of many local bodies and the National Environmental Engineering Research Institute, Nagpur has a major project in its on going R&D programme.

One of the interesting fall outs of the investigations on Activated Sludge was the fascinating studies initiated by Dr Subrahmanyan, the later Dr Pillay and their associates on the role of the peritrichous ciliates, vorticellids, in the biochemical processes involved in the clarification of sewage. These ciliates

transform the organic matter in the sewage and separate the water. The oxidised sludge and effluent from this process could be safely used for soil fertilization and crop production. It is interesting to note that smaller forms of protozoa such as *Colopoda*, *Colopodium*, *Balantiophonus* and simple *Vorticilla* bring about similar changes in ordinary agricultural soil. Immediately following the discovery of vitamin B_{12}, the Bangalore group also identified a protozooan organism isolated from sewage with a high potential for commercial production of this important vitamin. Mention must also be made of the fact that this school provided trained experts and consultants in the emerging areas of industrial hygiene and environmental sanitation. Dr SC Pillay, Dr CR Harihara Iyer, Dr TR Bhaskaran, Dr R Rajagopalan, Dr Gurbaxani, Dr Mohan Rao are some of the luminaries of this school. It is a pity that this rich background notwithstanding, Bangalore did not nourish any worthwhile School of Environmental Microbiology.

Self Sufficiency in Biochemicals

DuringWorld War II (1939-1945) the Indian Institute of Science, Bangalore and, particularly, the Department of Biochemistry made very significant contributions towards the development of indigenous technology for the preparation of a number of essential items. The exigency required not only feasible processes but also the creation of facilities to prepare the materials in some quantities for immediate use. Transforming a laboratory designed basically for academic research into one which could tackle problems of production and quality control was itself a challenge. This was accepted and it was to the credit of the Department of Biochemistry that powdered pituitary and rennet were supplied regularly for defence needs. Pituitary glands collected from slaughter houses located in Calcutta, Bombay and Madras were brought to Bangalore preserved in ethyl alcohol. They were processed by adaptation of knowhow already available in literature, the end products standardized and supplied in a powder form to the defence authorities. Similarly, calf stomach rennet needed for making junkets and cheese was prepared from the linings of calf stomach. Later, when the defence authorities wanted a vegetable rennet, an intensive research programme was initiated, a milk-clotting enzyme was prepared from the latex of the fig tree and its utility in preparation of cheese was demonstrated.

Desiccated thyroids and adrenals were prepared. The testing of the resultant preparations required pharmacological procedures and a nucleus for the same was organized which later branched off into a separate department. Animal testing and biological evaluation techniques for the activity of glandular products such as pituitarin, adrenalin, insulin and thyroxin or pyrogen testing were organized with that we would consider today as very primitive resources. All this required the introduction of a host of new laboratory procedures and the acquisition of expertise at short notice. Large scale refrigeration facilities were not available in the laboratory nor could

one buy those days dry ice. The technique of freeze drying on large scale was also unknown.

Enzymes such as pancreatin, trypsin and pepsin were prepared from animal glands. Mincing of pancreas or stomach linings their dispersion in appropriate buffers for extraction of the enzymes, salting out with ammonium sulphate or sodium chloride, recovery of the precipitated enzymes and their dehydration were all done in a shed with make-shift arrangements. One could not afford to wait for feasibility reports on the laboratory process and the process went straight into production. A food colour was extracted and prepared on a large scale from annato seeds. In the case of insulin considerable amount of research and spade work was done to devèlop an adsorption procedure of enrichment of the hormone. Calcium gluconate was produced by an electrolytic oxidation procedure using molasses as starting material. Some of these processes were handed over to small manufacturing units which were being set up in Bombay under the stimulus of the war. Besides gaining experience in taking up applied problems on a war footing, the above activities also brought a good amount of monetary benefits to the Institute and to the participating staff in terms of shared royalty and technical fees. Small quantities of penicillins were produced when they were not available in the market and the first samples after their evaluation in the laboratory were made available to doctors who were then in-charge of the medical care of Kasturba Gandhi who was seriously ill in jail. GB Ramasarma, NL Lahiri, Sanadi D Rao, SS Rao, PR Venkataraman, MV Lakshminarayana Rao, V Jagannathan, CN Bhima Rao, G Balasubramanian, S Balasundaram, Karnani, CR Krishna Murti, PV Kamath, S Kuppuswamy, A Rahman and many others were products of this hectic era of applied biochemistry in Bangalore in the forties of this century.

Evolution as a Food Scientist

Soil nutrition and food production were among the primary research interests of Professor Subrahmanyan in his early career. These interests were further stimulated when as a graduate student he came under the influence of Sir John Russel in England. His interest in sewage treatment which he owed to his association with Professor EG Fowler in Bangalore rested mainly on the possibility of using treated sewage as a source of nutrient for crop production. Had not the war intervened requiring the diversion of all his activities to more pressing problems in all probability he would have stuck to this area and continued to make notable contributions to agricultural sciences. This was not to be as we saw earlier.

The man-made Bengal Famine of 1943 was a rude awakener. It became clear in the aftermath of that calamity that food and population growth were closely knit together and any lasting solution has to be found by planned efforts with the backing of Science and Technology. In India, like in all

less developed countries, underlying the question of food supply lurks the more serious problem of undernutrition and maluntrition. The classical experiments of Robert McCarison and later by Aykroyd and Krishnan in the Nutrition Laboratories in Coonoor had demonstrated decades earlier that the diet made predominently of rice consumed by the poor in South India was multi-deficient. On account of its low content of protein the late Professor M Damodaran in a lighter vein, but very appositely suggested that in scientific literature the poor South Indian rice diet should be referred to as the lethal diet. Hailing himself from an area where such a diet kept alive on marginal health millions of people, Professor Subrahmanyan was only keenly aware of the problems of malnutrition. In a lecture on frontiers of food research delivered under the auspices of the Bangalore Science Association in 1945, he eloquently described the picture of poor children just bones and a scaly skin often with bloated abdomen and how that vision had become permanently etched on his mind in his younger days and which in turn led him to take a vow to do something to relieve those distressing conditions.

Chronic multi-deficient malnutrition as a national problem paled into insignificance when one watched helplessely thousands of people dying on the pavements in the city of Calcutta and elsewhere in the country for want of a handful of rice. It was clear to Professor Subrahmanyan that besides dedicated work in the laboratory a total social commitment was essential to face the challenges of the day. He made eloquent pleas for an energetic drive to conserve all food resources by preventing the losses associated prior to and after harvest by improving cooking and processing methods and utilizing the byproducts. He geared the limited facilities of the Department of Biochemistry to take up investigations on food spoilage and recovery. One of the very first problem to be tackled was the spoilage by storage of the fruit and rations of the armed forces. This was dealt with expeditiously by developing a heat flash method. The process was tested on a large scale in a commercial potato dehydration plant. Later the problem of spoilage of stored food grains and flour was referred to the Department by the Armed Forces. Here, the need was to arrest the proliferation of insects, a method for sterilizing the eggs and recovering the grain from the contaminants. The flash process was practised with an indigenously built contraption which had a chute at one end of a tunnel for feeding the spoiled grains or flour, a screw propellor to move the grain through a distance of 8-10 ft in an electrically heated cylinder, a holding chamber at the discharge end and simple arrangements to pack the treated grains in gunny bags. There was no engineering drawing or design nor even a good workshop to fabricate the required components. The temperature for flash heating and the interval of exposure to the elevated temperature for sterilizing the eggs and larvae and other design criteria were arrived at by trial and error approaches. Several thousands of bags of insect infested food grains were however,

reconditioned in the laboratory with this indigenously built flash heating processor.

While engaged in this important practical work Professor Subrahmanyan's restless mind was in search of sources of proteins for supplementing the poor rice diet. As part of studies on infantile hepatic cirrhosis on a project funded by the Indian Council of Medical Research, it had become more than apparent to him and his colleagues that the normal function of a healthy liver especially of a growing child was indeed intimately linked to adequate protein intake from the very beginning of its post-natal existence. The importance of pre-natal nutrition of the child was already recognized by the priority given to pregnant women as specially vulnerable to protein malnutrition. Professor Subrahmanyan read reports on the use of milk type preparations from Soyabean used by the Chinese for centuries for feeding children and adults. Soon with support from the Indian Council of Medical Research, he and his colleagues developed a process for preparing an easily digestible protein rich milk-like emulsion from soyabeans. The process involved seeping of soyabeans in water, steaming and dehulling, grinding the dehulled and soft dal into a paste in a stone idli grinder (edge-runner), dispersion of the paste in water with addition of buffering salts and heat treatment to stabilize the emulsion. All the equipments in which the unit operations had to be carried out were indigenously made. For a long time Professor Subrahmanyan was obsessed with the problem of the nutty flavour of the milk. It was found later that this could be overcome partially by fermenting the milk to curd. Subsequentily milk-like emulsions could be prepared by a similar process from groundnut, coconut and cottonseed. HSR Desikachar, N Subramanian, Moorjani and others were products of this era.

Another major project completed at the Biochemistry Department was the safety evaluation of hydrogenated vegetable oils as part of a multi-institutional programme sponsored by the newly set up Department of Food, a portfolio held in the first national cabinet by no less a person than the late Babu Rajendra Prasad. A committee consisting of Dr DV Karmarkar the Technical Adviser to Department of Food, Professor BC Guha, Department of Applied Chemistry, Calcutta University, Professor M Damodaran, Head Biochemical Laboratories, University of Madras and Professor Subrahmanyan was entrusted with the responsibility for overseeing this programme of work. Along with SM Bose, the author actively associated with the planning execution and final compilation of the comprehensive report which cleared the misgivings raised earlier by experiments conducted at the Indian Veterinary Research Institute, Izatnagar. While Bose struggled with the analysis of the total feacal and urinary output of six human volunteers put successively on five dietary regimens, Krishna Murti played with three generations of rats raised on a standard diet as well as on the poor rice diet. On the latter diet, true to the prediction of Professor Damodaran, the survival rate in the

second and third generations was less than thirty per cent. The team also conducted for the first time institution feeding trials in the orphanage attached to Good Shephered Convent and St. Philomena Orphanage in Mysore.

At the Central Food Technological Research Institute

A delegation on behalf of the Food Industries Panel and the Technical Secretariat of the Department of Food, Government of India visited many countries in Europe and the far East to study the status of food science and technology and rècommended the setting up of a Central Institute for Food Technology. Accepting this recommendation, the Government of India assigned the task to the Council of Scientific and Industrial Research. The late Sir SS Bhatnagar with his uncanny instinct for picking up the right person for the right task had no hesitation in choosing Professor V Subrahmanyan as the Planning Officer.

The Cheluvamba Mansion with the surrounding 130 acres of freehold land had been offered by the Mysore Royal Family to the World Health Organization to set up the Head Quarters of its South East Regional Office. Within moments of the announcement of WHO to set up its HQ in New Delhi in preference to Mysore, Professor Subrahmanyan exerted his tactful negotiatory skills and obtained the Cheluvamba Mansion as a munificient gift from the Government of Mysore and in December 1948 Pandit Jawaharlal Nehru accepted, on behalf of the nation, the Cheluvamba Mansions from the Maharaja of Mysore.

Starting from a bare building and a skeleton staff of 5-6 research assistants working on sponsored projects under his dynamic leadership, CFTRI at the time of the retirement of Professor Subrahmanyan had a staff of 250 scientists, two additional buildings, a modern food processing laboratory, workshop, a well stocked library and six experimental stations. The diverse problems tackled in the institute and the technologies transferred to user agencies raised CFTRI to the status of the most outstanding institution in South East Asia and an International Reference Centre for Food Science and Technology. The pioneering efforts of Professor Subramanyan in manpower development set the stage for the establishment in 1966 of the International Food Technology Training Centre (IFTTC) in collaboration with the Food and Agriculture Organization of the United Nations and subsequently in 1976 in the recognition of CFTRI as an associate institution of United Nations University.

Supplementary Protein Foods

Largely due to the tireless efforts and imagination of Professor Subrahmanyan the technology for plant based milks and supplementary foods was developed in the course of a decade. Tuber starches could be enriched with such proteins and after blending with minerals and vitamins could be processed into rice-like grains. Consumer acceptability was established by trials on large population groups in Kerala.

An integrated process was developed for extracting the oil, protein and carbohydrate from groundnut based on a continuous wet-grinding method. The unique feature of the process was the emulsification of the oil and protein in the whole kernel at suitable pH and separation of the oil by centrifugation and the protein by isoelectric precipitation of the oil free centrifugate. The process yielded relatively undernatured proteins and a good quality oil. The protein could be incorporated into a number of preparations like biscuits, macaroni etc.

The now famous Indian Multi-purpose Food and the Bal-Ahar were the offshoot of these activities. A number of commonly accepted sweet or savoury dishes could be easily prepared out of the multi purpose food. A more significant achievement was the organization of midday feeding trials on school children in Metropolitan Madras by which the nutritional efficacy of the product was established. This led to the establishment of a ten ton plant in Madras by UNICEF for the production of edible quality groundnut protein by solvent extraction.

Milk Based Baby Foods

The achievement for which Professor Subrahmanyan will ever be gratefully remembered by the nation is the 'breakthru' obtained in developing a baby food based on buffalo milk. The process led to the attainment of self-sufficiency in milk based baby foods against the teeth of opposition from multinational producers of baby foods who had till then monopolised the market. When Professor Subrahmanyan started the work on buffalo milk based baby food, the idea met with stiff opposition and even contemptuous derision by fellow scientists. The tough consistency of the curd of buffalo milk rendered it unsuitable for infants. Preprocessing of milk and subtle alterations in its composition enabled CFTRI, under Subrahmanyan, to convert buffalo milk into easily digestible dry milk preparations. The process was taken over by the Kaira District Milk Producers' Co-operative Union in Anand and after some minor changes was adapted for large scale production and sale under the trade name AMUL. This laid the foundation of a solid base for the indigenous Baby Food Industry with an annual turnover of over Rs. 100 crores and has paved the way for the development of a number of weaning foods.

Food storage, Preservation and Packaging

Following the lead obtained from the investigations conducted at Bangalore during the World War II years, Subrahmanyan initiated, in CFTRI, a major programme on the effect of grain infestation on the nutritive value of grains. The level of uric acid was found to be a good indicator of the degree of infestation. On the basis of this discovery and related studies on the biological value, changes in the content of vitamins etc during insect infestation,

the Ministry of Health has prescribed 10 mg uric acid per kg of grain as the permissible level for food grains meant for human consumption. Post harvest protection of grains at the producer's end as well as that of the stockists, insect proofing of gunny bags for storage, development of simple insecticide formulations for household pest control, rodent control, development of storage structures by ballooning techniques were other contributions made by Subrahmanyan in this vital area. The pragmatism of Subrahmanyan's approach led to the successful evolution of a feasible technology of protection of standing grains at pre-harvest stage and storage of the harvested grains in insect proof bags or storage facilities in the post-harvest stage. It was also to the credit of Professor Subrahmanyan to have introduced multidisciplinary techniques and strategies in a field of operation which was till then considered as a monopoly of entomologists. This sort of approach yielded rich dividends in relation to the 'monsooning process' and the ballooning technique for the storage of coffee bean.

The development of a non-toxic insecticide based on activated earth was yet another significant contribution. The active ingredient was found to be meta-hydrogen halloysite and electron microscopy, differential thermal analysis, x-ray diffraction, gas adsorption, oil bleaching index, bulk density and lipophilic nature were used in the qualitative assessment of the insecticidal activity. By its dehydrating property, the insecticide also inhibited the growth of saprophytic organisms.

Professor Subrahmanyan introduced the discipline of Food Packaging in India in the early fifties. A national survey was conducted with funds from FAO and many problems related to the transport and packaging of food articles were identified. Packaging materials and cartons based on indigenous raw materials were developed for the long distance rail transport of perishable articles like vegetables, fruits and fish.

At the Paddy Processing Research Centre, Tiruvarur

By adding a Rice Bran Oil Mill, a coconut processing unit and an R&D laboratory to the Modern Rice Mill complex at Tiruvarur with the support of local enterpreneurs, Professor Subrahmanyan established in 1969 the above centre at Tiruvarur. Treatment of standing paddy crops with a 15-20 per cent aqueous solution of sodium chloride led to the development of a simple and effective pre-harvest technique. Similar techniques were also evolved for the post-harvest storage of high moisture paddy. Systematic studies were conducted on the fermentative changes occurring during the soaking of paddy for parboiling. By incorporating 0.5 kg sodium chromate per tonne of paddy soaked, the problems of fermentative changes, loss of nutrients, development of off flavour, mycotic infection etc could be controlled. Formaldehyde, quarternary ammonium bases, hexamethylene tetramine and chlorine were also used with some success. The level of chromium absorbed by the rice grain during the process has been shown not to pose any health hazard by

safety evaluation studies conducted at the National Institute of Nutrition Hyderabad. Pressure parboiling technique could also be successfully used on freshly harvested paddy minimising losses due to post-harvest storage and transport. The Centre has also devoted a good deal of attention to the moderainzation of rice mills. A technology for bran stabilisation and preparation of edible grade rice bran oil was a direct outcome of these efforts. It is gratifying to note that many private mill owners and the Food Corporation of India have adopted these techniques with great profit reflected as higher yield and better quality products from the consumer's angle.

Basic Versus Applied Biochemistry

The dichotomy of basic versus applied science appears very incougrous and irrelevant while evaluating the contributions of Professor Subrahmanyan to Food Science and Technology. His attraction to mundane problems and the challenges posed by them appear to be almost inexorable. Who else would ever think of spending years tracking down the growth stimulatory property of tamarind and chillies to the small supplement of available calcium the condiments provided to the South Indian rice diet ? An inborn gift to pick the right problems at the right time contributed to-much of the practical success achieved by Professor Subrahmanyan in dealing with down to earth problems related to protein resources, processing and preservation. In attacking these problems he also played the historical role of a forerunner of areas of technology which failed to stimulate the interest of contemporary scientists but which nonetheless turned out to be of vital importance to national economy. He could read the writing on the wall in the aftermath of the Bengal famine. Though very impatient for action, he was prepared for the long gestation period required for a new technology to establish itself in the food science field in a tradition bound society. His pragmatism and unconventional approach led to his encouraging many new ideas and projects which appeared to be almost impracticable at that time of history but proved most appropriate in the subsequent decades. The story of AMUL is indeed a saga in the history of Indian Food Technology and deserves to be written by a person more competent than the author of this memoir.

Having said this, it will be unfair to leave untouched the question : What sort of impact all the above contributions of Professor Subrahmanyan had on the basic sciences related to Food Technology. This question assumes significance when one recalls the extremely elegant piece of basic biochemical work which he did in Cambridge in 1938-1940 along with David Green and Herbert Gordon. Several studies were in progress in Cambridge those days directed towards the understanding of the role of vitamins in cellular life and energetics. It was known that the metabolism of sugars was severely affected in vitamin B (thiamin) deficiency. Earlier studies of Embdon, Meyerhof, Needham and others had paved the way for elucidating the enzymic pathways mediating the use of glucose by cells.

One of the keysteps, the decarboxylation of pyruvate is carried out by an enzyme known as pyruvate decarboxylase which itself is now recogniżed to be part of a multi enzyme complex called pyruvic oxidase mediating the entry of pyruvate into the oxidative cycle. Professor Subrahmanyan, Green and Gordon were able to demonstrate the cardinal coenzymic role of thiamin pyrophosphate in pyruvate decarboxylase. This work is mentioned universally in all standard text books of biochemistry.

In the voluminous scientific output of Professor Subrahmanyan spread over 55 years the above piece of work stands out as a lone landmark. As to why he did not pursue this important line of work on his return to India there seems to be no clue. It is also surprising that this involvement with basic research in a vital area in biochemistry at a crucial stage of his career did not seem to have influenced his later approaches to major problèms in food science.

And yet, when one looks at the complexity of the problems tackled by him such as, for example, softening the texture of the buffalo milk curd which was indeed the breakthru in baby food manufacture, or the prevention of the setting of rot in the eyes of the coconut, the breakthru established by him which led to the stabilization of the copra processing industry in Phillipines, or the use of saline spray for the preharvest drying of *Kuruvai* paddy in Thanjavur delta or the prevention of microbial contamination and development of off flavour in parboiled rice by incorporating small amounts of chromates, that he was adept in the shrewd application of basic chemical principles in a disarmingly pragmatic manner is more than evident. Behind the change of phase of casein from a colloidal suspension to a micelle and then a curd there is a series of chemical reactions brought about by the clotting enzyme rennin accompanied by changes in the ionic mileu. Professor Subrahmanyan instinctively appreciated the role of calcium in the process. One of the studies the author of this memoir had to do in the early forties was to correlate the clotting time of different mammalian breast milks with their calcium content. On looking carefully through the laboratory experiments conducted in Mysore which preceded the development of the conditions for the spray or roller drying of buffalo milk, one fails, however to find any planned kinetic studies or investigations on the physico-chemical characteristics of the curd. And yet the breakthru was achieved by Professor Subrahmanyan by trial and error methods. Similarly, none of the developments on vegetable milks or protein supplements was supported by detailed basic studies on diverse aspects of their chemistry.

There is no doubt whatsoever of the fact that Professor Subrahmanyan was ahead of his times in introducing multi-disciplinary approaches to solve practical problems and giving full support to the introduction of Food engineering, packaging, storage and other facilities. The process development wing was equipped to carry out all unit operations : extraction, filtration, centrifugation, drying (including freeze shell drying). The design

unit helped in the fabrication of models of equipments for practical demonstration. As one of the foundation divisions, biochemistry and applied nutrition received his full support. Microbiology was introduced within two years of the establishment of CFTRI.

In summary one could say that leads for new vistas of biochemical and microbiological investigations into the as yet uncovered aspects of our traditional foods have been obtained by the first generation scientists of CFTRI. On the debit side there have been instances of missing the boat with regard to fundamental contributions. Thus the early work of Desikachar on idli fermentation was not followed to its logical conclusion. It was left to the team under Professor Hanskrauft at MIT, Boston, USA to give a convincing account of the role of *Lactobacillus bulgaricus* and *Leuconostoc mesenteroids* in bringing about the subtle changes in the texture and composition of *urd* dal during *idli* fermentation. The polysaccharides and proteins of *urd* are broken down by the combined action of the above two organisms to release gases giving rise to the softness of the dough and a gum which binds the constituents together and gives the taste and flavour to well prepared *idli*. The microbial process enhances the content of water soluble vitamins and what is more significant, introduces by *in situ* microbial synthesis, vitamin B_{12} and essential amino acids such as lysine, methionine and tryptophane. Again the early studies on tryptic inhibitors in the forties were given up when CFTRI was established and it was left to Leiner and others, in USA to open newer fascinating areas like the mitostatic role of tryptic inhibitors and plant lectins.

A biographical memoir is hardly the medium to analyse in depth the diverse socio-political mileu which sustained the subject of the memoir. And yet an assessment of Professor Subrahmanyan's contributions has necessarily to take into account the exciting growth phase of Indian science riding in the crest of the wave of what CV Raman rightly called the Nehru-Bhatnagar Effect. Path finding, building infrastructure on a firm foundation, identification of major problem areas and manpower development were mutually interlinked tasks which a socially committed scientist was called upon to undertake as the country was entering the era of political freedom and self-reliance. Professor Subrahmanyan's involvement in the above activities was total, resulting in some avoidable downgradation of the priority for basic studies. It is now for the inheritors of the edifice that he built to readjust the priorities and strike new ground in the vital field of Food Science and Technology.

Honours and Awards

Among the many honours and distinctions he received are Padma Sri from the President of India, Fellowship of the Indian National Science Academy (he was a Foundation Fellow of the National Institute of India Sciences from 1935), Fellowship of the Indian Academy of Sciences,

Bangalore and the American Institute of Food Scientists and Technologists. He received the prestigeous Babcock-Hart Award (1962) of the Institute of Food Technologists, USA, for his outstanding contributions to Food Technology resulting in the betterment of human health through nutrition, the Rafi Ahmed Kidwai Award of the Indian Council of Agricultural Research for 1960 for contributions to dairy science (Development of Baby Food) and again in 1961 for horticulture (technique of coating fruits and vegetables with fungicides and hormone impregnated wax). He won the Research Medal of the Royal Agricultural Society of London for his work on water logged soils and nutrition of the rice plant, the KG Naik Medal (1964) of the Baroda University for distinguished contributions to Biochemistry, the Sen Medal (1960) of the Institution of Chemists, India for contributions to Food Technology, the First Freesland Award (1965) of the Netherlands Association for the Advancement of Dairy Science for his contribution on the role of milk and milk products in tropical nutrition. The Indian National Science Academy chose him in 1969 to deliver the Biresh C Guha Memorial Lecture.

He was one of the founder members of the Society of Biological Chemists (India) and the Association of Food Scientists and Technologists, India.

Family Life and Some Personal Traits

Professor Subrahmanyan was happily married to Smt Saraswathi who predeceased him by a couple of years. Smt Saraswathi Subrahmanyan bore him three sons and three daughters and gave him by self-effacement, characteristic of noble women of that generation, the support of a home and family taking on her fragile shoulders the responsibility of nourishing her aged in-laws and growing children. She was a most affectionate hostess to the many students and visitors who frequented their home.

Short of height and with a frail physical frame, Professor Subrahmanyan's capacity for work was proverbial. His day in the office of the Department of Biochemistry, IISc, Bangalore started around 9 AM and ended around 8 PM with a short break for lunch. His walks from home to office and back were seized as the opportunity by most of the aspirants for very refreshing and informal chats on research problems. He was intolerant of his colleagnes falling sick and absenting themselves from work. His obsession with work contributed in a way to negligence of his own health. Soon after the opening of CFTRI in Mysore in 1950 one day he collapsed due to an acute exacerbation of a strangulated hernia. This happened in the very presence of the Late Sir Shanti Swarup Bhatnagar. Prompt medical care restored him to his feet. However, till the end of his life, almost in a masochistic fit, he punished himself with unending work.

He had an usually endearing but occasionally cryptic manner of dealing with his students and coworkers. Seized once with an idea, he was restless and flooded the team working with him with innumerable suggestions.

Written in his own hand in small neat letters on pieces of note pads, his communications were dubbed as Professor's 'love letters'. The notes contained very pragmatic suggestions but often they were crazy and we tended to ignore them. The following episode recalls the author's experience of 'love letters' when he was working on clotting of milk by enzymes. Professor Subrahmanyan had recently developed the technique for making 'vegetable milk' from soyabean, groundnut and cashew nut and wanted him to standardize the conditions for clotting these milks with rennet so that they could be converted to 'vegetable cheese'. All the efforts to clot the milk with animal rennet were unsuccessful. In one of the notes, which was waiting for the author one morning, he was asked to bubble carbon dioxide through the milk prior to adding animal rennet. As he was getting ready with a CO_2 generator (marble chips and dilute HCl in a Kipp's apparatus) Subrahmanyan walked in and started blowing with his mouth through a glass tube into the vegetable milks. The author was instructed to do this a number of times into several tubes in which samples of the milks had been kept. After a few hours of unenthusiastic blowing, he found himself in a mess and left the experiment to 'cool off' hoping that Professor would soon forget about it. That was under estimating Professor's imagination. Many suggestions followed. A few days later luck turned in author's favour. It was possible to clot vegetable milks with a vegetable rennet prepared from the latex of the fig tree. The trick that helped the action of the vegetable rennet was adjusting the pH of the vegetable milk to 5.0 with citric acid phosphate buffer. By blowing carbon dixoide, Professor Subrahmanyan was hoping to shift the pH of the substrate towards the acid range. The experiments taught us that whereas animal rennet was specific to procaseins of animals including man, the vetetable rennet of fig was non-specific and could act upon proteins of both animal and vegetable origin.

Another remarkable quality of Professor Subrahmanyan was his ability to maintain an exterior calm and an equitable temperment even under the most provocative situation. It was very rare to see him in a rage or angry mood. He was eminently free from even traces of cynicism or intellectual snobbery. Though unjust remarks about his personal appearance, his dress or his pet obsessions were bandied about liberally in the institute campus, he remained oblivious of them. What is more remarkable was his willingness in later years to help the very same colleagues who were his avowed opponents in the early part of his scientific career. It was also to his credit that even at the height of his official eminence he never turned a bureacrat and was accessible to his colleagues, junior and senior alike, and none had to wait endlessly in the ante-room to his office.

For those of us who were used to his image as one always at work, it was a pleasant surprize when on occasions he could be seen relaxing and enjoying company. He was fond of the movies and when SS Vasan's classic production *Chandralekha* was released he set a record by seeing it with almost the

frenzy of a child at least a dozen times taking with him for company one or two of his colleagues or even a visitor from outstation. Busy as he was with a number of projects of national importance, he did find the time to attend meetings of the Sectional Committee of INSA or the national committee for Biochemistry of which he was the first Chairman.

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