FOOD AND NUTRITION NEWS

Acharya N.G. Ranga Agricultural University

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ZINC IN HUMAN NUTRITION AND HEALTH

The importance of zinc (Zn) for human health has been recognized in the past 25 years. During this period remarkable progress has been made in the understanding of the clinical, biochemical and immunological aspects of the role of zinc in humans. Zinc has a fundamental role in human metabolism, being essential for the normal functioning of most biochemical pathways.

BIOCHEMICAL FUNCTIONS

The biochemical functions of zinc that determine physiological effects have received extensive investigation. Three different functions namely catalytic, structural and regulatory, define the role of zinc in biology. Zinc is a constituent of more than 200 enzymes. Important catalytic proteins such as carbonic anhydrase, alkaline phosphatase, copper zinc superoxide dismutase, ribonucleotide polymerase and alcohol dehydrogenase are zinc containing enzymes. The structural function of zinc is a rapidly expanding area of biological investigations. Structural roles for zinc exist in metalloenzymes. The zinc finger motif in proteins represents an extremely important structural role. Zinc finger tends to have the following general structure, $-C-X_2-C-X_n-C-X_2-C$ where C designates cystein and X designates other amino acids. This structural arrangement allows zinc to be bound as a tetrahedral complex with four cysteins. Some zinc finger proteins are involved in functions requiring protein-protein interactions, most of which appear to affect cellular differentiation or proliferation, but zinc-finger motifs are also found among signal transduction factors and may play a role in cell adhesion. A third generalised biochemical role for zinc is as a stimulator of transacting factors responsible for regulating gene expression. However, it is diffecult to reconcile these biochemical functions with established physiological effects of zinc function. Zinc deficiency signs are the result of diminution of one or more of the biological functions of zinc.

ZINC CONTENT & BIOAVAILABILITY

Foods vary greatly in their inherent zinc content. Foods of vegetable origin tend to be low in zinc except for the embryo portion of the grains, such as wheat germ. The presence of phytic acid and fibre in plant products is a major factor that limits zinc bioavailability from these sources. It has been argued, on this basis that vegetarians are more likely to have a compromised zinc supply. The richest source of bioavailable zinc are flesh foods.

Many developing countries in their anxiety to augment food production to meet the growing needs of their population, are today resorting to procedures and technologies which, while yielding attractive short term returns, hold out dangerous future possibilities. Zinc deficiency in soils and plant has particularly emerged as a possible major factor in the wake of intensive application of modern agricultural technology. The far reaching implications of such zinc depletion in the soil with respect to human nutrition has however not yet been fully appreciated.

Though zinc deficiency, does not always express itself with clinical symptoms, it may affect a very large segment of world's population, whose staple foods are cereal grains. Zinc nutritional status is highly dependent upon absorption from the diet since body stores of this essential element are quite small. Factors known to promote iron deficiency are shown to have a concomitant negative impact on zinc status. Additional factors that accelerate zinc deficiency are high doses of non heme iron and possibly folate supplements which induce antagonistic interactions with zinc.

PHYSIOLOGICAL EFFECTS

Growth

During periods of rapid growth, the physiological requirements for zinc are increased because zinc has such a critical role in synthesis and metabolism of nucleic acid and proteins. Zinc deficiency has far reaching consequences on the health of vulnerable groups such as infants and children and pregnant and lactating women. In children, zinc deficiency is likely to be an important but often overlooked factor in the aetiology of poor child growth. Additional non-nutritional factors that may exacerbate suboptimal zinc status

in children from developing countries are increased losses of zinc via sweat and skin, blood loss caused by parasites, and possibly excessive gastrointestinal losses during episodes of infectious diarrhoea. Suboptimal zinc status has been associated with disturbances in growth and lean tissue synthesis in children from developing countries. Zinc deficiency may be a factor in impaired cognitive development.

Zinc deficiency during pregnancy may have far reaching consequences for maternal and fetal outcomes and subsequent child survival. Results of several zinc supplementation studies have confirmed that zinc deficiency during pregnancy may cause poor fetal growth and complications during parturition, resulting in increased morbidity and mortality in mothers and neonates.

Antioxidat Role

Evidence suggests that zinc may play a critical role as an antioxidant and may be involved in the antioxidant defense system. The antioxidant properties of zinc have been linked partly to its role as an integral component of copper-zinc superoxide dismutase, as a stabiliser of cell membranes, as a protectant of the sulfhydryl groups of proteins against oxidation and as a competitor with copper and iron for binding to the oxygen ligands, thereby reducing the potential for hydroxyl radical (OH*) production from membrane phospholipid. However, most of these observations have been made in model systems under invitro conditions.

Absorption of Lipid Soluble Vitamins

Recent findings indicate that zinc nutriture is an important determinant of the intestinal absorption of lipid soluble vitamins. The biochemical and pathologic changes observed in zinc deficiency may be associated partly with the impaired absorption and hence, lower nutritional status of vitamins. Latest studies provide the first direct evidence that even marginal zinc deficiency lowers the lymphatic absorption of α tocopherol. The major common cause of the impaired absorption of lipids and lipid soluble vitamins in zinc deficiency is an insufficient supply of phospholipid via the biliary route to enterocyte during chylomicron formation. This inturn, causes a delay (or defect) in chylomicron assembly and hence transport of lipid soluble nutrients from enterocytes via chylomicrons. Zinc deficiency impairs the mobilisation of vitamin A from the liver and may also decrease the absorption of vitamin A and carotene, thereby contributing to vitamin A deficiency.

Immune System

Extensive evidence from early as well as considerable recent literature indicates that zinc deficiency compromises host defense in both humans and animals, leading to increased morbidity and mortality. Experimental studies over the past decade have shown a significant depression in several aspects of T-cell mediated immune activity with dietary zinc deficiency in mice and rats. Recent intervention experiments have suggested that zinc may improve such immune indicators as T-lymphocyte responsiveness in malnourished children. Zinc increases peripheral blood mononuclear cell synthesis of interferon Y, interleukins 1 and 6, tumour necrosis factor a and interleukin 2 receptor. Zinc may be needed for structure and activity of thymulin in plasma that stimulates T-cell development.

Brain Development

Zinc deficiency leads to both primary and secondary alterations in brain development and brain growth. Low availability of zinc to the developing fetus has tremendous impact on the developing brain; one of the most striking alterations is a primary neural tube defect. While many causal relationships are not well established, changes in brain zinc concentrations have been observed in a number of diseases including Alzheimer's disease, Down's syndrome, epilepsy, multiple sclerosis, retinol dystrophy and schizophrenia.

Alcoholism

Abundant evidence from studies on alcoholics and animal models indicates that excessive ethanol consumption is probably the major cause of zinc deficiency in adult Americans. The causes of zinc deficiency during chronic ethanol ingestion include inadequate dietary animal protein sources of zinc; decreased intestinal absorption, and increased urinary excretion related to low serum levels of zinc binding albumin. The potential consequences of zinc deficiency in the setting of chronic alcoholism include acrodermatitis; altered taste and smell, which may contribute to anorexia; night blindness, because zinc is required for synthesis of retinol binding protein and conversion of retinol to retinal; decreased testosterone production; altered cell mediated immunity due to decreased thymulin production, and impaired wound healing.

Others

Experimental zinc deficiency has been reported to cause anorexia among other symptoms. The sense of taste may be altered by zinc deficiency. Carbonic anhydrase IV has been proposed to play a role in the mechanism of taste, and restoration of taste in humans with carbonic anhydrase IV deficiency has been achieved by zinc supplementation. The strongest hypothesis explaining the anorexia associated with zinc deficiency is related to alterations in amino acid metabolism, which may cause changes in concentration of amino acid derived neurotransmitters.

In the light of the reported biochemical functions and physiological effects of zinc on human nutrition and health, dietary diversification/ modification may be used to improve the content and bioavailability of zinc. Pre-requisites for effective dietary diversification/modification include knowledge of dietary patterns, availability and cost of foods, information on food beliefs, preferences and taboos, data on nutrient and antinutrient content of local foods, information on economic and cultural factors and the ability to change attitudes and practices.

NUTRITIONAL STATUS ASSESSMENT

Lack of a specific sensitive biochemical or functional test for zinc

status is a barrier to the study of human zinc nutrition. Measurement of plasma zinc is used most frequently, but it is not ideal because metabolic conditions unrelated to zinc status cause it to decline. Plasma zinc is known to fluctuate with factors like infections and diet and hence is not regarded as a useful marker. Leukocyte zinc levels are less fluctuant and are widely used to assess zinc status in recent years. It was agreed that, of the biochemical indicators available at the moment and except in cases of very severe deficiency, hair zinc concentration in young children is the preferred confirmatory indicator. Hair zinc reflects chronic zinc status over the period of hair growth and is much more stable than plasma zinc. Hair zinc concentrations, unlike serum zinc are not influenced by diurnal or circardian variation or infection. A combination of hair and plasma zinc concentrations could be used because no single specific and sensitive biochemical index of sub-optimal zinc status exists.

RESEARCH HIGHLIGHTS

SOIL ZINC STATUS AFFECTS GRAIN ZINC CONTENT

Zinc deficiency in soils and plants (53% in A.P.; 50% in Punjab & 64% in Haryana) has emerged as a result of the use of modem intensive agricultural technology, not always accompanied by efforts to conserve soil wealth. A study was conducted to ascertain the relation between soil-zinc status and grain (rice and redgram) mineral content. Significant increase in the mean zinc content of rice and redgram samples was observed with increasing soil zinc levels. Soil zinc status was thus positively correlated to zinc content of rice ($r = 0.97^*$) and redgram ($r = 0.94^*$). Grain samples grown from medium soil-zinc status (1.5-3.0 ppm) seemed to be ideal for a balanced trace mineral composition in grain.

Latha Vijayan
V.Vimala

ZINC BIOAVAILABILITY IN RATS FED DIETS FROM ZINC DEFICIENT SOILS

Biological availability of minerals from plant foods is an indispensable nutritional consideration in addition to the amount of mineral in the diet. The mineral content in plant foods is principally a function of that present in soil and thus in turn may influence mineral nutritional status of the population, especially the 'pure' vegetarians. A study was conducted to assess bioavailability of zinc in rats fed rice and red gram obtained from Zn-deficient soils.

The results indicated that the weight gain (58.5 g) in the weanling rats fed with diets from Zn-deficient soils for three weeks was significantly lower than the group fed with diet from Zn-sufficient soils (63.53 g). The apparent zinc absorbed (both total and percent Zn) by the rats fed with rice-redgram diet from Zn-deficient soils was also significantly lower ($P<0.05$) than those fed the diet from Zn-sufficient soils. Similar results were observed with all the other indicators of Zn bioavailability like femur Zn content, serum Zn levels and alkaline phosphatase activity in kidney (Table-1). These results suggest that there is a need for Zn application in soils, not only to improve yield, but also to improve the Zn bioavailability from plant based foods.

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Table 1 : Effect of rice-redgram diet from zinc-deficient and sufficient soils on apparent zinc abosrption and tissue zinc content in rats

Diet	Rice-redgram diet from zinc-deficient soils	Rice-redgram diet from zinc-sufficient soils	Basal[#]
Zinc intake (ug/3days)	517.50[b] ± 64.1	777.16[a] ± 49.46	-
Apparent zinc absorption (ug/3days)	164.66[b] ± 28.9	295.43[a] ± 32.89	-
(% intake)	31.80[b] ± 2.0	38.19[a] ± 6.42	-
Liver zinc (ug/g) +	64.30[a] ± 3.4	68.14[a] ± 3.45	68.5 ± 6.8
Femur zinc (ug/g) +	154.00[b*] ± 4.28	174.15[a*] ± 4.91	186.0 ± 2.7
Serum zinc (ug/ml)	1.05[b*] ± 0.14	1.34[a*] ± 0.21	1.64 ± 0.05
Alkaline phosphatase activity (U/mg protein)	2.32[b*] ± 0.23	2.84[a*] ± 0.37	3.3 ± 0.12

\+ Dry matter basis

a-b Mean values with different superscripts in same row are significantly different ($P<0.05$)

\# Mean value of each group compared with basal values using student's t-test (*, $P<0.05$)

LEVEL AND SOURCE OF PLANT PROTEIN AFFECTS BIOAVAILABILITY OF ZINC

The bioavailability of zinc is affected by a wide number of dietary factors which may either promote or antagonize zinc absorption. Zinc bioavailability from three commonly used plant protein combinations such as rice-redgram, rice-greengram and rice-blackgram at three different protein level - 7,10, & 13 was studied. Results indicated that of the three protein sources, zinc bioavailability in rats was maximum from rice-redgram diet followed by rice-blackgram and rice-greengram. Of the three protein levels studied, zinc bioavailability from 7% protein diet was significantly lower than 10 and 13% protein diets. A tendency towards lower zinc bioavailability was observed when fed with the 13% protein diet, especially with rice-blackgram diets (Fig. 1). These varied effects on zinc bioavailability, may be due to the

variation in phytate content and presence/absence of the husk of whole gram. Results also indicate that zinc bioavailability may be better from rice-pulse diets at 10 percent protein level.

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RELATION BETWEEN SOIL ZINC, DIETARY ZINC AND ZINC NUTRITIONAL STATUS OF HUMANS

Another study was conducted to see the effect of consumption of the staple food grown in zinc deficient soil in East Godavari and Ranga Reddy districts of Andhra Pradesh, on zinc nutritional status of human beings. Thirty families were selected from one village each from an area which has been classified under >75%, 25-50% and 50-75% soil zinc deficiency. Zinc content of the soil, rice (grown in the same soils) and serum (of the people consuming the same rice) of the selected adults was estimated (Table 2). Results show that the soil zinc deficiency has an impact on the zinc content of rice grown in the same soil. Even though there is a significant decrease in the zinc content of the rice grown in severly zinc deficient soils of both the districts, a significant decrease in serum zinc levels was noticed only from the subjects of Ranga Reddy district. No difference in the serum zinc levels of subjects from East Godavari district was observed inspite of severe soil zinc deficiency which may be due to the regular consumption of fish in their diet.

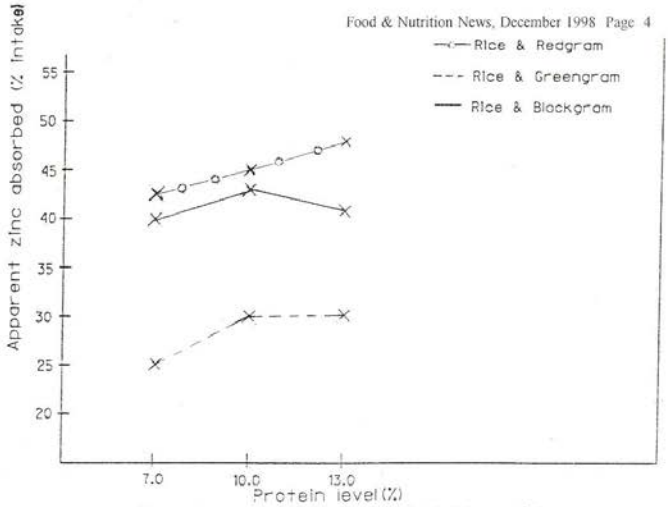

Fig.1 : Apparent zinc absorbed (% intake) in rats fed different plant protein at different protein levels

L.Sunanda
S.Sumathi

Table 2 : Mean zinc content of rice, intake and serum zinc levels

Soil Zn status	Zinc content of rice (mg/100g)		Zinc intake (mg/dl)		Serum zinc levels (µg/dl)	
	East Godavari District	Ranga Reddy District	East Godavari District	Ranga Reddy District	East Godavari District	Ranga Reddy District
Soils with normal zinc level	2.2 ± 1.1	1.9 ± 0.06	12.3 ± 0.06	10.1 ± 1.5	105.0 ± 7.9	105.4 ± 10.5
Moderately zinc deficient soils	1.5 ± 0.5	1.5 ± 0.2	*8.4 ± 1.9	*8.0 ± 0.8	103.5 ± 7.2	101.7 ± 7.7
Severely zinc deficient soils	*1.3 ± 0.2	*1.1 ± 0.1	*7.2 ± 1.8	*6.5 ± 0.2	102.7 ± 2.5	*90.7 ± 3.5

* Significant at 5 percent level

EFFICIENCY OF ZINC ABSORPTION IS RELATED TO ZINC STATUS

The efficiency of zinc absorption is reported to be related to the zinc status, being greater in zinc deficiency and lower under conditions of zinc excess. Studies carried out at this institute have also revealed similar results. It was interesting to note that with addition of the same amount of zinc (as $ZnSO_4$) to both Zn-deficient and Zn-sufficient diets, the increase in percent Zn absorbed by rats was greater (11%) when fed the diet from Zn-deficient soils than the diet from Zn-sufficient soils (7.4%). These results indicate that when additional Zn was added the efficiency of Zn-absorption by rats was greater from Zn-deficient diet than from Zn-sufficient diet.

Latha Vijayan
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INVITRO ZINC BINDING BY CEREAL AND MILLET FIBRE

Cereals and millets form an important source of minerals in Indian diets, especially for people living under poor socio-economic conditions. However, fibre and phytate present in these foods bind with these minerals, thus reducing their bioavailability. Hence a study was conducted to determine the invitro zinc binding capacities of sorghum, ragi, wheat and bajra flour, bran and neutral detergent fibre (NDF) at physiological conditions.

Zinc binding by NDF of these cereals and millets was found to increase with increase in pH from 4.0 to 6.5. The mineral binding capacity of whole

flour was 20-30% less than that of bran and NDF in all the foods, which may be due to the higher concentration of fibre in the bran and NDF.

Dephytinised brans bound more zinc than the native brans indicating that phytate is a major interfering factor for zinc binding. The contribution of fibre bound protein to zinc binding was 9.6% in sorghum and 19% in ragi, where as it has no effect on mineral binding by fibre of wheat and bajra.

R.Mahalakshmi
D.Geetha Rani
S.Sumathi

INVITRO ZINC AVAILABILITY FROM SELECTED CEREALS AND MILLETS

A study was conducted to estimate zinc content and its invitro availability from selected cereals and pulses. Zinc content of cereals was in the range of 2.6-3.1mg/100g and legumes 3.7-4.5mg/100g. Zinc content of cereal and legume combination in the ratio of 540:30 was in the range of 8-25mg. Invitro zinc availability was estimated by calculating phytate:Zn and phytate X Ca:Zn molar ratios and these ratios of raw as well as cooked cereals except ragi and legumes were below critical levels of <10 and <200 respectively. Breakfast items prepared from rice/sorghum and blackgram dhal had molar ratios below critical levels suggested.

R.V.Jamuna Rani
S.Sumathi

ENHANCED ZINC REQUIREMENTS IN RESPIRATORY DISORDERS

Respiratory distress increases the energy, vitamins and mineral requirements of persons by 10%, and use of steroids further increases the requirement. A study conducted on both acute and chronic steriod dependent and non-dependent subjects revealed significantly low serum zinc and high serum calcium levels.

P.N.Padma Kumari
Anurag Chaturvedi

BIOAVAILABILITY OF ZINC FROM RAW AND PROCESSED FOODS

Undetectable & very low amounts of soluble zinc were found in wheat and sorghum respectively despite considerable amounts of total zinc. Whole legumes had better soluble zinc as compared to cereals and millets. Green leafy vegetables contained very high percent of soluble zinc as compared to all the other food stuffs evaluated. Soluble zinc of foods was not found to be influenced by endogenous ascorbic acid, tannin and phytate, when individual foods were considered. However, pooled observations showed a significant positive correlation between phytate and percent soluble zinc. A prediction equation was derived from multiple regression analysis, to calculate percent soluble zinc of foods when ascorbic acid and phytate contents were known.

Different processing techniques such as roasting and cooking were found to enhance the invitro availability of zinc from selected foods, whereas malting of bajra did not show any change in the zinc availability. Germination of whole legumes resulted in increased levels of soluble zinc as compared to ungerminated samples.

Pranathi Das &
K. Chittemma Rao

WORLD FOOD DAY CELEBRATIONS

World Food Day was celebrated on 16th October, 1998, by the Department of Foods & Nutrition at College of Home Science. An essay writing competition was conducted both in English and Telugu to the students of Home Science Faculty on the theme of the day "Women feed the world".

Dr (Mrs) M. Uma Reddy, Associate Professor, welcomed the gathering. Dr (Mrs) Vijaya Khader, Professor & Univ. Head, and Director of Centre of Advanced Studies gave an introductory note on the significance of the day, stressing on the role of women in food production, food security and nutritional security of the family and nation at large. Dr (Mrs) R. Vatsala, Dean of Home Science, A.N.G.R. Agricultural University was the chief guest. In her address to the staff and students, she had enlightened the contribution of women in various agricultural activities, dairy and poultry management and income generating activities. Four prizes were distributed to the winners of the essay writing competition by the chief guest. Dr (Mrs) V.Vimala, Associate Professor, proposed vote of thanks.

BEST TEACHER AWARD

Dr (Mrs) Vijaya Khader, Professor and University Head, and Director, Centre of Advanced Studies, Department of Foods & Nutrition, College of Home Science, Acharya N.G. Ranga Agricultural University, Hyderabad has received State Best Teacher Award for the year 1998, Instituted by Government of Andhra Pradesh for her outstanding contribution in the field of Foods & Nutrition.

BEST POSTER PRESENTATION PRIZE

Dr (Mrs) N.Lakshmi Devi, Asst. Professor, Department of Foods & Nutrition, College of Home Science, ANGRAU has received best poster presentation prize (first) for the research paper entitled *"Vitamin losses in geriatric food supplements sequel to processing"* in the area of *"Health Foods and Nutraceuticals"* at 4th International Food Convention (IFCON-98) held at CFTRI, Mysore from 23-11-98 to 28-11-98. The work has been carried out under the guidance of Dr.(Mrs)Vijaya Khader, Professor and Head of the Department of Foods & Nutrition.

ANNOUNCEMENT

A short course on ***"RECENT ADVANCES IN NUTRITION FOR VULNERABLE GROUPS"*** will be conducted from 4-2-1999 to 23-2-1999, by the Centre of Advanced Studies, Department of Foods & Nutrition, Post Graduate and Research Centre, College of Home Science, ANGR Agricultural University, Hyderabad. Free boarding and lodging will be provided. Nominations of trainees from State Agricultural University teachers may be sent to:

The Director,
Centre of Advanced Studies,
Post Graduate & Research Centre,
ANGR Agricultural University,
Rajendranagar,
HYDERABAD – 500 030.

Last Date for the receipt of Nominations : 31-12-98

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