incidence on Earth. Undoubtedly their strength is minute, but a great deal of thought is going into the design of exceedingly sensitive receivers of gravitational waves. Once they are built, and make detections, a new window will have been observed on the universe: The era of gravitational wave astronomy will have begun.

Conclusion

This brief description of the field of gravitation has involved an introduction to our modern theory of gravitation, Einstein's general theory of relativity. The approach used has been largely non-mathematical but I hope has given the reader an impression of this area of science in which so much still remains to be explored.

Food prospects in India by the turn of the century

L. V. Venkataraman

The continuing population pressure demands greater efficiency in food production systems. Self efficiency in food front by 2000 AD can be achieved only by specific shifts in farm strategies. Coarse grains, the mainstay of rural population, needs greater attention. The losses of grains in field and storage are to be minimized. Biotechnological methods to augment food supplies should complement traditional technologies.

Today, India is the fastest growing country in the world. Our population is projected to grow even higher than that of China and is likely to touch the billion mark by the turn of the century. This alarming growth in population will in turn increase the demand for food. Meeting this need will require increase in food production, decrease in food losses, improvements in food processing, and enhanced nutritional quality and safety of processed foods.

World Development Report (WDR) 1990 has stated that there is considerable potential for progress towards reducing poverty in India. For this, higher investment with better domestic saving rates and external borrowing will be needed. India's growth rate is unlikely to exceed 2% per capita a year over the decade with 370 million people below the poverty line by 2000 AD. Between 1985 and 2000, the incidence of poverty in the developing world has been projected to fall from 33 percent to 18 percent and the number of poor from 1.1 billion to 82.5 million (Table 1).

The food problem cannot be separated from the challenges of population growth and efficient organization of food production systems. Current trends in population growth, food production and food consumption cannot continue; they need to be looked at very carefully. Population growth must be controlled if massive famines are to be avoided in a predominantly monsoon-dependent country like India.

The technological developments that are likely to have the greatest impact on food production should also emphasize simplicity, low cost, labour-intensiveness and appropriate technology. The fickleness of weather still determines whether the poorer section of the population will meet its food demand or face starvation. Our country will need to give maximum attention to agriculture in order to

1. assure basic food security to the people,
2. improve abysmally low nutritional standards and
3. create surpluses for poverty alleviation programmes.

Table 1. Poverty in 2000 AD

Region	Incidence of poverty (%) 1985	2000	Number of poor (million) 1985	2000
China	20.0	2.9	210	35
India	55.0	25.4	420	255
Developing countries	32.7	18 0	1125	825

Based on world development report. Poverty line at $ 370 annual income.

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Foodgrains

The term 'foodgrains' is used to cover cereals, millets and pulses. The production of these commodities increased from 55 million tonnes in 1950–51 to 179 million tonnes during 1988–89. The corresponding figures for oilseeds during these relative periods are around 5 and 13 million tonnes respectively. The compound annual growth rate with respect to area of production and yield indicates a growth of 3.15% for wheat, against the average yield of cereals of 2.2 per cent, and hardly 0.2 per cent annually in the last 20 years. Plan-wise, foodgrain production had reached 155.2 million tonnes at the end of the 7th Plan (1985–89) and the projected production for the 8th and the 9th Plans are 209.1 and 228.5 million tonnes (Table 2).

Cereals

Cereals are the principal food that meets the energy and nutritional needs of the Indian population. They include rice, wheat and coarse grains called millets. Before the green revolution, rice was the principal Indian crop and formed the staple diet of the majority of the population.

The bulk of the rice is grown during the *kharif* season, in the traditionally rice-growing regions of Andhra Pradesh, Bihar, Tamil Nadu and West Bengal. One of the recent developments in the rice economy of India is the emergence of Punjab and Haryana as major rice-producing states. The average yield of rice in India is 1568 kg per hectare, which has been achieved by use of improved varieties, quality seeds and new farming techniques.

The green revolution in India has been primarily a wheat revolution, where a real breakthrough in productivity has been achieved. The production registered a compound annual growth rate of over 3.15 per cent, against 1.92 per cent in the case of rice. It is the wheat revolution that has been considered responsible for increased grain production, which has reached a level of more than 150 million tonnes. This has led to the growing popularity of wheat in non-wheat-consuming states. India ranks fourth among the topmost wheat-producing countries in the world, and wheat is the second most important crop in our country, with a production of 50 million tonnes (1988–89), next only to rice (70 million tonnes). Wheat production, which stagnated at 10.5 million tonnes in 1965–66, reached a peak level during the 7th Plan. No other country has achieved this kind of spectacular increase.

Coarse cereals (millets) contribute to about 18.7 per cent of the foodgrain production. Despite their superiority in terms of nutritional value, e.g. protein and minerals, over rice, they are yet considered as inferior in terms of their economic and social status in the agrarian economy. Unfortunately, the total area under coarse foodgrains has come down from 39 per cent in 1951 to 31 per cent in 1989, and production from 30.7 to 19.7 per cent. The major coarse grains are jowar, maize and bajra, followed by ragi and small millets. The production of coarse cereals in absolute terms has increased from 16 million tonnes in 1950 to 31.2 million tonnes in 1988.

The high-yielding variety revolution has not totally bypassed coarse grains. The main constraint on their production is lack of irrigation, though they have the major advantage of being resistant to adverse climatic conditions. As the coarse grains are the mainstay of the rural population, production of coarse grains should not be ignored in favour of fine cereals.

Pulses

Production of pulses in the country has been stagnant around the level of 11.5 to 13.0 million tonnes per year over the last 25 years, and has suffered serious setbacks during drought years, e.g. the 1986–87 *kharif* season. In the pattern of foodgrain production, pulses, which contributed 16.7% of the total in 1960, came down to a miserable 8% in 1989. Per capita availability of pulses in India steadily declined from 70.0 grams per day in 1956 to 40.6 grams per day per capita in 1986 as the growth of pulse production has failed to keep pace with the growth of the population. The existing level of average pulse intake is substantially lower than the level of 70 grams per day per person prescribed by the Indian Council of Medical Research (ICMR).

Owing to short supply, prices of all varieties of pulses have soared, carrying them beyond the reach of the common man. The wholesale price index (WPI) of pulses as a group has moved up by 25.5% over the past one year. The largest increase has been for arhar (46.7%) and gram (21.1%). Import of pulses takes place periodically, at prohibitive cost combined with drainage of foreign exchange; nearly 2.0 lakh tonnes of pulses have been imported. Major pulse-growing areas like Uttar Pradesh, Punjab, Bihar and West Bengal have been showing a declining trend in production.

Table 2. Indian foodgrain requirements, present and for 2000 AD (in million tonnes)

Grain	1990	2000
Rice	72.0	96.0
Wheat	55.0	72.5
Coarse cereals	31.9	39.0
Pulses	13.2	21.0
Total	172.1	228.5
Oilseeds	3.5	6.0

Realizing the alarming situation in respect of pulses, the government had expanded the scope of the technology mission on oilseeds to cover pulses also. An integrated policy has been prepared for encouraging production of pulses during the 8th Plan. The policy emphasizes the corrective incentive through price mechanism and technology inputs. The lessons learnt in oilseed production may be employed to successfully promote production of pulses. A target of 25 million tonnes (present 11.5) by 2000 AD is likely to be achieved, if well-planned and coherent steps are taken now and in all earnestness to increase pulse production.

Oilseeds

The present position of edible oilseeds and edible oils in the country is somewhat ironic. India was one of the largest exporters of oilseeds before independence, and is now the largest edible-oil importing country. This is in spite of the fact that India has the largest edible-oilseed cultivation in the world. Oilseed production, raised in an area of 19 million hectares has stagnated at 10–11 million tonnes for the last ten years. Our yields are poor—e.g. groundnut yield per acre is 1000 kg compared to 3000 kg in the US and 3500 kg in Israel. Oilseeds are overwhelmingly dependent on rainfall (84%), and only about 11% of the total cultivated area receives irrigation. It has now been clearly established that adequate and timely availability of water alone would help in improving oilseed yields.

Since the beginning of the eighties, India has been importing a million tonnes of edible oil a year. This quantity of annual imports has increased of late, primarily owing to vagaries of the monsoon. The country imported about 2 million tonnes of edible oils during 1988–89 — 1.5 million tonnes of 1987–88 — at a staggering foreign-exchange cost of Rs 1000 crores. Vanaspati industries have been the most significant beneficiaries of governmental imports of soybean oil and neutralized palm oil, and got an allocation of 7.5 lakh tonnes. The government's plan to phase out oil imports will hit the vanaspati units most; inefficient units will also be phased out.

Rice bran, an unconventional source, now yields 3.75 lakh tonnes of oil, and its expected potential by the turn of the century is 7.5 lakh tonnes. This is primarily used by the vanaspati industries. Despite the high price paid by the consumer for oil, it does not reach the farmer, but is mopped up by the trader. If this trend is not reversed, India will become a predominant buyer of edible oils in the international market. The per capita consumption of 6 kg per year of edible oil in India is far below the world average of 11 kg, and less than half the nutritional norm of 14 kg per year per person prescribed by ICMR.

The Oilseed Mission set up a few years ago has been aimed at reversing the trend of imports and attaining self-sufficiency. Serious thought should be given to scientific water management. Genetically improved, drought-resistant, high-yielding strains are needed to boost local production. The highest priority must be given to groundnut, rapeseed, mustard, soya, sunflower and safflower among the edible oil crops, and linseed and castor among the inedible oil crops.

The National Dairy Development Board (NDDB), with its success in augmenting milk production, is involved in building a national edible-oil grid by linking producing and consuming centres by cooperatives through its 'operation golden flow scheme'. The Anand pattern of milk production has been adapted for oilseeds, which now have their own strategy of production, procurement, processing and marketing. In seven states they have linked 5.61 lakh growers of oilseeds under 3600 cooperatives. By 2000 AD at least 6 million tonnes of edible oil will be needed, which means that a gap of 2.5 million tonnes has to be covered, over and above the present production of 3.5 million tonnes. This is achievable, if the efforts of the Oilseed Mission succeed.

Fruits and vegetables

The production of 70 million metric tonnes of horticultural crops is well below the domestic requirement. Using the recommended per capita consumption of 60 grams of fruits and 280 grams of vegetables daily as a base for calculation, India needs 17.5 million tonnes of fruits and 81.80 million tonnes of vegetables. At this level, the extra requirement will be at least 30 million tonnes of fruits and vegetables. Notwithstanding this, Indian exports to the Middle and Far East and Western Europe of fruits and vegetables, both fresh and processed, has increased in the past decade from 17.2 crores in 1977–78 to 163.8 crores in 1988–89. However, this is insignificant in the global trade, which was valued at $ 20 billion in 1987, and our share in global exports is only 0.5%. Export of processed fruits and vegetables, including fruit juices, canned or bottled fruits, and dehydrated vegetables and pickles, has increased from Rs 14.28 crores in 1977–78 to Rs 54.55 crores in 1988–89. Nearly half of the processed fruits are mango-based.

Horticultural problems are many, with low productivity compounded by insect and microbial infestation and lack of storage and transport facilities for the highly perishable commodities, resulting in distress sales. Improvements in the production of fruits and vegetables can be achieved only by organized production and handling methods and organizing farm cooperatives in accordance with the pattern initiated in Delhi and Hyderabad by NDDB.

Plantation crops

Spices

India has been an important spice producing country, and spices have been a valued material of commerce and trade and linked to Indian history. These are good sources of food flavours, colours and taste, and make eating a pleasure. Spices like pepper, cardamom, ginger, turmeric and chillies are valued at Rs 3500 to 4000 crores annually. However, India's share in world trade is below 25%, in the total market of $ 1000 million. Pepper is the major spice exported, and India has maintained a strong position, in spite of the wide fluctuations in the international price and the highly volatile market.

Cardamom yields are poor in India at 60 kg per hectare compared to 250 kg per hectare in Guatemala, which is a leader in this crop. Cardamom exports are valued at Rs 18.5 crores, and the other spices add up to 29.4 crores in exports. Spice oils, oleoresins, and other value-added spice products, which constitute new foreign exchange earners, have added a new dimension in world trade. India today supplies about 50 per cent of total world demand of these products. The export trade of spices can flourish only through continued efforts in increased production, quality and competitiveness.

Beverages

Tea and coffee have been the most favoured drinks. Tea was introduced to India by the British in the nineteenth century after its relationship with China, which was a major producer, got strained. Over the years, India has lost its pre-eminence in the international tea market as its share in world production has steadily declined from 45% in 1951 to 29% in 1987.

A production target of 1100 million kg by the turn of the century is aimed at to cater to a domestic market of 721 million kg, leaving a surplus of 363 million kg for export.

The perpetual crisis in the coffee plantation industry is poised paradoxically to take a new twist with some indication that India may have to import coffee beans. This is due to a poor crop of 1989–90 at 1.4 lakh tonnes, and the prospects for this year also are depressing. The future for coffee production has not been quite stimulating.

Meat and meat products

Production and consumption of meat in India has always been an emotional issue intertwined with complexities of food habits, religion and culture. The per capita availability of meat in India is only 1.6 kg per year and has increased only by 350 grams in 20 years. This is in contrast to the West where the per capita consumption ranges from 65 to 95 kg per year. This is rather paradoxical, considering that India has a high population of cattle, buffaloes, goats and sheep, with nearly 400 million heads, and ranks sixth in the world in sheep population alone.

Meat yield per animal is among the lowest in the world viz. 43 kg of average yield per head of cattle, against 200 to 250 kg of beef per animal in the US. The total meat production of one million tonnes annually is very low and is about the volume of Australian meat exports. Meat industry is fairly old in India, but has not made much headway. The importance of the meat industry can be gauged from the fact that the economy of many countries, such as New Zealand and Argentina, is largely dependent on this industry. Meat industry has a long way to go before it can reach respectable levels and take its place among the world's meat-producing industries.

To establish a strong meat industry, it is essential to have a population of good animals, with best yield of meat. It is also essential to establish modern/semimodern abattoirs with adequate cold storage facilities. If meat industry is organized, exports can earn more than Rs 200 crores by the turn of the century.

Poultry

India has emerged as the fifth largest producer of eggs at 17,500 million eggs in 1987, though its per capita consumption is perhaps the lowest in the world. The Indian poultry industry, though it looks dismal in terms of egg consumption, has to its credit a high achievement in terms of egg production; it has virtually overtaken countries like Mexico, Brazil, France and West Germany in global output of eggs. Lower per capita consumption of eggs can be attributed to many factors, the primary reason being population, paucity of trade channels particularly to rural areas. There is an unfulfilled demand of eggs and chicken even in remote villages. Furthermore, surveys reveal that 45% of rural population are not eating enough eggs due to unavailability, while the remaining cannot afford them. Poultry production in India is growing by leaps and bounds, and getting into a more organized sector. Improved genetic stock, with better feed conversion efficiency, and short production cycle can bring a more rapid growth in the industry.

Fish

Our long coastline of 7500 km, with its adjacent exclusive economic zone of 2 million square km, offers

a great potential for the production of fish and marine products. India's annual fish production is merely 2.9 million tonnes and 50% of the available sources are not exploited, since fishing is primarily from the inshore region within 6 km of the coast. In the last five years, total fish production has gone up by 5.75%, with an average rapid growth rate of 7.5% in the inland sector. The inland production potential is estimated at 4.5 million tonnes, and the exclusive economic zone in the sea has a potential of another 4.5 million tonnes.

Though India is one of the important fish producing countries of the world, its share is only 3.5% of the world's production of 80 million tonnes. The average per capita consumption of fish and fishery products is very low at 4 kg annually. Sea food exports have crossed Rs 4.5 crores mark annually, and 82% of these earnings come from shrimps. The target by 2010 AD will be 18 million tonnes.

Storage losses

The losses of grains in the field and during storage due to physical, biological and chemical causes are staggering at an estimated cost of Rs 6000 to 8000 crores per year. Around 20 to 30% of the harvested produce is damaged by pests and diseases. Even if 50% of this is prevented, the food scenario in India will improve dramatically.

The Food Corporation of India (FCI) stores primarily wheat and rice, procured from farmers in its warehouses throughout India. The total storage capacity is 39 million tonnes which includes a buffer stock of 10 million tonnes of wheat and rice in equal quantities.

The FCI storage structures are both covered accommodation (63%) and open plinth area (32%) spread throughout India. In spite of the prophylactic and curative treatment given to grains, considerable quantities of grains are still lost by infestation. The loss incurred by the FCI on this account has been estimated to be around Rs 165 crores in 1988–89.

The major problem is that 70% of foodgrains are retained by farmers in the villages. The challenge of farm storage assumes huge dimensions, by the fact that there are 6 lakh villages where storage and handling facilities vary widely. Most farmers, particularly the small and marginal farmers, cannot afford to invest in storage structures or use protectants for their stored grains.

Despite all the controversies relating to the safety of pesticides, their use in grain storage is inevitable. The use of pesticide in India is one of the lowest in the world: 400 grams per hectare compared to 11,000 grams per hectare used in Japan. The size of the pesticide market in India currently is not more than Rs 700 crores, with nearly 1200 formulations based on over 100 pesticides. There is scope for at least a four-fold increase in pesticides, to prevent crop losses. The range of pesticides used is organochlorine, organophosphorus, carbomates and new generation pesticides like synthetic pyrethroids, of which 40 chemicals are made in India and over 60 are imported.

Recent changes in cropping practices and intensification of modern agriculture have all accentuated or modified the insect, fungal, weed and nematode problems.

The turn of the century will see a significant change in the nature of pesticides to be used which are relatively safe and biodegradable which may gradually replace the presently used hard pesticides. There will be increased use of pesticides from plant products, enzymes, pheromones, hormones and growth regulators. India is poised to gain on the grain storage front.

Biotechnology

India has to gain a lot through biotechnological innovations by the turn of the century in the food front. This includes improvement in plants, increased resistance to pests and diseases, nitrogen fixation ability in plants and increase in photosynthetic ability. The possibility of transferring genes from one species to another offers exciting potential to tap the unlimited gene pool available in animals and plants. Application of modern methods of biotechnology especially genetic engineering, hybridoma technology and computer controlled bioprocessing has resulted in several exciting developments in the field of food production and processing. Development of biopesticides, natural pathogens is another important area where biotechnology is becoming relevant. Application of biotechnological methods to augment food supplies is more relevant to India than developed countries and this will be complementary to the traditional technologies (Table 3).

Table 3. Biotechnology options for 2000 AD

Plant productivity	
Genetic engineering	Increased fertilizer and photo-synthetic efficiency
Somatic embryogenesis	Disease, salt, drought resistance
Hybridization	improved nutritional quality
Tissue culture	phytochemicals and novel compounds/processing characteristics
Animal productivity	
Genetic engineering	Transgenic varieties
Embryo transfer-breeding	Disease resistance/faster growth
Meat farming	Improved flavour/texture
Microbial productivity	
Recombinant DNA	Food value metabolites and enzymes.

Processed foods

Paradoxically India ranks in the bottom ten countries of the world in the international food market in spite of the fact that every fourth farmer globally is an Indian. Less than 1.0% of the total agricultural production is converted into processed products. On an average an Indian spends 52.4% of his earnings on food. The net disposable income is increasing. There is a great influx of people to the urban areas which contributes to the growth of consumer industry. Use of processed foods in Indian households has been a recent trend.

The factors that influence the marketing of processed foods in India can be attributed to the negative disposition of the consumer who is used to traditional foods. Quality problems of products and limited product range have also affected the growth of food industries. This trend can be reversed only by creating greater consumer awareness on processed foods, right product positioning and packaging with affordable price to the consumers. The export performance of the processed food products industry is likely to grow in coming years.

Conclusion

'Food for the future' and attaining self-sufficiency by the turn of the century is primarily dependent on the availability of adequate finances. There are several proposals to improve the food front prepared by experts with the government which need to be implemented. Food strategy for 2000 AD needs specific shifts in farm strategies which include modification of energy, intensive hybrid variety technologies, gradual shift from fine to coarse grains, changes in cropping pattern to match agro-soil-climate and new agricultural technology. The basic truth to be realized in the context of rural Indian economy is that the farmers will not grow crops if prices of produce remain low and subsidies benefit only the urban population and this needs to be phased out. Farmers will improve their land only if they own it and this must not be merely ideological but must become real. The present decade is crucial both in controlling population growth and reaching food sufficiency by all-round efforts for a strong India.

REVIEW ARTICLE

Synthesis and characterization of fullerenes C_{60} and C_{70} and superconductivity in K and Rb-doped C_{60}

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The synthesis of fullerenes C_{60} and C_{70}, its characterization and alkali doping of C_{60} are described in detail. K- and Rb-doped C_{60} are observed to be superconducting with T_c of 18 K and 27 K respectively. Bi and Pb have been co-doped along with K and the results of structure and superconductivity studies in these systems are presented and discussed. Further, preliminary results of on-going experiments on the structure of C_{70} and its variation with temperature and pressure are also presented.

KROTO *et al.*[1] in 1985 discovered the existence of stable carbon clusters of 60 atoms in the mass spectrum of laser-ablated graphite, for which they proposed a soccer ball structure and termed it as buckminsterfullerene after the designer of geodesic domes. The recent synthesis of macroscopic quantities of fullerenes by Kratschmer *et al.*[2] by striking an arc between graphite electrodes in a helium atmosphere has generated a flurry of interest in the close caged carbon molecules C_{60}, C_{70} and in the study of their solid state properties. The study of fullerenes received further impetus with the initial discovery of metallicity[3] in alkali metal doped C_{60} and the subsequent announcement of superconductivity[4,5] in C_{60} doped with K ($T_c = 18$ K), Rb[6] ($T_c = 28$ K), Cs[7] and their alloys[8,9]. Following these