SPEECH TO NUTRITION SOCIETY OF CANADA

NUTRITIONAL MANAGEMENT - A WEAK LINK IN INTERNATIONAL DEVELOPMENT

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The Napoleonic gastronome The Marquis de Cussy wrote "To dine well needs study and care. It is an art no philosopher need despise". The Marquis was of course speaking hedonistically of what our advertising world would call "satisfying taste sensations".

Whether or not we accept Sir John Boyd Orr's often quoted but as yet unproven statement that two-thirds of the world is malnourished, we can be sure that millions do not dine well either aesthetically or nutritionally.

When they kindly invited me to speak at this Conference, your officers asked me to suggest how the Nutrition Society of Canada might become more effectively involved in programs of international development. My purpose therefore is to describe the potential but as yet unfulfilled international role of the Canadian nutritional scientist, "Nutritional Scientist" being used to embrace all of the interrelated disciplines within the Society.

Though certain important nutritional problems require highly specialized attention, great benefit would result if nutritional scientists would accept a more comprehensive responsibility, a responsibility so far inhibited by what might be termed "Scientific isolationism".

The breadth and scope of the responsibility can be illustrated by the need for at least five categories of research into protein malnutrition:

a) a more precise definition of the Protein Problem: its location, nature, extent, magnitude and cause

b) reliable standards of protein quality and more satisfactory methods of analysis and evaluation

c) the development of improved protein sources which satisfy a defined human need

d) a more comprehensive understanding of plant biochemistry from which to develop high yielding disease-resistant plant protein sources

e) a greater influence in the formulation of national land international agriculture, food and nutrition policies.

It is worth remembering that many nutritional scientists from the less developed world are trained in North America and most of the nutrition literature originates in North America. Consequently what and how you teach and write can profoundly influence the nutritional standards, policies and practices of the less developed world.

Dramatic increases in wheat, rice and maize production offer hope that the world's population: calorie equation can be brought into balance. On the other hand, according to WHO, per capita

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consumption of protein is declining in much of the less developed world. A recent Latin American study indicates that protein malnutrition is an associated cause of 52% of all deaths of children between 1 and 4 years of age and of 55% of all deaths attributable to infectious diseases.

Certain nutritional scientists have debated whether the mental damage sustained by protein deficient infants is or is not reversible. Such debate appears to me irrelevant. Protein malnutrition clearly interferes with the child's ability to learn whatever its ultimate affect upon the size and condition of its brain. People in the poor countries have little opportunity to absorb in later life the learning they are denied in childhood. Furthermore, the malnourished child's susceptibility to infectious disease further retards the learning process.

FAO states that more than 300 million children in the less developed world suffer "grossly retarded growth as a result of malnutrition". Many such impressive global estimates are pronounced by the international agencies, but we lack specific population case studies from which to determine reliably the location, nature, extent, cause and consequence of protein malnutrition. Such data as exists has been largely collected using one of three general methods.

The food balance sheet method translates estimates of staple food supplies into average per capita availability of calories and major nutrients, which, when compared with recommended standards quantify the "nutritional gap". The method, being based upon national or regional averages, tend to overlook deviations caused by uneven distribution, seasonal changes and losses during storage, distribution and preparation. For example the diet of the Sandi, a Sudanese rural people, fluctuates each year between 1900 and 2800 calories and between 33 and 60 grams of protein per day dependent upon the season. Such variation does not appear in food balance sheets.

A second survey method analyses and relates income and food purchases. It can be misleading in that nutrient composition is usually derived from published tables of food analysis which, being averages, rarely take account of regional, seasonal and varietal differences in nutrient content.

The third and probably most reliable technique employs a clinical examination of a representative population sample and records simultaneously their dietary patterns. The method is the most difficult when undertaken under genuine and not simulated conditions. A further constraint is the apparent world-wide shortage of capable people willing to undertake clinical studies among rural communities

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of the less developed world.

The need is indeed urgent for reliable determinations of nutritional well-being among major groups within less developed countries. Most of the countries possess little information upon which to base food and nutrition policies or with which to convince their politicians that food and nutrition policies are even necessary. The Canadian National Nutrition Survey is indeed a welcome initiative. It is to be hoped that the unique competence of Dr. Sabri's team will eventually be made available to the developing world.

Traditionally, understandably and commendably the first objective of international plant breeding research programs is to increase the yield of crop per unit of cultivated land. But many plant scientists now seek to improve the nutritional quality particularly of the protein in many major crops. These plant scientists urgently need and seek the cooperation of nutritional scientists to provide reliable and relevant chemical and biological methods by which to assess protein quality and to determine specific amino acids. The methods need to be simple, rapid, reproducible and ideally non-destructive since the quantity of material available from the plant breeder for analysis and reproduction is severely limited.

Dye binding techniques are rapid and correlate

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well with Kjeldahl determinations provided the grinding of the grain to be analysed is standardized to prevent significant variation in particle size and starch cell damage.

Though ion-exchange chromatography provides probably the best standard method for lysine quicker techniques are required. One useful method records continuously the carbon dioxide liberated by lysine decarboxylase from cereal protein hydrolysates.

The lysine and trytophan content of maize varies more in the endosperm than in the embryo regardless of genetic backgroud. If a small portion of the maize endosperm is removed for analysis with a fine drill, the embryo remains untouched and seeds selected on the basis of dye-binding analysis can be subsequently planted. In the new high lysine varieties of maize lysine to tryptophan is in fairly constant 4:1 ratio. Consequently for rapid screening it is more convenient to determine tryptophan by the rapid Opienska Blauth method using acidified ferric chloride following hydrolysis with papain than to determine lysine by the somewhat tedious pyridine method.

The plant breeder urgently needs more rapid and economical biological methods of protein evaluation. As an alternative to the conventional weanling rat some scientists now favor young chicks or white mice. Of particular interest is the method of Dr. Fred Elliott and his colleagues at Michigan which employs the

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meadow vole (Microtus pennsylvanicus). The meadow vole weighs two to three grams at birth, it reaches sexual maturity in 25 to 35 days, it produces seven litters of 5 or 6 offspring annually and each young vole grows at an average rate of 1 gram per day. Each vole is fed daily six grams of a 7% protein diet and at the end of five days a conventional protein efficiency ratio is determined. Rat assays require 12 grams of food per day for 28 days, pigs need 1,200 grams of food per day for 28 days, pigs need 1,200 grams per day for 45 days. Thus the total food per test animal is 36 grams for the vole, 336 grams for the rat and 54,000 grams for the pig. The preference of the plant breeder for the vole is not surprising.

Even more attractive would be a microbiological method of determining the PER on a few milligrams of endosperm material.

To many of us the literature covering protein biological evaluation appears confused and confusing. Casein and egg yolk are no doubt convenient reference standards but should they be presented as desirable goals for plant breeding and protein supplementation programs? A very eminent plant breeder remarked recently he wished the nutrition guys would tell him clearly what protein standard he ought to be aiming for, casein, egg yolk or some other. I suggested he adopt a new slogan "Plant breeders of the world unite - you have nothing to lose but your yolks".

Using the tools of improved genetic manipulation and biochemical control plant scientists will be able to vary significantly the amino acid composition and protein content of future food grains and grain legumes. The nutritional scientist has the responsibility of defining what is truly desirable in terms of human need. Let us remember that ill considered or unnecessarily difficult nutritional objectives may result in the sacrifice of desirable agronomic properties and an excessively prolonged and costly breeding program.

If one reviews the past 50 years of cereal breeding research, certain facts relevant to our discussion of protein content are apparent:

1) Most of the research was at the genus or species level of botanical classification;
2) Wheat received most attention;
3) The rheological properties of hydrated wheat protein can be influenced by genetic manipulation, but the total protein nitrogen content of wheat appears more greatly influenced by agronomic factors than by genetic background;
4) Though lysine content does vary among wheat varieties and within varieties in different environments, no spectacular high lysine gene has yet been discovered in wheat.

The correlation between lysine content and protein content in wheat is of significant concern to the nutritional scientist and was discovered during

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a recent screening of the world collection of wheat varieties. Lysine expressed as a percentage of total protein content correlates negatively with wheat protein content (R = - 0.63). But lysine expressed as a percentage of the whole grain is in positive correlation with wheat protein (R = 0.83). This illustrates the importance of defining clearly what we mean when we ask the plant breeder to increase the lysine content.

In 1964 Mertz at Purdue University demonstrated that introduction of the opague-2 gene will double the lysine and tryptophan contents of maize endosperm protein. Both weanling pigs and hogs weighing more than 125 pounds are found to gain weight as quickly on a pure opaque-2 corn diet as animals fed on normal corn supplemented with soya bean meal. Opaque-2 corn meal was found to be biologically equal to skim milk when fed isonitrogenously in the diet of South American infants.

The Floury-2 gene in maize presents an interesting problem for the nutritional scientist. Many strains containing this gene are by analysis equivalent in lysine and tryptophan but in protein efficiency ratio significantly inferior to opaque-2 strains. The reason for this biological anomaly has not yet been satisfactorily explained.

High lysine corn varieties present many problems for the plant scientist to wrestle with. In addition

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to lower yields and greater susceptibility to certain diseases and parasites the opaque-2 strains are unfamiliar in appearance and unacceptable in endosperm properties to those major consumers of Latin America who are accustomed to flint type corn. Nevertheless, if nutritional and plant scientists cooperate, these difficulties can be overcome and farmers will be provided with a whole new generation of corn varieties suited to a wide range of environments and possessing high protein of good biological value and properties satisfactory both to the agronomist and the consumer.

Though the amino acid profile of rice is superior to that of conventional wheat and maize the protein content averages less than 7%. During screening of more than 8,000 varieties the International Rice Research Institute discovered a few which in succeeding generations maintained a significantly higher than average protein content. These were back crossed with high yielding varieties such as the famous IR 8 and from these have been derived a number of lines now in the F5 plant generation which demonstrate good plant characteristics, protein contents between 10 and 13 percent, lysine up to 5% of the protein and PERs equivalent to casein.

Triticale is an artificial genus created by plant scientists hopefully to outperform traditional cereal crops under a wide range of ecological conditions.

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When a cross between wheat and rye is made the F1 plant is normally sterile. It was discovered in 1937 that when an F1 seedling was treated with colchicine its chromosone makeup was doubled and the resultant triticale plant was partially fertile. This discovery opened the door to the genetic improvement which has since taken place.

Though this new man-made cereal is still under development, certain triticale strains derived from a promiscuous cross known as Armadillo display remarkable nutritional characteristics. The range of protein and lysine contents among the various derived strains of triticale are significantly wider than one finds among varieties of either wheat or rye. Most important, among the triticale strains are some high in both lysine and protein and which demonstrate extraordinarily high biological values. Strains have been reported containing more than 16% protein with lysine at 3.7% of protein and 0.6% of the total grain. Protein efficiency ratios as determined with the meadow vole have exceeded casein and in one reported instance even egg yolk.

Millet and sorghum, though of immense importance as food grains in the arid regions of Africa and Asia, have received less attention from the plant breeder and nutritional scientist than have wheat, maize and rice. Little is known about the genetic factors which

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affect protein quality in sorghum but recent research has revealed some intriguing nutritional problems. During a large screening test with week old chicks it was found that lysine retention varied among sorghum samples from below 50 to 98 percent. Using the nylon bag technique with fistulated steers, dry matter disappearance among 1,000 samples ranged from 17 to more than 80 percent. Rat feeding studies on sorghums ranging from 6 to 17 percent protein varied in digestibility from 37 to 86 percent. It is known that the biological value of sorghum is influenced by tannins present and can be improved by flaking and steam processing. Nevertheless, much more needs to be learned about the variability in biological value and digestibility of this important cereal crop.

A brief word about a much neglected family, the grain legumes. Grain legumes contain two to three times the protein content of cereal grains and being high in lysine and threonine their amino acid profiles are largely complementary to cereal protein. Throughout the less developed world the grain legumes are normally eaten in combination with cereals. Many varieties of Phaseolus are grown and eaten together with corn in Latin America; chick peas, mung beans, lentils and soya beans are served concomitantly with rice in Asia, and cow peas combined with millet and sorghum, form the staple diet of many Sub-Saharan Africans.

The significant variation in protein content and amino acid profile among and within varieties, the high incidence of toxic compounds and anti-metabolites among the grain legumes demonstrate the scope for profitable collaboration between nutritional and plant scientists. Comparison of electrophoretic patterns has turned up several oriental soya bean varieties which are distinctly different genotypes and contain significantly lower levels of trypsin inhibitor than varieties customarily grown in North America.

If widespread protein malnutrition is significantly suppressed it will be largely through the development of improved food crops. But if we are to avoid a total reliance upon empiricism we need a greater knowledge than we possess of plant biochemistry, of the physiological function of chemical substances which influence germination and plant growth, of the mechanism of nitrogen uptake and translocation, and the means of controlling disease and infestation by biochemically induced resistance. The work of WAIN with VIOLA XANTHIN and related alkaloids which retard plant growth, and with the specific herbicide SIMAZINE, and with the naturally occuring antifungal antibiotic WYERONE illustrate the potential contribution of the biochemist to plant breeding.

Nutritional scientists might also give their attention to improving protein by reducing demonstrable

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losses and by fortification of staple foods. Post harvest losses expressed in terms of the percentage by weight or volume destroyed by infestation fails to take full account of the nutritional implications. Many insects prefer protein to starch and therefore preferentially attack the protein-rich fractions of stored grains. It is well documented that certain micro-fungi attack specific amino acids such as methionine which is first limiting in many grain legumes.

More opportunities exist for protein fortification of staple foods than have as yet been explored or exploited. Bread consumption is increasing throughout Africa at between 8 and 10 percent per year. A recent survey in India predicts a 13.2% annual compound growth rate in bread consumption over the next five years.

The fortification of bread is a convenient example by which to illustrate the opportunities and difficulties of improving the quality of cereal proteins.

Greater attention could profitably be given to fortification with selected proteins of the cereal grains. The flour mills in many developing countries export all of their wheat bran and germ to the animal feed industries of more prosperous nations. Yet recent research has demonstrated the technological feasibility of producing high lysine, high protein concentrates by selective milling of wheat bran and germ.

Using novel methods of bread making, high protein legume and oilseed flours can be combined with wheat and other cereals to produce cheap nutritious bread.

Much has been written about fortification with amino acids. Synthetic lysine and threonine can be considered as bread supplements only when they can be satisfactorily manufactured and distributed among many small mills and bakeries within the less developed bread eating countries.

High quality fish protein concentrate is nutritionally attractive on account of its high protein and lysine content. It is probable that its reportedly adverse influence upon bread volume, color and flavour can be overcome by improved technology. But whether it can be produced consistently, economically and in adequate quantity within the less developed countries has yet to be demonstrated.

Single cell protein, the protein derived from micro-organisms, appears to be exciting exceptional interest among Canadian food scientists, probably based upon the knowledge that organisms will grow upon virtually any waste or cheap carbohydrate or hydrocarbon source. Since yeast is one of its four basic ingredients, bread would appear to be an ideal vehicle for single cell protein fortification.

But in addition to potential toxic hazards, many micro-organisms possess indigestible cell walls and contain high levels of nucleic acids, excessive intakes of which can cause gout and the formation of uric acid

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stones in the kidney. The processing necessary to remove the cell wall and nucleic acid material would undoubtedly raise the cost of production.

I would advance a more fundamental objection to the wide spread acceptance of single cell protein in the less developed world. To be economical, single cell protein must be made in large factories using continuous fermentation and concentration procedures. Such factories employ a very low labour input. Agriculture in the less developed world is both the source of nutritional well being and the principal means of livelihood. Consequently I would prefer to see our development resources devoted to improving and protecting cereal grains and grain legumes in the tropics than to the construction of microbial protein factories.

I have just finished a review of some 300 papers dealing with protein fortification of bread. These fall into two classes:

(a) those by cereal technologists which describe how added protein affects the volume, crumb texture and color of bread;

(b) those by nutritional scientists which report the influence of added protein upon biological value, in most cases expressed as the Protein Efficiency Ratio.

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The latter results demonstrate an almost perfect correlation between PER and the amount of lysine added to the bread in the protein supplement. In very few instances is any reference made to the total nutritional benefit of the added protein, and the relative cost is almost completely ignored. These points can be best illustrated by the slide which shows:

(a) the amount of supplement to contribute 0.25% of lysine;

(b) the amount of additional protein added;

(c) the cost of the addition.

At first glance, synthetic lysine appears to offer the best value for money. But all of the other protein sources add not only lysine but additional protein, calories and other nutrients. Furthermore, all but lysine provide water-binding solids and therefore increase the total quantity of bread produced. 9.6 lb. of milk powder or 8 lb. of soya would increase the bread yield by 10%; 23.6 lb. of wheat protein concentrate by close to 30%. Consequently I would urge that when nutritional scientists report on protein fortification they quote not only PERs, but evaluate the total consequence of the added protein.

Finally, may I refer briefly to what I term: "total nutrition management". International development cannot be defined solely in terms of economic growth. It is above all concerned with the quality of human life. But many politicians think only in economic terms and regard food and agriculture as of economic consequence but malnutrition as a matter for social welfare. Food and nutritional scientists need to demonstrate to policicians that economic growth depends upon adequate health, welfare and nutrition and that malnutrition and the consequent loss in human efficiency and productivity represent a significant drain upon the national economy. Food and agriculture, and nutritional well-being, are in fact indivisible. Food is for people and the protein gap exists not in the farmers field but in the people's stomach.

There is evidence to indicate that good health derived from a satisfactory diet may influence family size. A recent study of vital statistics in India suggests that rural families must bear more than six children to ensure the survival of one son to the father's 65th birthday. The average number of births in India per couple is about 6.5 which indicates that parents deliberately produce the size of family which empirically they have discovered will ensure security in their old age.

As a nation develops economically and technologically the quality of its work force is more important than sheer physical output. Human energy tends to be replaced by machines and more highly refined human skills. If its mental and educational development is impaired during childhood the efficiency of the agricultural and industrial labour force will prove inadequate to manage the new technologies essential to national growth.

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It is interesting to observe in countries which pay little attention to the nutritional well being of urban and rural working populations that the army is invariably well fed. It would appear to be time for the nutritional scientist to persuade the politician that the battles for men's survival are fought and won not on the playing fields of Eton but in the paddy, wheat and corn fields of the rural countryside.

In October of this year at MIT there will be an important conference dealing with food and nutrition in national policy planning. I would strongly urge that the Nutrition Society of Canada be well represented.

The objectives of international development is to create a good quality of life for all people. For most people in the less developed world this means first a better diet. To this end more nutritional scientists must address themselves to these broader issues of nutrition management and policy making which I have so sketchily reviewed. The responsibility lies squarely with the nutritional scientist to convince national and international policy makers that "for a nation to dine well needs study and care. It is an art which no politician need despise".