EVERYMAN'S SCIENCE

Vol. XLVI No. 4 (Oct '11 – Nov '11)

COVER PHOTOGRAPHS

Past General Presidents of ISCA

1. Dr. Atma Ram	(1968)
2. Dr. A. C. Joshi	(1969)
2. Prof. A. C. Banerjee (died pre-maturely)	(1969)
3. Prof. L. C. Verman	(1970)
4. Prof. B. P. Pal	(1971)
5. Prof. W. D. West	(1972)
6. Dr. S. Bhagavantam	(1973)

Printed and published by Prof. S. S. Katiyar on behalf of Indian Science Congress Association and printed at Seva Mudran, 43, Kailash Bose Street, Kolkata-700 006 and published at Indian Science Congress Association, 14, Dr. Biresh Guha Street, Kolkata-700 017, with Prof. S. S. Katiyar as Editor.

Annual Subscription : **(6 issues)**

Institutional ₹ 200/- ; Individual ₹ 50/-

Price : ₹ 10/- per issue

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EDITORIAL

USE OF GEOGRAPHICAL INFORMATION SYSTEM (GIS) IN MALARIA

Malaria is one of the major parasitic diseases and a global health problem. It affects 3 - 3.5 billion people worldwide with more than a million deaths annually, majority in the developing countries.

India has the largest population in the world, which is at risk of malaria with 85% living in malarious areas[1]. Though, there were phenomenal successes during the NMEP from 1958 onwards these could not be sustained, mainly due to increasing resistance of parasite to drugs and the vectors to the institutes. This was compounded by other reasons like increasing costs of insecticides etc. At moment more than 1.4 million cases of malaria occur annually in India and, there is also a rise in *P. falciparum* cases, which is with resistant to several anti-malarials and also causes severe complications.

The risk of getting malaria is related to various environmental factors including change in climate, which influence survival of vectors and transmission of disease. This has lead to the WHO as well as India to pursue and develop new techniques and models to assess the role of environment in the country or pockets where malaria is highly endemic.

Geographic information system (GIS) or spatial technology is a technology, which helps in monitoring of the environmental conditions. Rather, the use of spatial technology is now revolutionizing methods of epidemiological research. It is a powerful tool to study the relationship between disease prevalence and vector distribution and has found a key role in the study of vectors and disease transmission in use of malaria.

One other major advantage of spatial technology is that it can give us an idea of the probable data on disease transmission/vectors/ and in areas, which would be normally inaccessible to routine epidemiological/field surveys. This has certainly led us to a better management of malaria/control as with its help, maps can be generated showing risk areas/hot areas with various risk factors.

What is spatial technology & GIS?

Spatial technology includes wide varieties of technologies, which are being increasingly used in medical field. This includes (a) Geographic information system (GIS) (b) Remote sensing (RS) and (c) Global positioning system (GPS).

Definition of GIS: An information system that is used to input, store, retrieve, manipulate, analyze and output geographically referenced data or spatial data. However, we take GIS as a term which under its umbrella includes/or integrates a wide range of data sets available from different sources including RS & GPS.

GIS in malaria control

Where can GIS be used in terms of malaria control and also in certain research areas is evident from the increasing use to get data, especially from remote areas of the country.

(i) Data source for different regions

Aerial photographs as well as satellite imaging is now a powerful tool to provide data on descriptive climatic as well as landscape features, especially in remote and inaccessible regions. In India too, this is being increasingly used for the monitoring and surveillance of breeding habitats of vectors and malaria risk. For example, GIS has been used recently to construct an information management system for Madhya Pradesh for identification of hot spots and the efficient control of malaria[2]. This system has also been used to map mosquito breeding sites as well as anti- larval measures in Malaysia and in a number of countries in Africa[3-5].

Another method of further referencing the data is to combine the data from surveillance activities with GIS. This enhances the efficacy of the map generated for breeding habitats and analysis of high prevalence areas. This has been done in a number of areas in India and Africa to improve malaria control.

(ii) Spatial epidemiology of malaria.

Mapping of malaria

GIS has also emerged as powerful tool to map the various areas of risk of malaria at the national, regional or local levels. This can be of immense value in the control of malaria. An example is the use of GIS for mapping of malaria in Sir Lanka[6] and also to check for malaria receptivity in Mewat region of Haryana, India[7]. Another area, which can be targeted, is the development of maps for the distribution of malaria vector mosquitoes as has been done in Africa, South- East Asia and India.

Digital elevation mode for ground topography (Terrain)

Elevations data are used to create a DEM, which may be in the form of hot spots, heights of counters. These are of use to study the slope, aspect, wetness index etc. that are important in malaria vector epidemiology. These are but a few areas where the technology of GIS can be applied. Other areas also include a) Buffer zone analysis (b) Geostatistical analysis etc.

In conclusion, use of different GIS tools is powerful armamentarium in the mapping and control of malaria. The capability of GIS needs to be fully utilized by the scientists for the identification of breeding habitats of mosquitoes/ vectors and analysis of high prevalence malarious areas. This is more so for inaccessible areas transmission of burden. This could be a powerful tool in not only in malaria control but for other important vector borne diseases like Leishmaniasis, Dengue, Japanese Encephalitis, Filariasis etc.

Prof. R. Sehgal & Prof. R. C. Mahajan

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PRESIDENTIAL ADDRESS

AGRICULTURAL SCIENCE AND HUMAN WELFARE

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First of all, let me express my deep gratitude to the scientists of India for the signal honour they have conferred on me by electing me the General President of the Indian Science Congress.

Coming to the subject of my address, I have chosen a title, relating to a topic of world-wide interest, which is both comprehensive and ambitious. I shall, however, partly because of shortage of time, and partly because of my lack of detailed knowledge of the other areas, restrict myself mainly to a consideration of the biological group of agricultural disciplines, and more particularly to genetics and plant breeding, these being my own field of specialization. I shall also in my discussion bear in mind specially the Indian sub-continent, though I will, of course, refer to developments in other parts of the world also, where necessary.

The paramount importance of Agricultural Science as the main instrument, along with education, with which we can convert old and sometimes primitive agriculture to a modern industry, employing the advances in research to improve its technology, is now well-recognized and needs no emphasis. It is realized that, with the great explosion in the human population, everything possible must be done to extract from the soil, water and other natural resources available, the maximum quantities of food and other material required in trade and industry. And, while family planning campaigns strive to slow down and ultimately to reduce the disturbing expansion of the human race, well-coordinated, carefully-thought-out action has to be taken to ensure a massive integrated advance on the agricultural research front.

The problem of agriculture and the world food supply despite its many complexities appears, at first glance, to many to be deceptively straightforward and, as pointed out by I. L. Bennett, liable to over-simplification. But the nature of farming must be understood if appropriate measures are to be developed in the hungry nations. Farm production is based upon the growth processes of plants which utilize solar energy through photosynthesis. Because the basic process of farming depends upon solar energy, it must always remain widely distributed over the face of the earth so that the sunlight can be utilized where it falls. As Bennett has stressed, no other single fact has greater significance for agricultural development.

Another fact which I think should be mentioned here is that no agricultural technology can be transferred successfully from one country to another without the necessary "tailoring" by means of research carried out within the country itself, in view of the widely different soil and climatic

* General President, Fifty-Seven Indian Science Congress held during January, 1971 at Bangalore.

conditions. In fact, each country must develop its own research programme to suit the genius of its people and its own requirements. If we look at the world picture, the shortages of food are so vast, and the means at the disposal of the developing nations relatively so limited, that the eventual alleviation of world hunger will require many years. It is dependent on very many factors, including far-reaching social reforms and long-range programmes of hard work which offer no promise of quick automatic results, comparable with the building of mighty dams, the successful launching of a module into space, of other such spectacular events. H. E. Thomas has referred to the "impatience of the modern vast moving world... expressed in the desire of philanthropists (individual, foundations, national, and international) for concrete evidence of good they are doing expressed in the hope of the specialist during the tour of 1 $^1/_2$ or 2 years, to leave a permanent mark upon the culture that has been evolving for 1 $^1/_2$ or 2 millennia."

As every one is aware, there has been an upsurge in agriculture development in this country, based upon the research of agriculture scientists. It is a matter of much satisfaction that utilizing the results of the labour of our own scientists, supplemented with the achievements of researchers in other countries, our farmers have been able so quickly to learn and adopt modern agronomic techniques, and thus greatly to increase agricultural production in our country. The current so-called green revolution is based mainly at present on the advances in five major food crops namely, rice, wheat, sorghum, pearl-millet and maize. In the case of the first two crops, a beginning was made by importing dwarf, high-yielding and fertilizer-responsive varieties developed in Taiwan and the Philippines the case of rice, and Mexico in the case of wheat. These were not just haphazard introductions; our plant breeders maintain and study comprehensive selections of varieties obtained from all parts of the world. But because of differences in soils and climates, it is only occasionally that a variety bred in one country is able to perform equally well in another. These new strains of rice and wheat represent a radical change in our ideas regarding these crops. Whereas at one time tall varieties were to rule, the breeders changed the morphological structure of the varieties to produce dwarf types which would respond well to high doses of fertilizers and yet not lodge when there were strong winds especially after irrigation, although the original introductions were highly successful in that because of their extraordinarily high yield they were welcomed by the farmers, their grain quality was not found fully acceptable. In India people like the fine-grained varieties of rice and preferably those which have some scent as well. In the case of wheat they like the hard, amber-grained or *sharbali* types as they are called. Our breeders have been busy crossing the imported types with the best Indian varieties, and by growing two crops in a year, the breeding work has been greatly accelerated. Already some new types which are superior to the original imported ones have been developed during the last one year or two.

In the case of the other three food crops which were mentioned earlier, the phenomenon of hybrid vigour has been used. Hybrid vigour was known to our ancestors when they made the cross between the horse and the donkey and produced that sturdy animal, the mule. Some plant hybrids (they were called "plant mules" at one time) also show much greater productivity than either of the parent strains and these can be commercially very important. We now have several hybrids of sorghum, pearl-millet and maize which are doing very well, and which have been developed under Indian research programmes. The contribution of the Indian workers unfortunately is not well-known outside this country, and many scientists in other countries are unaware of how the scientific bases for the green revolution were developed. I quote from a special report published in 1969 by the Rockefeller Foundation as this is one of the rare instances where an overseas agency has given full credit where it is due in the field of agriculture.

"The lion's share of the credit belongs to the leadership, scientists, and farmers of India. They have played, and are still playing in ever-increasing numbers, the leading role in the exciting drama of their country's agricultural development. From the Presidents and Prime Ministers of India to her underrated farmers, it is the Indians themselves who have changed the nearly hopeless food situation of only three or four years ago to one that today allows the country to face the future with realistic confidence."

It is also not generally known that the first crop in which a breakthrough in yield was achieved was hybrid maize in a project sponsored by the Indian Council of Agricultural Research. The pattern which was evolved at that time of an all-India research project covering the major soil-climate zones where the crop is grown, in which scientists worked together on a common programme whether they belonged to Central institutes, agricultural universities or research institutes belonging to State Departments of Agriculture, has proved to successful that it has since been applied to other crops, and to other areas of research including animal sciences projects, land and water use projects, etc. Another fact which is not well-known is that besides the five food grain crops which have been mentioned, there have been, in very recent years, remarkable advances in some other important crops also. For instance, in potatoes a new series of varieties have been released which are a great advance on the older varieties not only in yield and quality, but, in some cases, in important attributes such as resistance to the dreaded late-blight disease or to damage by frost which is a significant factor, especially in north-west India. A very early variety of castor, new hybrids between the mangoes of north and south India, and new varieties of vegetables are a few of the other items, out of many, in which advances have been recorded. In response to the quickened tempo, and the everlasting demands for a better agricultural technology, much thought has been spent in formulating plans which are multi-disciplinary in approach, and are based on a concept of team work between not only the agriculture scientists themselves but also with those working in other fields of Science.

Before I go further, however, I would like to point out that while we have no doubt made a substantial contribution towards the amelioration of the food problem in India, tremendous problems stare us in the face. The high-yielding varieties on which the greater food production drive has been based belong only, as already mentioned, to five of our food crops. There are many other plants which are vital to us as sources of food, materials for industry and so on. We have the whole group of pulses which are important sources of protein for the people of a largely vegetarian country, the oilseeds of which we have such a range of varieties and where we have done relatively little so far; the important fiber plants like cotton, jute and kenaf; a great array of fruits and vegetables, medicinal plants, essential oil plants, and so on. Not only have we to increase the yielding ability of our economic plants but we have to pay special attention to quality, thus, increasing the protein content and quality in our food crops is very important. Again, a good part of the research so far done is relevant mainly to irrigated areas or regions of assured rainfall. We all know that unirrigated farms occupy nearly 80 per cent of our total cropped area of 138 million hectares. This is the area where there is neither dependable irrigation nor adequate rainfall, so that cropping offers relatively poor returns and there is great instability. We have to do a great deal of intensive research for this vast unirrigated area and it is only when, based on scientific findings relating to better tillage, soil and moisture conservation better varieties and better nutrition are made to interact that the yield-and-income-jump of the type which is desired is likely to be achieved.

When we come to the vast field of animal husbandry we find that comparatively little has been done. We do have some fine breeds of cattles and buffaloes, and useful strains of sheep, poultry and so on have been developed. Our research has also established certain sera and vaccines which have played an important part in keeping down the losses due to the devastating disease that prey upon our domestic animals and birds. In a country of mixed farming like ours, it is patently necessary to give much more attention than has been done in the past to bringing about advances in animal and animal products production, which would be comparable to some extent to what has been achieved on the crops side. Again, we are surrounded on three sides by a vast ocean, permitting a great development of modern marine fisheries. Inland fisheries are also important, and we need to give much more attention to the problems of developing our resources of fish, prawns, shrimps and other items. Promoting industries based on these could add substantially to the country's wealth.

I have indicated in a very sketchy way some of the advances we have made and a few of the problems that still loom ahead of us. In the past we have made use of the scientific knowledge available at the time but we were not in a position to take any bolder steps towards solving our agricultural and animal husbandry problems. Recently there have been epoch-making discoveries in the world of science in the field of genetics, physiology and many other scientific areas which have placed at our disposal, entirely new tools for advancement.

Regarding future possibilities, let us take wheat, which is the crop in which we have achieved the largest measure of success. At the beginning of the First Five Year Plan, i.e. 1951, the production was about 11 million tons. Our production from virtually the same area is now about 20 million tons and this has been achieved by the use of the new, high-yielding dwarf wheat and the appropriate modern technology. Very recently the first of the so-called triple-gene dwarfs has been released, and it is expected to mark yet a further advance in wheat yields. In the past, agricultural experimenters have frequently been forced, because of lack of fundamental knowledge, to use a largely empirical approach to the problem of increasing yields. More recently, however, intensive efforts have been made to identify the inherent characteristics of the individual plant and other cropping factors which limit productivity, and also to examine cultural practices from more fundamental principles.

In the earlier studies, attention was mainly focused on the factors determining the overall dry-matter production in the plant. But with crop plants where we rarely use the whole of the plant, the usable part normally constitutes only a proportion of the total material produced in photosynthesis. As Wareing has pointed out, it is easy to visualize that in some situations the over-all growth rate may be limited by the rate of production of assimilates, whereas in other situations the limiting processes may be the rate at which assimilates may be transported to and accumulated in the usable parts of plants. When a critical analysis is made of the wheat plant it has been pointed out that it is not productive as, for instance sugar-beet, kale or grass. The wheat plant occupies the ground for several months and during this period it produces several tall stalks and leaves before ears emerge. But the present evidence indicates that the carbohydrate which is accumulated in the grain is derived almost exclusively from the uppermost or flag leaf and from the green tissue in the ear itself. Thus a new possibility that seems to suggest itself for the attention of the wheat breeder is the breeding of new varieties in which the senescence of the flag leaf may be delayed, and the period of photosynthesis by it thereby extended. It is believed that the high yield of the well-known barley variety "proctor" in the U.K. is at least partly attributable to such delayed leaf senescence. In countries where awnless varieties of wheat are used, the addition of the awns to the ears would seem to be another way in which the supply of assimilates which contribute to the grain development can be increased. There are also possibilities of increasing the number of grains, the growth rate of the grains and the length of time over which the grains can accept photosynthates. The floret number, which in turn influences the number of grains, can be increased, for example, by wide crosses. Thus some of the crosses between *Triticum* and grasses like *Elymus* and *Agropyron* which have been used by Tsitsin in Russia, and by others in other countries, can contribute towards this.

It has been pointed out also that yield in wheat could be increased by reducing the total number of tillers formed while increasing the proportion which produce an ear. It has even been suggested by work done in India by Asana, and in Australia by Donald, that under certain conditions wheat which produce a single stem might be the most useful (by a higher rate of seeding, the plant population could be maintained at the optimum level). Such single-tiller genotypes of barley have already been produced and are being tested at Aberystwyth. Similarly, horticulturists now-a-days are trying out new approaches. Prof. J. P. Hudson, for example, has suggested that in fruit-growing the large-sized tree should be got rid of as it is an unnecessarily huge and cumbersome framework for bearing fruit. He suggests that pears and apples should be grown by planting one-year "maiden" trees in dense spacing. After fruiting in the second year, the trees would be scrapped and then the process would be repeated.

There has been much progress recently in studies of photosynthesis under the field conditions. At high light intensities it has been reported that photosynthesis is often limited by the supply of carbon dioxide, and that the main rate-limiting step under these conditions is the physical resistance of CO_2 diffusion in the leaf. If this is so, Wareing has pointed out that breeding for anatomical characters such as the number and size of the mesophyll cells for the leaf should be undertaken. It has also be suggested from researches relating to photosynthesis that breeding programmes could include screening for high levels of rate-limiting enzymes which have been studied as another possible factor in this connection. Here it may be mentioned that a Japanese scientist, Dr Yoshida, working in the International Rice Research Institute, Los Banos, has shown that there are marked differences between the photosynthetic efficiency of different rice varieties. This indicates another direction in which the plant breeder could utilize the finding of the plant physiologist. Yet another direction in which the efficiency of the varieties could be improved is by breeding those which are able to grow and yield well at cool temperatures in certain cases, and at high temperatures in another. Also to facilitate multiple cropping, varieties with a shorter life period (without reducing the yield) and which are relatively insensitive to photoperiod are a desideratum. For such work, however, our main plant breeding institutions should have better facilities than at present. We do not yet have a phytocron in this country though the importance and quantum of crop breeding work would justify it.

The young field of radiation research in agriculture is full of promise and important work in using various mutagenic agents to produce plant mutants some of which are of great potential value has been done in India itself by M. S. Swaminathan and others.

I do not propose to survey the whole field of new ideas in the field of crop improvement such as, for instance, the use of many types of chemicals for delaying germination in the field to facilitate the use of pre-emergent herbicides, to thin out fruits in cases where a large number of fruits prevent a proper development or, again, to prevent fruit drop in other cases, etc. But I would like to mention the work with isolated plant protoplasts which has been carried out by Prof. E. C. Cocking and his group at Nottingham University. Similar work has also been reported from Sweden. It has been shown that two isolated protoplasts obtained from entirely unrelated plants can be made to fuse. The next step is to obtain fusion of the nuclei, and if this can be achieved, there is a chance that regeneration of hybrid whole plants can be affected in a way which was previously impossible. How wonderful it would be if, as speculated upon by J. Van Overbeek, we could transfer a block of genetic information from a blue-green alga capable of photosynthetic nitrogen fixation, to the chloroplasts of cereal crops like rice and wheat which could then use the nitrogen of the air rather than that from fertilizers, we will have achieved a whole new step in sophistication in food production. It is a goal as lofty at least as flying to the moon, and I would expect it to be far less costly." More and more, by processes which can conveniently be referred to as genetic engineering, breeders will be able to design, and bring into reality, new types of plants. Donald has said: "The design, breeding, testing and exploitation of plant ideotypes is a logical step towards new levels of yield and should be pursued with imagination."

Having obtained, by the modern tools now available, high-yields and otherwise very superior new strains of crop plants, the next step is to devise cropping patterns and rotations which will enable farmers to produce the maximum output per unit of time, per unit of land. Blessed with abundance of sunshine and absence of very low growth-limiting winter temperature over a large portion of the land, India is fortunately placed for a great advance in multiple cropping.

What has been narrated so far indicates quite clearly, I think, that we have within out reach the possibility of making far-reaching advances in the wide array of fields covered by the term agricultural sciences. But this can only be done by proper planning and coordination and the sufficient allocation of resources. To a large extent the requirements of the agricultural scientists are similar to those in other fields. They all look forward to the right to have adequate facilities in the way of up-to-day comprehensive libraries and modern equipment. They also need an atmosphere in which they can work with the requisite degree of freedom to develop their own ideas. At the same time, in a field like agriculture which must of necessity stress applied research very strongly, there must be over-all policies so that the work is done in the context of the requirement of a national plan.

In this country in the past the whole field of agriculture was relatively neglected and it has left a backlog of institutions which are lacking in high quality staff but have an abundance of staff at the lower pay-scales because these were easier to get sanctioned. This has resulted, in the past, in a good deal of routine work. It is only very recently after the reorganization of the Indian Council of Agricultural Research that pay-scales comparable to those in other major scientific organizations have become available some extent.

In the early part of my address I have referred to education as the other main instrument for the transformation of our agriculture. That means that we should give more attention to education both at the school and the college levels, in relation to different types of experts and other categories relevant to agriculture which we wish to create in the numbers necessary to back up our progress towards a modern and therefore more sophisticated agriculture. In discussing the food problem of India, our great botanist, the late Prof. P. Maheshwari, cited for purposes of comparison the position in another field of national importance, namely, military defence. He said, "It is not enough to make guns, tanks, parachutes and fighter planes. It is also important to train men to use them and a surplus to replace those who die in war. In agriculture — India's biggest industry — there are even greater risks than in war and nothing but the best talent will serve the purpose." He went on to say that it was unfortunate that those in authority and those concerned with planning has not paid sufficient attention to this factor and that biology continued to be considered as a sort of an inferior subject "meant only to introduce refinement to the facts of life and to enable them to do a little bit of gardening in their homes." He was of course referring more particularly to biology, specially botany, and the contribution which it could make to the advancement of agriculture. But the whole agricultural sector itself has been very much neglected in the past in the matter of availability of funds, levels of pay-scales and many such matters. In high-level committees if scientists are included, it is usually difficult to find a representation of those who have devoted their lives to agriculture. Prof. Maheshwari said, "It is plants which provide us with all our foods and plants science must, therefore, be transferred from the present tail end of our scientific hierarchy to its head."

The recent renaissance in agricultural research has become possible because of a number of important changes which have taken place. One of these has been the reorganization of the I.C.A.R to make it more truly a scientific body, and of the transfer to it of a large number of institutes which were controlled in various ways without a proper mechanism or coordination. The coming into being of the agricultural universities has also made available a pattern of integrated research, teaching and extension education which has facilitated the implementation of the all-India coordinated research projects to which a reference has been made earlier. But agricultural science must not lag behind the mainstream of science and must be in close touch with it, being continually refreshed by the new advances that are taking place. In this context, the Indian Science Congress plays an important role in providing the main forum where a large number of our scientists, especially the younger scientists, drawn from all the various disciplines of Science, can meet and interact. At the same time agricultural science must not allow itself to be caught in the fruitless whirlpool of endless discussion in committee rooms. It has been said that the higher we soar on the winds of Science, the worse out feet seem to get entangled in the wires.

I have emphasized the role of agricultural sciences in the welfare of mankind because food is the first necessity. Seneca said, two thousand years ago, "A hungry people listens not to reason nor is its demand turned aside by prayers." While plants can make their own food, animals cannot, and it is the fundamental right of human beings to have enough food of the right quality. Agriculture helps to provide this and also many other things which are required for a better life. In recent times, modern Science has developed to give mankind, for the first time in the history the human race, a way of securing a more abundant life which does consist in taking away from someone else. Let us, therefore, make full of this modern Science, first of all to give us the agricultural base which we require and then all the other things which civilized humanity request. Let us dream of a better time for those who inhabit this land. Without a dream there is no vision and without vision the people perish.

METAL FUME FEVER

J. Vijay Rao

Metal Fume fever is an acute self limiting condition caused due to inhalation of metal oxide fumes. Symptomatology of metal fume fever can mimic other conditions that must be considered in the differential diagnosis. The abrupt onset of symptoms on the job or within 3 to 10 hours after work and a history of welding or galvanization of steel should make the diagnosis. Treatment of metal fume fever is symptomatic and nonspecific. Prevention includes implementation of engineering controls like fume extractors built into welding equipment.

MEDICINE IS BOTH AN ART AND SCIENCE

The scientific community and the public have become increasingly aware of and justifiably concerned about the presence of toxic substances in their working and living environments and about the health impact of those substances. There is a consequent increasing demand to evaluate the potential health risk of those substances under the conditions in which they are used.

According to WHO there are atleast four categories of occupational disease syndromes ; (i) diseases that are only occupational in origin eg. Pneumoconiosis, (ii) those in which occupation is one of the casual factors eg. bronchogenic carcinoma, (iii) those in which occupation is contributing factor in complex situations eg. chronic bronchitis and (iv) those in which occupation may aggravate pre-existing disease eg. asthma.

Acute metal fume fever is one of the few ancient occupational disease conditions encountered still in modern industrial practice in our country. Medical Professionals who are in industrial sector may be aware of it but general practitioners and specialists are ignorant of this condition.

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Metal fume fever is an acute self-limited syndrome caused due to inhalation of high concentrations of metal oxide fumes. The association of febrile illness with metal inhalation has been ascribed to Datissier in the early 1820's. Thackrah in 1832 wrote of disease related exposure to yellow brass in brass melters and Greenhow in 1862 described brass founders' ague in brass-casters. Other names that have been used for metal fume fever include monday fever, brass chills, zinc ague, welder's ague, spelter shakes, foundry fever, the smoothers, brass founder's ague and copper colic.[1]

METALS KNOWN TO CAUSE - METAL FUME FEVER

Antimony, arsenic, beryllium, cadmium, aluminium, magnesium, nickel, selenium, cobalt, copper, manganese, chromium, lead, zinc and tin.

OCCUPATIONAL EXPOSURE

Zinc : Occupations where fumes are generated by cutting, welding, smetling or galvanising operations of metals. The most common metal associated with Metal Fume Fever is Zinc. Fumes of zinc occur as the result of volatilization of the metal in air. The volatilization of zinc occurs so rapidly (melting point = 419 °C, boiling point = 907 °C) that zinc oxide is formed in the ambient air and constitute potential hazard for inhalation.

It is widely believed that the only way that metal fume fever can occur is during exposure to freshly generated fumes. Blanc and Boushey reported that heavy exposure to 'mature' zinc oxide dust in the respirable range can cause fume fever.[2,4,6]

All the chemical substances are toxic at some concentration. A concentration exists for substances from which no injurious effect will result, no matter how often the exposure is repeated. This concentration has been termed as Threshold Limit Value (TLV). In other words, TLV is a time weighted average concentration of hazardous agent in atmosphere. TLV means the Maximum allowable concentration of contaminants in the environment where worker can work 8 hours a day/5 days in a week without any adverse effects. Each (chemical) metal have a threshold limit value eg. TLV for zinc oxide is 5mg/m^3.

Exposure to zinc oxide fumes occurs mainly during welding or the galvanization of steel. Galvanization of steel may involve significant fume exposure during dipping, electrolysis or zinc spraying. Two compounds of zinc namely zinc oxide and zinc chloride produce adverse effects in humans. Zinc oxide is highly volatile i.e. has significant vapour pressure even at relatively low temperatures and so is evolved during any operations in which the molten metals are used. Welding on galvanized metal can also produce dense clouds of white zinc oxide fumes.[3]

Fumes of other metals such as copper, magnesium, aluminium, antimony, cadmium, iron, manganese, nickel selenium, silver and tin can cause metal fume fever. However, most cases are caused by zinc, copper or magnesium fumes.

EXPOSURE SOURCES

The following operations involve zinc chloride fume and lead workers to exposures to this substance :

- Etching of metals and copper plating of iron
- Soldering with zinc-chloride-containing fluxes
- Browning steel and galvanizing iron
- Arc welding of galvanized iron and steel pipes
- Use in vulcanizing and reclaiming processes in rubber manufacture
- Generation of smokescreens for military use

LEAD[5] : Examples of lead-risk occupations are :

- Abrasive blasters and coaters
- Cable layers
- Demolition workers
- Electricians
- Plumbers
- Metal workers

Sources of Lead (TLV–Time Weighted Average (TWA) of 0.05 mg/m^3) (Boiling point : 1740° C, Melting point 327.5° C)

Lead is described as a 'multi-source toxin'. Workers are particularly at risk as they are often exposed to many sources of lead over long periods of time. Main sources of lead at work are:

- Lead paint including :
  ★ domestic paint used in many houses built before 1970.
  ★ Protective coatings used on industrial buildings, plant and equipment.
  ★ Marine, automotive and vehicle paints.
  ★ Specialised paints, such as road marking and sign writing applications.
- Building products which can contain lead including flashing, sheet lead, PVC products, lead solder and plumbing fittings.
- Petrol and lubricants including leaded petrol, some types of oil and grease and waste oil.
- Hazardous lead dust which can accumulate in old buildings or workplaces which are not

cleaned properly. Many work practices commonly used in industry, such as burning, sanding and grinding, can disturb or create hazardous lead fumes and dust which workers can take into their bodies.

There are many other materials and products, often inadequately labelled, commonly used in industry, which contains lead.

Pathways for lead to enter human body :

- Breathing in dust and fumes is the main way by which lead enters a worker's body. Fine particles of lead can penetrate deep into the lungs and rapidly pass into the blood.
- Eating contaminated food and drink can occur if workers don't wash their hands before meals and eat in workplaces where lead dust is present. Smokers can accidentally take in lead dust on their hands or cigarettes.
- Absorption through the skin can occur where leaded petrol or lubricants are handled without gloves or barrier cream. Recent research suggests that fine particles of lead may be able to enter the body through sweat pores in the skin.

Chromium : TLV for chromium is 0.5 mg/m^3 (Melting point 1860 °C, boiling point 267 °C). It is a hard, corrosion resistant grey metal that exist in several oxidative states. The hexavalant compounds are much more chemically aggressive than the trivalent compounds. Hexavalent chromium (chromate) is used in pigments and for chromium plating. Stainles steel contains nickel and chromium is oxidized to hexavalent chromium. Some types of cement and treated wood products contain hexavalent chromium.[7]

As hexavalant chromium compounds are more chemically aggressive they cause more irritative symptoms when inhaled. Inhalation of hexavalant chromium particles may cause sneezing, rhinorrhoea, lesion of the nasal septum, metal fume fever and occupational asthma.

In general, hexavalant compounds pass through biological membranes while trivalent chromium compounds do not. Exposure to hexavalant chromium compounds are associated with an increased risk of lung cancer.

Magnesium : Magnesium chloride (Melting point 650 °C, Boiling point 1107 °C) is used for a variety of other applications besides the production of magnesium: the manufacture of textiles, paper, fireproofing agents, cements and refrigeration brine, dust and erosion control. Mixed with hydrated magnesium oxide, magnesium chloride forms a hard material called Sorel cement. Prolonged inhalation of magnesium chloride fumes may cause metal fume fever.[6]

Route of entry

Welding is an occupation associated with respiratory symptoms and bronchial obstruction. Metal Fume Fever and Acute Bronchitis seem to be quite common. The route of entry is mostly inhalation only.

MODE OF ACTION

The mechanism of the causation of metal fume fever has endangered controversy and is not well understood. An immune reaction was hypothesized in reports by Lehman and Mc Cords.[10] These hypothesis suggested that modified lung proteins and the metal oxide itself elicit an antibody reaction. There is little support for these hypothesis. Blanc and colleagues have associated this with the release of cytokines which are known to have effects on thermoregulation.[4] Two particular cytokines are important as pyrogenes; tumor necrosis factors released from macrophages, lymphocytes and other cell types. These cytokines are important in causing systemic symptoms, fever, and neutrophil attraction and may have a role in tachyphylaxis.[10]

SIGNS AND SYMPTOMS

The diagnosis of metal fume fever is usually made when the clinical picture is combined with the history of metal fume exposure. The disorder is usually of short duration lasting not more than 24 to 48 hours. The chief complaints will be metallic taste in the mouth, fever, chills, malaise, fatigue, headache, myalgias and chest tightness, dyspnoea, and cough usually occur within 2 to 10 hours after exposure. The work relatedness of this condition may be missed because the symptoms may start when the employee is at home.[8]

PHYSICAL FINDINGS

Physical findings may vary from person to person. Fever, sweating, tachycardia, chills, pleural friction rub and pulmonary rales will be present.

DIFFERENTIAL DIAGNOSIS

The symptomatology of metal fume fever can mimic other conditions that must be considered in the differential diagnosis. Influenza can present for medical evaluation with symptoms of chills, myalgia, sore throat, fatigue, fever and listlessness. The abrupt onset of symptoms on the job or within 3 to 10 hours after work, and a history of welding or galvanization of steel should make the diagnosis. Other common fever conditions for differential diagnosis are malaria, urinary tract infection and acute upper respiratory tract infection.[9]

LABORATORY FINDINGS

Laboratory studies include leukocytosis (15,000 to 20,000 cells/ml) with excess of polymorpho nuclear cells. Lactate dehydrogenase may be elevated with the pulmonary fraction showing the greatest increase. Zinc levels may be elevated in the serum and urine but the absence of zinc does not rule out exposure or the diagnosis.

Pulmonary function study results may be normal or may show acute changes consistent with reduced lung volumes (forced vital capacity and forced expiratory volume in 1 second) and decreased carbon monoxide diffusing capacity. Over a time the pulmonary function abnormalities revert to normal.

Chest roentegenograms obtained during the course of illness usually are reported as normal. Increased interstitial markings have been described in certain cases.

TREATMENT

The treatment of metal fume fever is symptomatic and nonspecific. Pulmonary sequels are not present and hospitalization is unnecessary for uncomplicated cases. Milk has been described as a folk remedy but no clinical studies have been established. Since it is a self limiting syndrome, Broad spectrum antibiotics and unwarranted radiological exposures usage may be avoided.

DISABILITY

No permanent disability established.

PREVENTIVE MEASURES

Prevention of metal fume fever includes implementation of engineering controls, general room ventilation, local exhaust ventilation, process enclosure, down-draft or cross draft tables, and use of fume extractors built into welding equipment. When local exhaust ventilation is not available or not feasible, personal respiratory protection should be used under the workers face shield. It should be noted that user acceptability is limited because of the discomfort and elevated temperature noted beneath the breathing device. Medical and environmental surveillance measures should also be undertaken, targetted to those agents produced by the welding process.

CONCLUSION

Globally every year over 2 million people suffer from various occupational related disabilities. To minimise this a thorough study of the causes and preventive measures in occupational related problems in industrial set up is essential.

Knowledge of metal fume fever by the Medical Practitioners in Industries helps them to minimise the use and abuse of drugs. This also helps them in recommending various preventive measures to the managements of the various industries where such incidents are reported. A proper history from patients also avoids unwanted use of drugs (antibiotics) and unwarranted radiological exposures by the General Practitioners.

It may be noted that no Indian data is available because metal fume fever usually occurs between 8-12 hours after exposure to metal fumes when employee is at home and also it is not properly reported in our country.

In this context it is imperative that medical professional in various industries and General Practitioners around the Industrial Township's be aware of such occupational related factors.

ACKNOWLEDGEMENTS

The author is indebted and grateful to Shri R. N. Jayaraj, Chief Executive, Nuclear Fuel Complex, Hyderabad for all kinds of institutional help in preparing and presenting this paper.

He is equally thankful to Shri G. V. S. Hemantha Rao, Deputy Chief Executive, Nuclear Fuel Complex, Hyderabad for the kind cooperation extended on preparing this paper.

He also takes opportunity to express his sincere gratitude to Dr. M. R. K. Dilip Kumar, HMS Nuclear Fuel Complex, Hyderabad whose humanistic inspiration has always been a blessing to the author.

Finally, the author is thankful to all staff members of Medical Services of NFC for their active participation and help.

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DIETARY ANTIOXIDANTS : THE INSURER OF HEALTH

Mohammad Imtiyaj Khan and P. Giridhar*

Free radicals are chemical species that cause oxidation, which results in different disease conditions in the body. Antioxidant enzymes and endogenous antioxidants in the body, and dietary antioxidants counteract free radicals. To keep lifestyle diseases away, the importance of dietary antioxidants and various health benefits they provide are reviewed.

INTRODUCTION

Traditional Indian cuisines are known to be rich in vegetables and functional food components like spices and dairy products. Change in food habits owing to increased disposable income among the middle-class people, is posing a serious threat in the form of higher incidence rate of diabetes, cardio-vascular diseases, cancer, etc. India has been referred to as 'diabetes capital' of the world, recently. Increase in the incidence of life-style diseases and multi-factorial complications like stress, indicates that there is an urgent need for 'diet policing'.

Foods not only supply calorie but also protect body from the onset of diseases. Hence, some foods are branded as 'functional foods', 'health foods' or 'nutrifoods' and their components as 'nutraceuticals', 'bioactive substances', 'oleoceuticals', 'futureceuticals', etc. The word 'nutraceutical' is an umbrella term, which includes all the above terms. Nutraceutical is 'a food (or part of a food) that provides medical or health benefit, including the prevention and/or treatment of a disease'[1]. As a part of marketing strategy, above names have been designed to entice customers and survive the cut-throat competition in provoking health-conscious and self-care consumers. In general, every food is functional if required quantity is consumed at right time.

In the pathogenicity of many chronic diseases, oxidative stress due to the production of reactive oxygen (ROS) and nitrogen species (RNS) by all aerobic organisms is involved[2,3]. In addition to having a role in intra- and extra-cellular signaling, the reactive molecular species or oxidants may damage biomolecules. In response to such damage, a complex machinery of endogenous antioxidant defense system works. Dietary antioxidants are exogenous but contribute a great deal toward this defense system directly or through indirect biochemical cascades. It is believed that an imbalance between the oxidants and antioxidants leads to various physiological disorders.

WHAT ARE FREE RADICALS/OXIDANTS ?

Chemical species with one unpaired electron in the outermost shell are called free radicals that are formed during metabolism or physiological processes inside the body. They are very unstable due to the extra electron present on the outermost shell and tend to initiate a chain reaction of oxidation by donating or absorbing an electron to balance its outermost shell. They act like transition elements (in metal-complexes) that can accept or donate electron. There are a number of damaging oxidants that we are exposed to on daily basis. The

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most common are hydroxyl (OH), superoxide (O_2), hydrogen peroxide (H_2O_2), ozone (O_3), nitric oxide (NO) and peroxynitrite (ONOO)[4]. The sites of free radical formation are plasma membrane, mitochondria, endoplasmic reticulum and other vesicular bodies in cells[5]. Approximately 1% of oxygen that we inhale forms ROS and in a year we produce 1.7 kg ROS through oxidative phosphorylation (or respiration)[5].

WHAT ARE ANTIOXIDANTS AND ANTIOXIDANT ENZYMES ?

Antioxidants are electron deficient chemical species that have capacity to absorb electrons in its structural arrangement without undesirable effect. The reactivity of a free radical can be quenched by donating or accepting an electron. Some of the antioxidants like ascorbic acid, tocopherols, etc. are also capable of donating one hydrogen atom in order to scavenge an oxidant. There are endogenous antioxidants like glutathione and uric acid whereas most of the antioxidants are exogenous or come from our diet. Antioxidants act at different levels in the oxidative sequence involving lipids, proteins, DNA and others. To cope with potentially damaging free radicals, tissues contain endogenously produced antioxidant enzymes also[5]. Antioxidant enzymes are molecules that defend the body from the harmful effect of free radicals by scavenging the radicals and converting them to harmless entities that are sent out of the body *via* series of coordinated steps. Superoxide dismutase, glutathione peroxidase, glutathione reductase, catalase, etc. are some antioxidant enzymes. In a metabolically active tissue in a healthy subject with a 'formulated' dietary antioxidant intake, damage to tissues will be minimal, and most of the damages occurring will be repaired by this natural defense system in which lion's share is contributed by exogenous antioxidants.

WHAT ARE DIETARY ANTIOXIDANTS ?

Members of the Food and Nutrition Board of the National Research Council (USA) recently defined a dietary antioxidant as a substance in foods which significantly decreases the adverse effects of ROS, RNS, or both in humans. Categories of structurally different antioxidants present in our food are shown in Table 1.[4,6]

Table 1. Antioxidants in food and diet

Functional/ Structural types	Important antioxidants	Sources
Vitamins	A,B,C,E,K	Fruits, vegetables, citrus fruits, dairy products, fish, meat, oilseeds
Isoprenoid derivatives#	Carotenoids	Carrot, tomato, palm oil, micro-organisms
Benzopyran derivatives (Polyphenols/ Flavonoids)	Proanthocyanins, Anthocyanins, catechins, flavonols, Lignans, flavones, Isoflavones, Isoflavonoids, Catechin, gallic acid, catechol	Grape, apple, pomegranate, banana, pineapple, brinjal, beverages, oilseeds, cucumber, olive oil, pomegranate, green tea, spices such as rosemary, sage, cloves, oregano, waste from vegetable products
N-Heterocyclic tetrapyrroles#	Betaine, Pteridin, Riboflavin, Phenazines, Phenoxazines, Betalains	Vegetables, Beet root, pear fruit
Quinones (desaturated cyclic ketone)	Dibenzoquinones, Dianthraquinones, and Dinaphthoquinones	Chloroplasts of higher plants and algae, bacteria, insects, fungi
Phytosterols	Campesterol, stigmasterol	Vegetables, seeds
Ferulic acid ester	Oryzanol	Rice bran oil
Alkaloids	Capsaicinoids, berberine, caffeine	Chilli, beverages, herbs
Polyamines	Putrescine, spermidine, spermine	Pea, apple, citrus fruits, spices, liver, meat
Metals	Zinc, Selenium, Copper, Manganese	Vegetables, meat, egg, dairy products

The isoprenoids, benzopyran derivatives and n-heterocyclic tetrapyrroles are mostly plant pigments with wide range of colour.

An antioxidant molecule might clean up harmful free radicals/oxidants by scavenging the radical, inhibit generation of reactive chemical species, raise the levels of endogenous defensive force by up-regulating expression of antioxidant enzymes, chelating transition metals, forming part of metalloenzymes or other biomolecules (in case of antioxidant metals), and effect gap junction mediated cell communication[4]. A schematic diagram of the mechanism of antioxidant action is depicted in Fig. 1. In Box 1 the benefits of antioxidants have been summed up and in Fig. 2 the different body parts believed to be benefitted from different antioxidants have been illustrated.

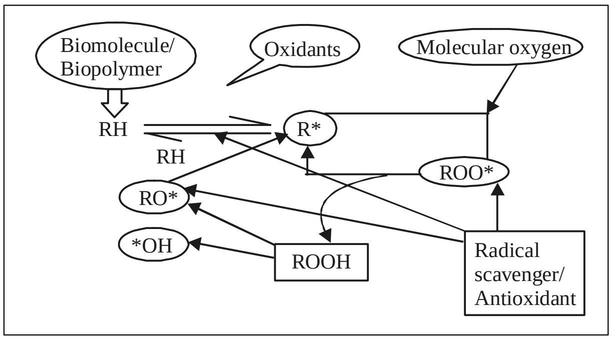

Figure 1. **Mechanism of combating free radicals by antioxidants**

Box 1. Health benefits of antioxidants

- Protects damage to fatty acids in cell membranes to preclude deterioration of cell membranes. Brain cells are particularly prone to oxidation due to higher quantity of unsaturated fatty acids.
- Activates enzymes which are blocked/jammed by free-radicals.
- Salvages proteins from breakdown.
- Defends damage to the DNA leading to reduction of the risk of cancer.
- Prevent damage to arteries that supply blood to the heart. Damages to arteries could lead to hardening of the arteries and a heart attack.
- Antioxidants serve to protect the gradual damage of brain cells, proteins, and DNA that occurs with the ageing process.

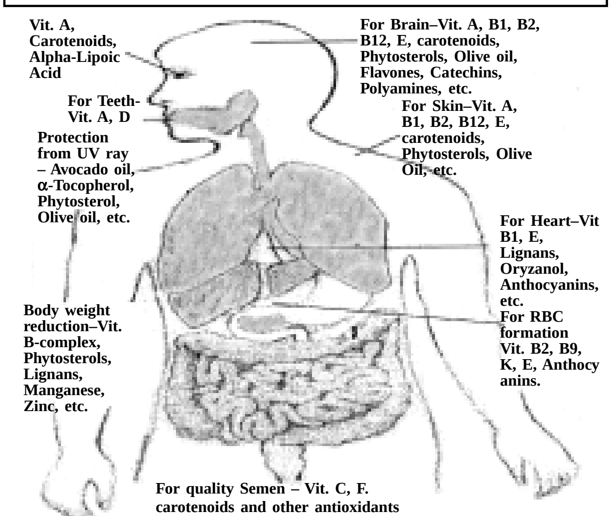

Figure 2. **Different body parts and antioxidants benefiting them**

Antioxidant requirements in the body

The antioxidant potential of a molecule can be determined by its Oxygen Radical Absorbance Capacity (ORAC) score. An ideal daily ORAC intake is between 1,500 and 2,000 units, however some experts still believe that the range should be 3000 - 4000 units[2,8].

Recommended Daily Allowance (RDA) of vitamin C is 40 mg per day[9]**.** Smokers are more likely to suffer from biological processes that damage cells and deplete vitamin C; hence they need an additional 35 mg per day[8].

RDA of vitamin E is 8-10 mg (11.7-14.7 International Units) per day[9]. Lipid peroxidation of membranes is significantly reduced by vitamin E. Vitamin E comprises of four isomers each of tocopherols and tocotrienols. Palm and rice bran oil are good sources of tocotrienols (another class of compounds with vitamin E activity). The antioxidant activity of tocotrienols is stronger than tocopherols but *in vivo* their activity is controversial and also bioavailability is low[9].

Among the minerals vital for antioxidant enzymes and other free-radical quenching processes, selenium – 40 μg, zinc – 12 mg, manganese – 2-5 mg, copper – 1.35 mg, magnesium – 340 mg, chromium – 33 μg, molybdenum – 75 μg[8], calcium – 600 mg per day are required as RDA for Indians[9]. Cobalt and nickel are also required at the same level as manganese[8]. The upper safe intake level for selenium is 400 μg/day[9]. For a balanced mineral intake lacto-ovovegetarian or omnivorous diet is recommended as vegetables lack some of the important minerals and also micronutrients[10]. The antioxidant content of some of the common fruits and vegetables have been given in Table 2 and in Boxes 2 and 3 the servings required per day to get required antioxidant intake have been summarized[10, 11].

Box 2. Required dose of antioxidants[11]

- Lignans heat-stable natural antioxidants. Recommended Daily Allowance (RDA) - 115 mg/day[8].
- Anthocyanins and proanthocyanins are reported to significantly, terminate cancerous growth when consumed 150-200 mg/day[8].
- Betalains are excellent source of essential amino acids and nitrogen and also antimicrobial, anti-proliferative and protection from diseases have been reported.
- Phytosterols are plant sterols (cholesterol equivalents) required for functional properties like reduction of 'bad cholesterol' (VLDL + LDL cholesterol) and total cholesterol absorption in the body, RDA - 2 g/day[8].
- Polyamines are strong biological bases with free radical scavenging activity and protection from peroxidation of cell membranes. RDA - 100 - 500 μmol/day[9]. However, the requirement differs largely based on the population group.
- Alkaloids act as stimulant, RDA for caffeine is 90-120 mg/day[9].
- β-carotene and other carotenoids are plant pigments that help in improving vision and brain cell development, RDA - 4.8 mg/day[8].

Table 2. Major antioxidants in some common fruits and vegetables[10]

Vegetables, fruits and seeds	Antioxidants	Concentration (mg/g)	ORAC score/ 100 g fruit
Apple	Proanthocyanidins	1.26	207
	Phytosterol	0.12	
	Vitamin C	0.05	
	Alpha Tocopherol	0.002	
Carrot	Alpha-carotene	0.08#	200
	Beta-carotene	0.17	
Beet root	Betalians	6–22	800
Grapes	Proanthocyanidins	0.06–0.5	740
	Anthocyanins	0.04	
Tomato	Lycopene	0.04	200
	Alpha-carotene	0.192#	
Pomegranate	Proanthocyanidins	0.01	3,307
Sesame seed	Lignans	0.01	19,700*

Units are in microgram/gram. All the values in the table are approximate. *Value refers to a commercial preparation of flaxseed hull.

Box 3. The source and balanced supply of antioxidants[11]

- 5-38 g of flaxseed or sesame seed, based on personal requirement, have been considered the therapeutic dose for obtaining lignans specially for women's health and reduce prostrate cancer risk.
- 1 cup (125 g) of grapes per day may supply the requisite anthocyanin quantity in body.
- 2-3 cups of brewed coffee per day provide the harmless dose of caffeine.
- $^1/_2$ cup of canned carrot juice may meet the dietary requirement of β-carotene.
- 1 cup of orange juice provides about 100 mg of vitamin C which is recommended to meet the daily requirement of a healthy body, ORAC score for orange is 750/100 g.
- 25-30 g of palm/soybean oil may supply adequate Vitamin E to body.
- Vitamin B complex and minerals can be obtained from green-leafy vegetables, egg, dairy products, fish and meat.

There is low incidence of diseases like cancer, cardio-vascular diseases and diabetes among tribes of north-eastern parts of India, Andes and Amazon valley in South America, who consume plenty of fruits, and wine prepared from fruits and meat. They also have longer life span. The well-known 'Mediterranean diet' which comprises of vegetable salad, olive oil (rich in monounsaturated fatty acid and polyphenols), and fish (good source of vitamin A and essential fatty acid) has been hailed for its health benefits[12].

STABILITY OF ANTIOXIDANTS

Antioxidants in foods are prone to degradation during processing, storage and cooking. They are sensitive to heat, light, pH, water activity (a_w), air and other food components (through antagonistic effect). However, response differs from one antioxidant to another. Lignans, caffeine, catechins, etc. are heat-stable to certain extent whereas flavonoids, carotenoids, tocols (collective term for tocopherols and tocotrienols), anthocyanins, betalains, etc. are heat-sensitive[4]. At standard cooking temperature, 180°C for about 100 min, sesame oil lignan like sesamol (which is a potent antioxidant *in vivo)* increases rapidly, however on prolonged exposure the level comes down[6]. Cooking for 100 min may result in loss of two-third of palmolein carotenoids and half of tocols in sesame oil and palmolein[7]. Interestingly, it has been confirmed that lignans protect tocols from degradation during cooking[6], tocols protect polyunsaturated fatty acids (PUFA) at ambient conditions by way of providing antioxidative protection[7] while a mechanism for antioxidant synergism has been proposed for tocotrienols and carotenoids during heating[7]. An antioxidant molecule can scavenge another antioxidant species by accepting an electron, which results in the protection (or regeneration) of the latter molecule.

CONCLUSION

In present context, it is imperative to 're-design' dietary intake by way of dropping junk foods and inclusion of 'functional foods' so that India does not become 'cancer capital', and 'cardio-vascular disease capital' in future. Antioxidants are natural remedies, which dispense their action slowly and steadily. Intake of antioxidants may not show immediate recognizable benefits. However, antioxidants can be compared to health insurance. If leading and potential companies cash in, Indians could be re-designing their food intake very soon.

DECLARATION

The data provided have been adapted from FDA, Ministry of Agriculture, USA; ICMR, New Delhi, India.

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NUTRITIONAL IMPORTANCE OF MEAT PRODUCTS IN HUMAN DIET

K. Jayathilakan* and K. Radhakrishna

Animal foods are vital sources of nourishment for man because of higher availability of nutrients. Foods of animal origin are quite varied in nature, ranging from fluids such as milk to solid materials such as meat and fish. Eating is a process essential for the maintenance of life. Very few foods like meat can quiet the pangs of hunger and satisfy the appetite quickly and completely. Meat is defined as those animal tissues which are suitable for use as food. It is an excellent source of high quality protein and characterized by high bio-availability, balanced amino acid profile and higher digestability. Meat and meat products are important sources of all the B-complex vitamins and excellent sources of some of the minerals and play an important role in the prevention of zinc and iron deficiency. With limited range of foods available in primitive societies throughout history, meat provided a concentrated source of a wide range of nutrients. Through the recorded history, the consumption of meat has indicated a position of social and economic prestige.

INTRODUCTION

Meat has long been a central component of the human diet both as a food in its own right and as an essential ingredient in many other food products for atleast 2 million years. Human genetic make up and physical features have been adapted over 4-5 million years for a diet containing meat. The main function of food is to provide nutrients to meet the metabolic needs of an individual. Meat and meat products are an important part of diet in many parts of the world, especially in developed nations where consumption of animal protein per capita is at its highest.[1] Meat is a highly nutritious and versatile food and has a special place in human diet. Meat is a good source of readily digestible protein and contains all the essential amino acids in a balanced form. The primary importance of meat as a food lies in the fact that when digested, its protein is broken down releasing amino acids; these are assimilated and ultimately used for the repair and growth of cells. In the United Kingdom, meat and meat products supply 30% of dietary protein intakes.[2]

Meat is a nutrient dense food, providing valuable amounts of many essential micronutrients. It supplies fatty acids, vitamins, minerals, energy and water and is involved in the synthesis of proteins, fat and membranes in the body. With a limited range of foods available in primitive societies throughout history, meat provided a concentrated source of a wide range off nutrients. Meat is also a good source of the vitamins of B group but usually low in fat-soluble vitamins (A, D, E, K) and vitamin C. It is also a good source of minerals like Cu, Zn, Na, K, Fe and P. Meat contains Fe and Zn bound to heme protein, which is readily incorporated into the body. However, it is low in carbohydrates. All of the iron in our body comes from our diet, and meat is a rich dietary source. Concern about iron deficiency is one

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nutritional reason for recommending eating at least some meat.[3]

LIVESTOCK SCENARIO

The livestock wealth of India is one of the richest in the world. It is unique in number and diversity. The meat and meat products are treated as the by products of animal husbandry. The entire gamut of meat production, processing and marketing is a neglected one in the country. Marketing of livestock, meat, procesed meat products and by products has remained more or less unorganised in India.[4]

In India the acceptance of meat as a part of diet is very often governed by the regional, cultural and religious bias. In spite of religious beliefs and socio-economic constraints, it still finds a prime place in the diet of nearly 70% Indians.[5] However, due to low purchasing power and local food habits, the majority of Indian population consume meat occasionally. The per capita meat consumption is about 2.5 kg in India compared to the global average of 32 kg per annum and over 100 kg in many developed countries. Consumer preference for goat or lamb meat is dictated by cultural and traditional background and the socio-economic status of the community. In India goat, lamb and chicken meat are widely preferred, while bovine meat and pork are consumed only by a small segment of the population. Meat produced in India is characterised by low yielding non-descript animals. Sheep, goats and pigs are raised primarily by a large number of small shepherds and farmers, with little or no land holdings.

Livestock marketing as it relates to cattle, buffalo, sheep, goat and pigs begins when the animal leaves the farm and enters the marketing channel. It includes transportation, marketing, organisation services, information services and even some aspects of processing. Meat processing includes the slaughter and sale of carcasses for wholesale and retail outlets. In the whole process large numbers of people are employed in handling, transportation and processing of the meat, involving huge transactions. Marketing also involves the distribution of products, which require huge work force, thereby creating vast employment opportunity. As a result much importance is given to livestock production sector since there is an increasing trend in meat consumption and trade, the demand of which is being more or less matched by enhancing production. Population of different livestock species and their contribution to meat production is depicted in Table-1.

Table–1. Population of different livestock species (in million) and meat production.

Species	Population			Meat Production (tonnes)
	India	World	% To world	
Cattle (cow, oxen, bullocks)	185	1355	13.65	1493
Buffalo	98	174	56.32	1487
Sheep	63	1080	5.83	238
Goat	120	807	14.87	475
Pig	14	960	1.46	497
Hen/Fowl	430	16725	2.57	1900

Source : FAO 2005[1]

PRODUCTION OF MEAT

The marketing of meat and meat products is more complicated because of the highly perishable nature which may further affect the availability at short notice depending on fluctuations of demand, the unfavourable hot and humid climatic conditions particularly to India, lack of transportation facility as well as religious taboos of consumers.[4] The attitude of policy makers to meat is to treat it as a by-product and not a commodity.

The meat meant for export has to pass through ante-mortem and post-mortem examination after

24 hrs resting period of the animals. The meat is chilled for 24 hrs to bring down the pH below 6. Thereafter, it is deboned and deglanded. The meat is then packed into different cuts and frozen at – 40° C for 12 h to bring down the deep bone temperature to – 18° C. The frozen meat is stored in cold storage for export.

The meat produced for the domestic market is sold as hot meat. It is estimated that approximately 2% of meat is converted into processed meat products.[6] India's share in international trade is hardly 1% and can be increased substantially. Buffalo is the major contributor accounting for more than 95% of total meat exports, whereas goat and sheep meat contributed very little (5%) to the total meat export (Table–2). Poultry meat and meat products need to be promoted with better processing and marketing approaches.

through implementation of Good Manufacturing Practices (GMP) and Total Quality Management (TQM) has a greater significance under the changed world meat trade scenario.

MEAT COMPOSITION AND NUTRITIVE VALUE

In a broad sense the composition of the meat can be approximated to 75% of water, 19% of protein, 3.5% of soluble non protein substances 2.5% of fat, but an understanding of the nature and behaviour of meat and of its variability, cannot be based on such a simplification. On the contrary, it must be recognised that meat is the post mortem aspect of a complicated biological tissue, viz. muscle. Meat is composed of lean tisue or muscle fibre-cells, fat and connective tissue. Fat or adipose cells can be found in upto three depots or locations in meat. Fat can be deposited intramuscularly as marbling or contained between muscles or it can be found as external fat or subcutaneous fat. These three major components of meat, fat, lean or the myofibrillar components and connective tissue affect meat quality in different ways.

Table 2 : Export of meat and meat products and casing during 2004-2007 (Value in crores)

Product	Year					
	2004-05		2005-06		2006-07	
	Quantity (MT)	Value (Rs)	Quantity (MT)	Value (Rs)	Quantity (MT)	Value (Rs)
Buffalo meat	337777.65	177451.85	459937.63	262956.97	494111.48	321170.26
Goat & Sheep meat	9024.49	8127.43	7177.51	8037.11	5481.55	6304.85
Poultry pdts	1062265.65	28774.23	1185142.77	31565.71	710880.12	31590.27
Animal casing	552.73	1263.99	1125.82	1751.33	435.98	950.65
Processed meat pdts	1359.7	944.85	256.04	242.7	825.01	680.45

Source : APEDA 2006–2007[7]

India has got several advantages in meat export like leanness of meat and low cholesterol content, lower cost of meat production, proximity to importing countries, good upcoming modern infrastructure, safer meat free from toxic residues etc. However, meeting the phytosanitary standards

A comparison of the composition of raw and cooked meat from different animal sources is given in Table-3.

Table 3 : Comparative composition of cooked meat from different animals[8]

	Raw				Cooked			
	Energy (Calories)	**Total fat**	**Saturated fat**	**Protein**	**Energy (Calories)**	**Total fat**	**Saturated fat**	**Protein**
Beef	182	10.4	4.3	21.5	278	18.8	8.0	27.0
Pork	248	18.3	6.4	20.8	352	28.2	10.2	24.7
Lamb	190	11.3	4.8	21.2	270	18.8	8.6	25.6
Chicken	160	4.1	1.1	30.4	222	6.8	1.8	39.5

LIPIDS IN MUSCLE SYSTEM

Animal fat is composed chiefly of neutral fats and phospholipids. The neutral lipids are principally glycerol esters of straight chain carboxylic acid of triglycerides, which typically contains 16-18 carbon atoms. Phospholipids are found in animal fats in small percentage. They play a key role as structural and functional components of cells and membranes. Phospholipids constitute a major portion of intra-muscular lipids of muscle foods. They normally comprise about 0.5 to 1% of lean muscle. As the total lipid in a muscle decreases from 5 to 1%, the percentage of phospholipid to total lipid increases from less than 10% to nearly 70%. Polyunsaturation of phospholipids fraction is about 15 times greater than that of the tri acylglycerol fraction. There is also significant variation in total phopholipids content among species from muscle to muscle location in the same animal. Poultry and fish muscle is known to be higher in phospholipids than red meat.

Meat contains a mixture of fatty acids both saturated and unsaturated. The predominant saturated fatty acids in meat are stearic acid and palmitic acid. In general terms saturated fats are known as the "bad" fats as they tend to raise blood cholesterol and cause atherosclerosis. However, not all saturated fats are equal in their effects on blood cholesterol. For instance stearic acid does not appear to raise blood cholesterol or other thrombotic risk factors. Stearic acid is a prominent saturated fat in meat, for example it accounts for approximately one third of the saturated fat in beef. Similarly palmitic acid, another major saturated fat in meat does not consistently raise blood lipids. On the other hand, myristic acid is the most atherogenic fatty acid, it has four times the cholesterol raising potential of palmitic acid. Myristic acid is found only in minor quantities in meat.

Meat contains a mixture of unsaturated fatty acids, Poly Unsaturated Fatty Acids (PUFAs) and Mono Unsaturated Fatty Acids (MUFAs). MUFAs are the dominant unsaturated fatty acid in meat and they account for approximately 40% of the total fat in meat. Meat and, meat products are the main contributors to MUFAs in the British diet, supplying 27% of total MUFA intake[2]. MUFA in meat is oleic acid.

The PUFAs have a structural role as they are found in the membrane phospholipids and they are also involved in eicosanoid synthesis. There are two types of PUFAs, the omega-3 (n-3) and the omega-6 (n-6). Meat and meat products supply 17% n-6 and 19% n-3 PUFA intake. Linoleic acid and linolenic acid are essential fatty acids as it cannot be synthesised in the human body. In the body these are further elongated and desaturated to longer chain derivatives, arachidonic acid, decosa pentaenoic acid, eicosa pentaenoic acid and decosa hexaenoic acid. The positive effects of the consumption of n-3 fatty acids are indicted by GISSI trials for the reduction in the coronary heart disease deaths[9] in addition to anti-inflammatory and anti-tumour urogenic properties. Meat and fish are the only significant sources of preformed very long chain n-3 PUFAs in the diet.

An emerging dietary benefit for meat is Conjugated Linoleic Acid (CLA). The best natural dietary sources of CLA are ruminant products such as beef and lamb. Factors affecting the CLA content of meat include the breed age and diet of the animal. Since CLA is formed predominantly in the rumen the CLA content of ruminant meat, beef and lamb is much higher than non-ruminant meat such as pork, chicken etc. Meat and meat products supply approximately a quarter of dietary CLA in Germany. CLA appears to have a variety of potential health benefits. It has been shown to have tumour-reducing and atherosclerotic-reducing properties. CLA may also reduce adiposity and delay the onset of diabetes. The data from 14 European countries reveal that the fat content of meat does not correlate with the percentage of trans fatty acid content. Trans fatty acids did not influence Low Density Lipoprotein (LDL) and High Density Lipoprotein (HDL) cholesterol and a weak inverse association was found with total serum cholesterol.

PROTEIN IN MEAT

Meat is a good source of protein and it contains all the essential amino acids. Muscle food proteins are characterised by high bio-availability (NPU value around 0.75 as against 0.5-0.6 for plant proteins) balanced amino acid profile and higher digestibility.[10] The high protein intake has no adverse effects on renal function.[11,12] Some of the amino acids are limiting in plant protein like lysine in wheat, tryptophan in maize and sulphur containing amino acids in Soya bean. The damage to protein caused by cooking is of little practical significance and it can be argued that if there is meat in the diet it is likely that the quantity of protein would compensate for any shortfall in quality.

The nutritional quality of the proteins of meat rich in connective tissue is low since collagen and elastin are poor in the sulphur amino acids. There is only 0.8g of each per 100g of total protein compared with values of 2.6 and 1.3 of each respectively in "good meat". Meat is tough to eat when it is high in connective tissue and such meat is often used for canning since the relatively high temperature involved in the sterilisation process partly hydrolyses the collagen so making the product more palatable. However, it still result in a product with NPU as low as 0.5 compared with a value of 0.75-0.8 for good quality meat.[13]

MEAT AS A SOURCE OF VITAMINS AND MINERALS

Meat and meat products are important sources of all the B-complex vitamins including thiamine, riboflavin, niacin, biotin, vitamin B_6 and B_{12}, pantothenic acid and folacin. The last two are especially abundant in liver which with certain other organs is rich in vitamin A and supplies appreciable amount of vitamins D, E and K. Some losses of B-vitamins occur during cooking and the amount lost depends upon the duration and the temperature of the cooking method.

Pork and its products including bacon and ham are one of the richest sources of thiamine. Pork contains approximately 5-10 times as much thiamine as beef or lamb.[14] Meat is the richest source of niacin. Meat and meat products supply more than a third of niacin intakes in Britain.[2] Vit B_{12} is exclusively of animal origin as it is a product of bacterial fermentations, which occurs in the intestine of ruminant animals such as cattle, sheep and goats. Vit B_{12} is required to produce red blood cells and acts as a cofactor for many enzyme reactions. Deficiency of B_{12}, B_6 and D vitamins lead to the development of many diseases and physiological disorders.[15]

Meats are excellent sources of some of the minerals such as iron, zinc, selenium, copper and manganese, and play an important role in the prevention of Zn deficiency,[16] and iron deficiency. Iron deficiency anaemia remains the most common nutritional disorders in the world today. It affects between 20-50% of the world's population.[17] Meat and meat products provide 14% of iron intake in the UK diets.[2] Meat has an important influence on iron bioavailability due to its enhancing properties and overall greater absorption capacity. Studies have shown that despite the fact the vegetarians have either a similar or a higher iron intake than their omnivore counterparts, their iron status are lower[18,19] probably due to presence of iron inhibitors in their diet that limit iron absorption/ utilization.[20]

Muscle foods are rich source of zinc that provides resistance against infection caused by viruses, bacteria and other pathogens. It plays an important role in immunity, reproduction and cognitive development.[21] Selenium, a trace element, is an important component of the enzyme glutathione peroxidase and acts as an antioxidant. It is considered to protect against coronary heart disease and certain cancers, such as prostate. The daily acceptable intake/requirement for Selenium is 40µg/day for adult man/woman.[22] Meat contains about 10µg selenium per 100g, which is approximately 25% of our daily requirement. Beef and pork contain more selenium than lamb. Bioavailability of selenium from plant foods was thought to be greater than that from animal foods, but available data suggest that the bioavailability of Selenium is highter from meat.[23]

Meat also contains phosphorous, a typical serving provides roughly 20-25% of an adult's requirement. The daily recommended allowance of phosphorous is 600mg/day for adult man/ woman.[22] Phosphorous has important biochemical functions in carbohydrate, fat and protein metabolism. Meat also provides useful amounts of copper, magnesium, potassium, iodine and chloride.[24]

CONCLUSION

Meat is highly demanded food items of human beings due to the presence of plentiful proteins, minerals and all the B-complex vitamins with excellent digestability and well balanced composition of essential amino acids. The meat industry is an important sector of food industry in the world and India is the largest producer of animals. There is a growing demand for processed, packaged, convenience and ready-to-eat or ready-to-serve meat products that require minimal preparation. Meat and meat processing industry in India is growing steadily with the increasing urbanisation, quality consciousness and change in food habits. Most of the meat products for domestic consumption are made from locally available fresh meat. The products are cooked and consumed on the same day. Very little meat is processed to make value added meat products like patties, sausages, nuggets etc. Hence, there is a market for scientifically produced meat products. Meat is likely to remain an economically important, organoleptically enjoyable and nutritionally valuable food commodity.

The incidence of iron deficiency anemia is much greater in India than western countries. So, it is especially important for vegetarians to get their protein, iron and zinc from sources other than meat which are equivalent sources of proteins like soya-based foods, beans, lentils and chickpeas, seeds, nuts and nut butters like peanut butter. This is possible if there is accessibility, availability and affordability to diversify food to enhance absorbility of iron in the general population. For the vulnerable groups food fortification and food supplementation are important alternatives that complement food-based approaches to satisfy the iron needs.

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LIGNIN IN LIGNOCELLULOSICS - A BOON OR A BANE FOR RUMINANTS

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Lignocellulosics are renewable energy source but the presence of lignin in their structure though essential for the growth and protection of plants prevents their exploitation to the maximum. Physical, chemical and biological means of lignin degradation employed have their limitations. The common practice followed universally for their disposal is biomass burning which adds to environmental pollution. Modifying the lignin content and composition of these lignocellulosics through genetic manipulation can improve the utilization of lignocellulosics for production of biofuels, be beneficial to paper and pulp industries as well as enhance their digestibility within the ruminant system thereby increasing animal productivity.

INTRODUCTION

Lignocellulose is the major structural component of woody plants and non-woody plants such as grasses and crop residues and represents a major source of renewable organic matter consisting of lignin, hemicellulose and cellulose. Large amounts of lignocellulosic "waste" are generated through forestry and agricultural practices, paper-pulp industries, timber industries and many agro industries which poses an environmental pollution problem. Much of this lignocellulose waste is often disposed of by biomass burning. But for lignin, this large amount of residual plant biomass considered as "waste" can potentially be converted into various different value added products including biofuels, chemicals, cheap energy sources for fermentation and improved animal feeds.

SIGNIFICANCE OF LIGNIN

Lignin is the second most abundant biopolymer on earth and together with cellulose can be considered as the batteries of the planet. Agricultural wastes and forest materials contain high levels of lignocellulose a renewable resource with considerable biotechnolgical potential, from which many useful biological and chemical products can be derived. Accumulation of this biomass in large quantities every year results not only in deterioration of the environment but also in loss of potentially valuable materials that can be processed to yield energy, food, and chemicals. Lignins are complex phenolic heteropolymers associated with the polysaccharidic components of the wall in specific plant cells. True lignins have been identified in the first vascular plants, the pteridophytes and they are likely to have played a key role in the colonization of land by plants. They represent the second most abundant organic compound on earth after cellulose accounting for about 25% of plant biomass. In accordance with their major fuctions, lignins occur in the greatest quantity in the secondary cell walls of particular cells providing rigidity and structural support to plant tissues and water-proof the vascular elements allowing the conduction of water and solutes. Lignins are also located in lower amounts

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in periderm, where they play a protective role in association with suberin. Defence lignins are formed in plants in response to pathogens and mechanical stresses.

Lignins result from the oxidative coupling of three monomers, namely coumaryl, conifer-yl and sinapyl alcohols giving rise within the polymer to H (hydroxyphenyl), G (guaiacyl) and S (syringyl) units (or residues). They exhibit a high degree of structural variability depending on the species, the tissue, the cells and the environmental conditions. This very important heterogeneity is related

(1) to the relative proportion of the three constitutive monomers,

(2) to different types of inter unit linkages and

(3) to the occurrence of 'non conventional' phenolic units within the polymer.

Though lignin plays an important role in plants, it often represents an obstacle to the utilization of plant biomass as the digestibility of forage crops by cattle is limited owing to the presence of lignin.

LIGNIN STRUCTURE AND IT'S ROLE OF IN PLANTS

Lignin is formed in vascular plant cell walls by the oxidative coupling of several related phenylpropanoid precursors: coniferyl alcohol, sinapyl alcohol, and *p*-hydroxycinnamyl alcohol . Lignin is covalently associated with hemicelluloses in the cell wall via numerous types of linkage. Among the most important are ether bonds between the benzylic carbon of lignin and the carbohydrate moiety, ester bonds between the benzylic carbon of lignin and uronic acid residues, and lignin-glycosidic bonds. In graminaceous plants, hydroxycinnamic acid residues are frequent in the lignin, and are attached to hemicelluloses via ester linkages. The matrix of lignin and hemicellulose encrusts and protects the cellulose of the plant cell wall.

Lignin offers many benefits to the growing as well as mature plant. They provide an exo-skeleton giving rigidity and support, enabling the water column to reach the plant apex and they serve as a protective barrier against predators and pathogens. However, the expensive, energy-intensive process of turning wood into paper costs the pulp and paper industries many billion $ a year. Much of this expense involves separating cellulose from lignin, the glue that binds a tree's fibers, by using an alkali solution and high temperatures and pressures. Although the lignin so removed is reused as fuel, wood with less lignin and more cellulose would save the industry millions of dollars a year in processing and chemical costs.

ROLE OF LIGNIN IN ANIMAL NUTRITION

Cellulose and hemicellulose represent about 50% to 70% of the total dry matter in legumes and grasses but, these are not digested by animal enzymes. The ability of animals to use structural carbohydrates for nutritive purposes depends on the presence of symbiotic microorganisms, such as bacteria, protozoa and fungi, in the gastro-intestinal tract, which can degrade cellulose and hemicellulose to produce volatile fatty acids and other simple compounds digestible by the animal host ; the latter can also digest the microbial cells. Higher animals are divided into two groups: animals where the symbiotic, microorganisms live before the true stomach (ruminants, hamsters, voles) and those in which symbiosis occurs in the large intestine (pony, rat, elephant and rabbit,). The absorption of nutrients is high in the small intestine but low in the large intestine and so postgastric decay is generally of low nutritive importance. Moreover, the utilization of feeds with high fiber contents (structural carbohydrates) is generally higher in animals with a pregastric digestion site and, of which ruminants are of particular interest. The possibility of increasing fiber digestibility of high fiber content feeds by ruminants to obtain high protein quality products (meat, milk etc.) is of particular interest in developing countries, where these feedstuffs constitute the main or only dietary component for animals, since feeds of higher energy and protein value (cereals, legumes etc.) are reserved for human needs and cannot be spared. Cellulose and hemicellulose are potentially totally digestible in the rumen by microbes, while lignin is a factor which contributes to reduced fiber digestibility.

Lignin is solely responsible for the digestibility, or lack thereof, of forage crops, with small increase in plant lignin content resulting in relatively high decrease in digestibility. Crops with reduced lignin content provide more efficient forage for cattle, with the yield of milk and meat being higher relative to the amount of forage crop consumed. Because lignin has a negative impact on forage digestibility, modifying the lignin content and composition can improve the digestibility of the forage crops to ruminant animals. In industries, lignin is removed from the cellulose by chemical treatment to enhance pulp quality and yield. But these treatments are costly, energy-consuming and environmentally hazardous, making this approach unsuitable for enhancing digestibility to ruminants. Therefore, approaches based on genetic modification of the trees/plants have gained importance.

OTHER ROLES OF LIGNIN

The quality of other plant products used in animal or human nutrition is also hampered which is true for the pulp and paper industry where lignins have to be removed from wood through expensive and polluting processes in order to recover cellulose. Of late research on lignin biodegradation has accelerated on account of the substantial potential applications of bioligninolytic systems in pulping, bleaching, converting lignins to useful products, and treating wastes.

DEGRADATION OF LIGNIN IN THE RUMEN

Lignin was considered 'indigestible' and used as an internal marker to calculate the digestibility of feedstuffs in animals. Later it was realized that lignin, determined either with sulphuric acid or potassium permanganate, was apparently digested to variable extents ranging from 2% to 53% Degradation has been shown to occur in white rot fungi the *Basidiomycetes*, a process involving extracellular peroxidases, oxygenated compounds, the presence of readily available substrate under aerobic conditions. Anaerobic degradation of lignin fragments by bacteria and fungi, with the production of soluble compounds has also been reported but these natural degradation processes are very slow and efforts to degrade lignin at a faster rate employing alternative strategies are thus required.

NEED FOR LIGNIN DEGRADATION

The use of fungus prior to pulping offers an attractive opportunity for mechanical wood pulp facilities. This technology could save an estimated 30% of the energy consumed in refining the mechanical pulp. The technology also improves paper strength, reduces pith content, and could reduce the emissions of volatile organic compounds. Alternatively, pulp can be bleached with white-rot fungi and their lignolytic enzymes, enabling chemical savings to be achieved and a chlorine free bleaching process to be established. On the context of ruminant feeds lignin degradation in crop residues would enhance the availability of cellulose and hemicellulose, the energy rich components for productive purposes.

PROBLEMS OF LIGNIN DEGRADATION

Degradation of lignin is a complex process. As the polymer is extremely large and extensively branched, ligninolytic mechanisms ought to be extracellular. Since, it is interconnected by stable ether and carbon-carbon bonds, these mechanisms must be oxidative rather than hydrolytic. Since lignin consists of a mixture of stereo irregular units, fungal ligninolytic agents have to be much less specific than typical biological catalysts. Finally, the fact that lignin is insoluble in water limits its bioavailability to ligninolytic systems and dictates that ligninolysis is a slow process.

STRATEGIES EMPLOYED FOR ENHANCING LIGNIN DIGESTIBILITY OF CROP RESIDUES

A number of mechanical processing techniques like soaking, grinding and pelleting and/or Gamma Irradiation have been used for feeding ruminants, with varying degrees of success.[6] Chemical treatment with sodium and calcium hydroxide , hydrogen peroxide and urea/ammonia have been reported to improve the intake as well as nutrient digestibility but these are cumbersome and hazardous.[8,9] Biological approaches like ensiling with chemicals or microbes have also not been very successful and it is argued academically whether anaerobic ensilage of such ready digestible materials within crop residues is economically beneficial to the animal.

LIGNIN DEGRADATION BY WHITE-ROT FUNGI

The ability to degrade lignocellulose efficiently is thought to be associated with a mycelial growth habit which allows the fungus to transport scarce nutrients, e.g. nitrogen and iron, over a distance into the nutrient-poor lignocellulosic substrate that constitutes its carbon source. White rot basidiomycetes fungi are the primary known organisms which are capable of degrading lignin extensively to CO_2 and H_2O. They degrade all the major polymers in wood-cellulose, hemicellulose, and lignin and degrade lignin more rapidly and extensively than any group of organisms.[4,5]

LIGNOLYTIC ENZYMES

The mineralization of lignin is achieved by a group of peroxidase and phenoloxidase enzymes known as Lignin-Modifying Enzymes (LME's). They produce highly reactive radicals which oxidize phenolic and non-phenolic lignin components and thus are of great significance to the pulp and paper industry as well as the agricultural community and an inexpensive and readily available supply of these enzymes is highly desirable. The white rot fungi or the wood decay fungi as they are called are the most efficient to degrade lignin on account of their ligninolytic enzymes - the ligninases , and *Basidiomycete* mushrooms of the genus *Pleurotus* along with a few others like *Phanerochaete chrysosporium* are the most recognized. Solid State Fermentation (SSF) is an attractive alternative process to produce fungal microbial enzymes using lignocellulosic materials from agricultural wastes due to its lower capital investment and lower operating cost.[7] The use of enzymes to attack the lignocellulose structure of crop residues for enhancing their feeding value is thus very attractive. Crude enzyme products, with cellulolytic, hemicellulolytic and lignolytic capability are added to fibrous feeds in attempts to improve digestibility. Limiting amounts of lignocelluloytic enzymes are however, produced by them, which impedes their commercial use and also prevents true assessment studies of various potential applications. Biotechnology techniques such as cloning, mutation and overproduction of lignocellulolytic enzymes have helped to overcome these limitations.

BIOTECHNOLOGICAL APPROACHES TO MODIFY LIGNIN CONTENT

● Over-expression of white-rot fungi lignin-degrading enzymes

White-rot fungi produce extra cellular lignin-modifying enzymes, the best characterized of which are laccases, lignin peroxidases and manganese peroxidases. The genes encoding these lignin-degrading enzymes have been cloned and over-expressed in various forage crops for e.g. manganese peroxiodase (Mn-P) from *P. chrysosporium* was over-expressed in maize seed.[3]

● Down-regulation of genes involved in lignin biosynthesis

Various enzymes of the monolignol pathway have been targeted for down-regulation, primarily using the antisense strategy and RNA interference (RNA). Genes encoding seven enzymes of the monolignol pathway were independently down-regulated in alfalfa using antisense and /or RNA interference.[2] In each case, total flux into lignin was reduced, with the largest effects arising from the down-regulation of earlier enzymes in the pathway. Down-regulation of genes involved in lignin biosynthesis has been attended in tobacco, poplar, aspen and tall fescue. Numerous studies have shown that by down-regulating expression of certain genes in the lignin pathway the ratio of S/G monomers can be manipulated. Along with changes in lignin content, even small changes in the S/G ratio can have a significant impact on fiber digestibility as can changes to lignin structure. CAD-and COMT-deficient transgenic tobacco and alfalfa have also been shown to have slightly improved digestibility.[1]

● Gene discovery using reverse genetics

Mutant collections using T-DNA/transposon tagging (insertion as well as activation tagging) have been developed . Phenotypic evaluation of these mutants might identify lignin-deficient lines, which can be used for forward genetics to unravel gene(s) controlling the phenotype, otherwise, the publicly available flanknig sequence tag (GST) data, mutants which have been tagged for the genes involved in lignin-biosynthesis can be identified, and acquired from the curator. Reverse genetics approach involving phenotypic evaluation for lignin is expected to reveal the role of tagged gene in lignin biosynthesis apart from any other associated adverse phenotypic changes.

CONCLUSIONS

Lignocellulosics are renewable energy resources having great potential for bioconversion and utilization as biofuels and animal feed. Lignin has a negative impact on forage digestibility and is removed from the cellulose by chemical treatments to enhance quality of pulp and yield during paper manufacture. These treatments are costly, energy-consuming and environmentally hazardous, making this approach unsuitable for enhancing digestibility to ruminants. Modifying the lignin content and composition through manipulations based on genetic modification of trees/plants could improve digestibility within the ruminant system and thereby increase productivity . The potential utilization, of lignocellulose represents an important target for underdeveloped/developing countries and could be a solution to prevent the unprecedented loss of biological energy otherwise unutilized by the cattle into productive processes.

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FISH AND SHELLFISH BASED NUTRACEUTICALS

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Seafood is the single most important food we can eat for good health. Regular consumption may help to increase intelligence, reduce the risk of various diseases and disorders. Fish is rich in omega-3 fatty acids which are known to contribute for the healthy development of brain tissue and retina in children. Eating of fish reduces the risk of heart disease and stroke by reducing blood clots and inflammation, improving blood vessel elasticity, lowering blood pressure, lowering blood fats and boosting good cholesterol. This article deals with the different nutraceuticals obtained from the fish and shellfish and their applications in different areas.

INTRODUCTION

The health benefits associated with fish consumption have resulted in favourable consumer image fish by products. Various health organizations in world have emphasized the importance of varied diet to meet nutritional requirements for achieving ideal body weight. In this context, seafood products can play an important role in nutritional picture as rich source of protein, vitamin, minerals and relatve low caloric diet. In addition, fish are excellent sources of omega-3-poly unsaturated fatty acid, which, appears to have beneficial effects in the reducing the risk of cardiovascular disease and positive benefits in many other pathogenical conditions particularly certain types of cancer and arthritis.

Marine, fresh water and cultured fish, shellfish and other aquatic species provide a rich source of food as well as by-products that could be used for production of a wide range of health promoting compounds. These bioactives include omega-3 fatty acids, proteins and biopeptides, carotenoids and carotenoproteins, enzymes, chitinous materials and glucosamine as well as minerals, among others. The bioactives present in sea foods and aquatic resources are effective in rendering beneficial health effects and reducing the risk of a number of chronic diseases. Thus, such bioactives may serve as important value-added nutraceuticals, natural health products and functional food ingredients that can be used for health promotion and disease risk reduction.

Seafood products such as fish, shellfish and molluscs have traditionally been used because of their variety of flavor, colour, texture and accessibility in the coastal areas. More recently, sea foods are appreciated because of the emergence of new evidence about their role in health promotion and disease risk reduction, primarily arising from their bioactive omega-3 fatty acids, among others. A large proportion of by-products, upto 75%, and low-value fish are also procured as a result of processing and harvesting.

Marine-derived products are in high demand, and experts predict contined growth in the months and years ahead. The scientific community continues to perform more and more research to support the health claims of Marine Nutraceuticals.

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Different types of fish and shell-fish based Nutraceuticals summarized in table 1.

Table No. 1 Nutraceuticals and natural health products for marine resources

Components	Application
Astaxanthin	Nutraceuticals
Omega-3 oils	Nutraceuticals, immune enhancement, CVD, others
Chitin, Chitosan, and glucosamine	Food, water and juice clarification, agriculture, supplements
Chonodostin sulfate	Dietary supplement, arthritic pain
Squalene	Skin care
Biopeptides, collagen and protein	Nutraceuticals, immune enhancement, etc.
Carotenoids and Carotenoprotein	Nutraceuticals, others.
Minerals (calcium)	Nutraceuticals
Enzymes	Food and speciality application, others
Vitamins	Nutraceuticals

ASTAXANTHIN

Astaxanthin is a carotenoid found in micro algae consumed by salmon and crustaceans. It is responsible for giving salmon their characteristic pink color. It is a powerful antioxidant. It may maintain healthy cholesterol levels by reducing the effects of oxidative stress. Astaxanthin is shown to protect cellular membranes and ocular tissue against photo-oxidation. It may be beneficial in protecting against age-related mascular degeneration.

OMEGA-3 FATTY ACIDS

Eicosa Pentaenoic Acid (EPA) and Docosa Hexaenoic Acid (DHA), are the two most important long-chain Fatty Acids from fish, valued for their contribution to vitality and health. EPA and DHA have been shown to support proper cognitive and mental development in infants. The FDA has issued a qualified health claim for products containing EPA and DHA to help to reduce the risk of coronary heart disease. Some experts believe that taking fish oil (in any form) can help regulate cholesterol in the body, because fish oil has high levels of omega-3 fatty acids.

Supplements on the market today contain oils from sardines, anchovies, herring, tuna, cod, salmon, menhaden, hoki and other fish. In general, sardines and anchovies are highest in total EPA+DHA content. Data from a recent Frost & Sullivan market research study commissioned by the Global Organization for EPA and DHA Omega-3s (GOED) show that more than 90% of the fish oil on the market, by volume, comes from anchovy and sardine fisheries.

The two next most important sources of EPA and DHA are cod liver and tuna oils, which fill unique niches in the market. While cod liver oil is considered one of the best sources of omega 3s, globally it is not generally consumed for its omega 3 content. Actually, it is primarily taken in Scandinavia and the U.K. for its vitamin content and its decades-old use in preventing rickets. Tuna, on the other hand, has a unique omega 3 profile, with levels of DHA ranging from 21-24%. This makes it a good source for brain and children's health applications.

CHITOSAN

Chitosan's properties allow it to rapidly clot blood, and have recently gained approval in the USA for use in bandages and other haemostatic agents. Chitosan is hypoallergenic, and has natural anti-bacterial properties, further supporting its use in field bandages. Chitosan is frequently sold in tablet form at health stores as a 'fat attractor'. It is supposed to have the capability of attracting fat from the digestive system and expelling it from the body so that users can, it is claimed, lose weight without eating less.

GLUCOSAMINE

Glucosamine is a popular alternative medicine used by consumers for the treatment of osteoarthritis. Oral glucosamine is commonly used for the treatment of osteoarthritis. Since glucosamine is a precursor for glycosaminoglycans, which is a major component of joint cartilage, supplemental glucosamine may help to rebuild cartilages. Studies reporting beneficial effects have generally used glucosamine sulfate. A typical dosage of glucosamine salt is 1,500 mg per day.

Glucosamine is also extensively used in veterinary medicine as an unregulated but widely accepted supplement. It is also found to have role in treating immunosupression, autoimmune diseases, osteoporosis, pain, psoriasis, skin rejuvenation, depression, fibromyalgia, athletic injuries, back pain, bleeding esophageal varices (blood vessels in the esophagus), cancer, congestive heart failure, kidney stones, migraine headache, spondylosis deformations and wound healing.

CHONDOSTIN SULFATE

Chondroitin is an ingredient found commonly in dietary supplements used as an alternative medicine to treat osteoarthritis. Also it is approved and regulated as a symptomatic slow-acting drug for this disease in Europe and some other countries. It is commonly sold together with glucosamine. Chonodostin and glucosamine are also used in veterinary medicine. Chondroitin is sometimes used in conjunction and animal studies suggest that chondroitin may increase its efficacy.

COENZYME Q10

Coenzyme Q10 (Co-Ql0) is a very powerful antioxidant. The heart muscle uses Co-Ql0 for energy. It helps sustain heart health and blood pressure.

SQUALENE

Squalene is a natural organic compound originally obtained for commercial purposes primarily from shark liver oil, though there are botanic sources as well, including amaranth seed, rice bran, wheat germ, and olives. Squalane is a saturated form of squalene in which the double bonds have been eliminated by hydrogenation. Because, it is less susceptible to oxidation, it is more commonly used in personal care products than squalene.

CAROTENOIDS

Carotenoids and carotenoproteins are present in salmonoid fish as well as in shellfish. These Carotenoids may be recovered from shellfish processing by-products and used in a variety of applications[3]. In addition, certain carotenoids, such as fucoxanthin occur naturally in seaweeds[1,5]. Fucoxanthin has been shown to have anti-proliferative activity on tumor cells and has also been implicated in having anti-obesity and anti-inflammatory effects. Fucoxanthinol is a known metabolite of fucoxanthin.

VITAMINS

Vitamins A, C and E show antioxidant activity. They all reduce oxidative stress in the body by neutralizing free radicals. Natural Vitamin E is now available to customers. Vitamin E scavenges free radicals that cause oxidation of LDL, thereby maintaining proper LDL cholesterol levels.

MINERALS

Among fish processing by-products, fish bone or skeleton serves as a potential source of calcium which is an essential element for human health. Calcium from fish would be easily absorbed by the body[7]. However, to incorporate fish bone into calcium-fortified foods, it is necessary to first convert it into an edible form by softening its structure. This could be achieved by hot water treatment and heat treatment in an acetic acid solution.

Pepsin-assisted degradation of Alaska Pollock bone in acetic acid solution led to highest degree of hydrolysis and dissolution of both mineral and organic parts of fish bone[8]. The intake of small fish with bones could increase calcium bioavailability[7]. Fish bone contains hydroxyapatite, which unlike other calcium phosphates does not break under physiological conditions and takes part in bone bonding. This property has been exploited for rapid bone repair after major trauma or surgery.

ENZYMES

The aquatic environment contains a wide range of genetic material and hence represents exciting potential for discovering different enzymes[6]. Therefore, much effort has been made to recover and characterize enzymes from fish and aquatic invertebrates[4]. Digestive proteolytic enzymes from stomachless marine fish such as Conner, Crayfish and Puffer appear to inactivate polyphenol oxidase and/or pectin esterase in fruit juices. Successful application of such enzymes has also allowed inactivation of polyphenol oxidase in shrimp processing as an alternate to sulfating[2]. Alkaline phosphates from shrimp may be used in different diagnostic kits and some enzymes may be recovered and used in de-skinning of fish/ squid and cleaning of fish roe for caviar production.

COLLAGEN AND GELATIN

Collagen is an important protein that exists ubiquitously in the body. It is naturally present in high amounts in the skin, bone, joint cartilage, blood vessels, tendons, and teeth and occupies one third of total body protein maintaining youthfulness, health and beauty. Gelatin is a multifunctional peptide obtained from the bone and skin of fish and has food and pharmaceutical applications.

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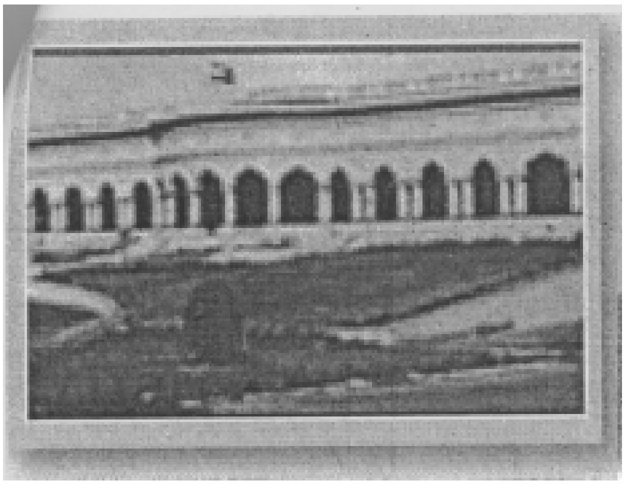

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- **Printing Facility**

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Contact :

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Contact :

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S & T ACROSS THE WORLD

A ROBUST APPROACH FOR PREPARING POLYMER-COATED QUANTUM DOTS MAY FIND USE IN A WIDE RANGE OF APPLICATIONS

Quantum dots (QDs) are tiny crystals of semiconducting material that produce fluorescence. The color or the wavelength of the fluorescence is dependent on the size, shape and composition of QDs. Larger QDs tend to emit light at the red end (longer wavelengths) of the electromagnetic spectrum. As the size of the QDs decrease, so does the wavelength of emitted light. This tunability of emission wavelength is one reason why QDs have become popular for use as fluorescent markers in biological research. For example, scientists can attach QDs to single molecules and cells and track their movements over time using fluorescence microscopy.

Dominik Janczewski, Nikodem Tomczak and Ming-Yong Han at the A*STAR Institute of Materials Research and Engineering and co-workers have now described in Nature Protocols 6, 1546-1553, 2011 a protocol for the preparation of quantum dots coated with an amphiphilic polymer — a polymer that contains both water-attracting and repelling components. "Our aim is to develop a robust approach for the preparation of QD for use as fluorescent tags for bioimaging, sensing and therapeutics," says Han. "The method we have developed is applicable to any nanoparticles, not just QDs."

Most biological applications require the use of QDs that disperse and remain stable in an aqueous solution. Conventional approaches for synthesizing QDs typically endow the QDs with a coating of hydrophobic ligands, which are repelled by water. Although it is possible to exchange the ligands after synthesis, a ligand shell that is exchangeable is, by its very nature, unstable and might result in the release of toxic materials, such as cadmium, into solution.

Instead of exchanging the ligands, an alternative method to make the QDs disperse in water is to coat them with a polymer that has both hydrophilic and hydrophobic parts. This works on the simple principle that like attracts like — or in other words, hydrophobic parts of the polymer attract hydrophobic ligands that stabilize the QDs, and hydrophilic parts of the polymer attract water molecules in solution.

The new protocol describes the procedure in detail and aims to provide the benefits of the research team's experience in QD synthesis to others whose interests might be focused more on applications rather than the development of synthetic methods. The synthesis of the polymer coating allows the incorporation of a wide variety of functional groups. "In the future we hope to work towards image guided therapy," says Han. "QDs could be prepared that not only produce an image of cancer cells, but also release drugs at such a target."

MEMORY FORMATION TRIGGERED BY STEM CELL DEVELOPMENT

Researchers at the RIKEN-MIT Center for Neural Circuit Genetics have discovered an answer to the long-standing mystery of how brain cells can both remember new memories while also maintaining older ones.

They found that specific neurons in a brain region called the dentate gyrus serve distinct roles in memory formation depending on whether the neural stem cells that produced them were of old versus young age.

The study appeared in the March issue of Cell and links the cellular basis of memory formation to the birth of new neurons—a finding that could unlock a new class of drug targets to treat memory disorders.

The findings also suggest that an imbalance between young and old neurons in the brain could disrupt normal memory formation during Post-Traumatic Stress Disorder (PTSD) and aging. "In animals, traumatic experiences and aging often lead to decline of the birth of new neurons in the dentate gyrus. In humans, recent studies found dentate gyrus dysfunction and related memory impairments during normal aging," said the study's senior author Susumu Tonegawa, 1987 Nobel Laureate and Director of the RIKEN-MIT Center.

Other authors include Toshiaki Nakashiba and researchers from the RIKEN-MIT Center and Picower Institute at MIT ; the laboratory of Michael S. Fanselow at the University of California at Los Angeles ; and the laboratory of Chris J. McBain at the National Institute of Child Health and Human Development.

In the study, the authors tested mice in two types of memory processes. Pattern separation is the process by which the brain distinguishes differences between similar events, like remembering two Madeleine cookies with different tastes. In contrast, pattern completion is used to recall detailed content of memories based on limited clues, like recalling who one was with when remembering the taste of the Madeleine cookies.

Pattern separation forms distinct new memories based on differences between experiences; pattern completion retrieves memories by detecting similarities. Individuals with brain injury or trauma may be unable to recall people they see every day. Others with PTSD are unable to forget terrible events. "Impaired pattern separation due to the loss of young neurons may shift the balance in favor of pattern completion, which may underlie recurrent traumatic memory recall observed in PTSD patients," Tonegawa said.

Neuroscientists have long thought these two opposing and potentially competing processes occur in different neural circuits. The dentate gyrus, a structure with remarkable plasticity within the nervous system and its role in conditions from depression to epilepsy to traumatic brain injury ~ was thought to be engaged in pattern separation and the CA3 region in pattern completion. Instead, the MIT researchers found that dentate gyrus neurons may perform pattern separation or completion depending on the age of their cells.

The MIT researchers assessed pattern separation in mice who learned to distinguish between two similar but distinct chambers: one safe and the other associated with an unpleasant foot shock. To test their pattern completion abilities, the mice were given limited cues to escape a maze they had previously learned to negotiate. Normal mice were compared with mice lacking either young neurons or old neurons. The mice exhibited defects in pattern completion or separation depending on which set of neurons was removed.

"By studying mice genetically modified to block neuronal communication from old neurons—or by wiping out their adult-born young neurons—we found that old neurons were dispensable for pattern separation, whereas young neurons were required for it," co-author Toshiaki Nakashiba said. "Our data also demonstrated that mice devoid of old neurons were defective in pattern completion, suggesting that the balance between pattern separation and completion may be altered as a result of loss of old neurons."

COMPUTER SIMULATIONS SHOW HOW KEY PROPERTIES OF NANOWIRES CHANGE AS THE DIAMETER INCREASES

Silicon nanowires are widely recognized as candidates for use in next-generation sensors, battery electrodes and solar cells, and first-principle calculations are an important tool in the development of these applications. Most of the calculations performed so far have only considered nanowires with diameters of less than 4 nanometers, although in practice, nanowire devices typically have much larger diameters.

Man-Fai Ng at the A *STAR Institute of High Performance Computing and co-workers in Singapore have now performed first-principle calculations to simulate the properties of silicon nanowires with diameters of up to 7.3 nanometers. The researchers have examined nanowires ranging from atomic scales (~1 nanometer diameters) to the large-diameter limit, at which point they begin to resemble bulk silicon. The researchers studied the nanowire bandgap—a key parameter that affects both electrical and optical properties—and found that this decreased with increasing diameter. The simulation results were consistent with those obtained from experiment, and the trend was more predictable at larger diameters.

Ng and his co-workers also studied how the 'direct' and 'indirect' bandgaps change when the diameter of the silicon nanowire increases. Bulk silicon has an indirect bandgap, which means that the excitation of a mobile charge carrier must be accompanied by a simultaneous change in its momentum. Because this is relatively unlikely, bulk silicon is a poor absorber and emitter of light. Semiconductors with direct bandgaps, on the other hand, are optically active. The team of reseachers found that silicon nanowire bandgaps assumed indirect characteristics above diameters of around 4 nanometers, and direct characteristics for smaller diameters.

The researchers were also able to calculate the way in which nanowire diameter affects the location of dopant atoms along the nanowire radius. "Foreign atoms like boron are used to increase the density of mobile charges, and their exact location can have a strong effect on nanowire behavior," says Ng. "We showed that boron-dopant atoms are more likely to be found at both the nanowire core and surface in larger-diameter nanowires, and mainly at the surface for smaller diameters."

Ng and his co-workers envision that elucidating the relationship between bandgap and diameter will be useful for the development of nanoscale silicon devices. The work is also significant as a proof of principle. "As computational resources continue to improve and drop in price, the demand for first-principles simulations of large-scale problems will grow. Our work demonstrates the feasibility of addressing one such problem," says Ng.