Non-nutrient food functions

by Mark L Wahlqvist

Food functions depend on nutrients and non-nutrient compounds, and this broader concept of food offers opportunities for food technology developments.

Foods that characterise the various food cultures of the world subserve various social, behavioural, nutritional (related to agreed nutrients) and other physiological needs. To this extent the enhancement of any one of these functions in a food may merit identification and their awareness has led to the emergence of a new classification of foods as "functional".

Mostly such foods are fortified with various nutrients. But the potential for novel physico-chemical development of foods and the manipulation of composition as it relates to non-nutrients of biological importance may be just as great, if not greater. It may be better to talk about "designer foods" rather than "functional foods" when these changes are made.

For this to occur, an agreement about what constitutes basic commodities, traditional recipes and restoration rather than fortification or "property enhancement" would be required. Such designer foods, if used for frankly medical purposes, ought then to be designated as medical foods. The best examples of such foods are formula feeds for nutrition support of various kinds – for wasted patients, obese patients, and those with various inherited disorders of metabolism.

In some cultures, traditional foods may also be medical foods (for example ginseng tea in Korea). Here food law or regulation would need to acknowledge the lack of foundry in relation to medical use and/or medical supervision.

There is increasing evidence, for physiological and pathophysiological reasons, that food needs to be considered as such and not only as nutrients.

One of the more important lines of evidence for this view comes from the work on food memory by Taketoshi Ono and his colleagues. This work, in Japanese primates, has painstakingly revealed that there are food specific neurons in the central nervous system, particularly in the amygdalar and lateral hypothalamic neurons.

In the first place, the amygdalar neurons provide a mechanism for the distinction between food and non-food. Then, it would appear from now extensive work of this group, that the sum total of the visual, tactile, smell, taste, texture and other inputs allow the recruitment of food-specific neurons. It is also possible that these neurons may be extinguished. This central mechanism presumably accounts for our ability to make fine distinctions between different cheeses or different wines and also what is biologically, organoleptically and probably emotionally, acceptable as food.

A convincing example has come from the study of neuronal recognition of foods not ordinarily accessible to wild Japanese monkeys; these creatures ordinarily do not have access to bananas, but feeding them leads to the development of banana-specific memory, which can, however, be extinguished by the use of combinations such as bananas and salt (personal communication).

In the grey area between food and medicine, which some of us are describing as "medical foods", this knowledge of primate physiology will assume increasing importance.

Non-nutrients in food.

Texture and food physico-chemistry. For the same chemical composition, food may have a wide range of physico-chemical properties. These may be evidenced in, for example, particle size and viscosity. To some extent, the ability for food to assume these wide-ranging characteristics depends on the presence of certain components, such as dietary fibre, its amount and type. But the presence of the chemical components of dietary fibre does not itself ensure these characteristics. This is nowhere more in evidence than where fibre is extracted from plant foods and reintroduced at some other point in the food chain, such as with wheat bran.

Colour. The colours in food may themselves have biological effects aside from creating interest in food, yet ordinarily they are dismissed as nutritionally irrelevant.

The brown products of the Maillard reaction are, of course, sugar-amino acid complexes and have the potential for physiological effects as recent data suggest. Again, lycopene, which accounts for most of the colour of tomatoes, has been largely ignored from a nutritional point of view because it is not a vitamin A precursor, although it is a carotenoid. However, recent evidence indicates that it is a powerful agent to trap singlet oxygen, potentially damaging to tissues.

The flavonoids in various fruits and vegetables are also responsible for some of their colour and their biological actions include ones which are oestrogen-like. Even more recently, the anthocyanins, which account for colour in berry fruits, have been shown to have LDL-cholesterol lowering properties.

Taste and smell. The food chemistry that accounts for taste and smell depends on literally hundreds of compounds. For example, the flavours of various fruits usually depend on a dozen or more compounds. For the olfactory contribution to flavour alone, this means that there are many different receptors in the olfactory apparatus. It seems unlikely that these compounds, in the gut or post-absorption, will not find, to some extent, representation in receptors elsewhere than in the olfactory apparatus.

Of course, the teleological argument that they will then have physiological

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effects elsewhere does not necessarily follow, but the possibility certainly exists. A great deal more work is justified in this area.

Coffee is a good example of the extent to which a range of volatile constituents can form during progressive roasting. These constituents of the aroma of coffee include a range of furfuryl and pyrrole-type compounds. It is therefore of interest that, among these compounds in coffee itself or its aroma, there are those which are opiate receptor ligands. Exactly what this means in terms of human nutritional physiology remains uncertain.

It has also become clear that there is a lipid-rich coffee fraction, not including caffeine, which will elevate serum LDL cholesterol and triglycerides in humans

Compounds of physiological importance. These can be defined chemically or physiologically.

Defined chemically. While by no means exhaustive, the examples given in Table 1 and the source references will provide some insight into the extent to which these compounds have been neglected and might be of importance in human physiology.

Defined physiologically. Likewise, Table 2 is an effort to categorise non-nutrient compounds in food from the point of view of human physiological effects. It is another matter, of course, what the plant physiology of substances in food is.

One of the most interesting classes of physiologically active compounds is the phyto-oestrogens. Work recently from our group indicates that foods such as soya flour, clover sprouts, and linseed seeds significantly improve vaginal cytology and decrease serum FSH levels, in post-menopausal women, in much the same way as hormone replacement therapy.

The agent tamoxifen does much the same and yet it is actually anti-oestrogenic at the breast and is used in the management of breast cancer. Thus, compounds found in plants with oestrogen activities may have a hierarchy of oestrogenic effects at different tissues ranging from the anti-oestrogenic to the pro-oestrogenic.

A particularly important question is what trace compounds will do to bone and what they do to cardiovascular risk. In the meantime, it is noteworthy that the work of Lee and colleagues in Singaporean women shows that soya products (this will be mainly of the tofu kind) appear to be protective against breast cancer in women.

However, oestrogenic effects from foods may be achieved not only by way of oestrogenic compounds themselves, but by the stimulation or alteration of endogenous oestrogen secretions. It is therefore interesting that amounts of boron given to post-menopausal women in quantities similar to that obtainable from fruits like apples (about 3mg) significantly increase serum oestradiol, especially where magnesium intake is low. At the same time, women fed with these amounts of boron decrease their urinary calcium excretion.

Non-nutrients of physiological importance defined chemically
Ajoene/Allicin
Caffeine
Coumestans
Flavonoids
Salicylates
Saponins
L-Dopa
Capsaicins
Lectins
Trace elements
Peptides
Novel amino acids and fatty acids
Peppermint oils

Table 1.

Non-nutrients defined physiologically
Opioids or exorphins
Other neuro-endocrine factors
Digestive enzyme inhibitors
Glycaemia altering
Lipid lowering
Satiating
Thermogenic
Behaviour modifying

Table 2.

There are also a number of dietary factors that affect lipoproteins other than dietary fat and these include: energy balance, fat -amount and quality, cholesterol, protein, dietary fibre (of various types), alcohol, coffee factor, and other non-nutrients (allicin, anthocyanins, saponins)

Although reduction in saturated fat intake is of paramount importance in dealing with abnormal serum lipoproteins in individuals at risk of coronary heart disease, a broader and more integrated nutritional approach to food from the point of view of not only lipoprotein control, but macrovascular disease protection, is highly desirable.

Thermogenic effects have been seen with the combination of mustard and chilli at breakfast where the increment in the thermogenic response to a meal attributable to these spices can be almost double.

Potential therapeutic or pharamcological properties. From what has been documented already, it will be clear that non-nutrient components of food have potential therapeutic or pharmacological properties. This might apply in the management or, indeed, prevention of obesity, lipid disorders and diabetes, Parkinsonism, gut motility disorders and motion sickness.

Recent data from our own group indicate that a broad bean extract, in conjunction with carbidopa (an enzyme inhibitor that decreases the loss of L-dopa) is at least as useful as the combination of carbidopa and L-dopa in commercial pharmaceutical preparations. Moreover, there is a prolongation of the therapeutic effective period in those with Parkinsonian motor fluctuations with the oral broad bean mixture as a single meal in the morning.

Of considerable interest is the way in which ginger preparations have been used in both traditional oriental medicine and are used in contemporary Western cancer medicine for their anti-nauseant properties. A study in which ginger powder (derived from *zingiber officinale*) was compared with placebo and dimenhydrinate as an anti-motion sickness agent revealed it to be superior to dimenhydrinate.

The dichotomy in occidental thought between food and medicine is less in evidence, if at all, in oriental thought. If this is appreciated, the advent of a new dynamic in Japanese food technology, which is leading to the production of an array of so-called functional foods is much more understandable. It may also help food legislators in countries like Australia to deal more effectively with the positioning of such foods, however they might be described, as "food analogues", "functional foods" or "medical foods".

The need for food technology to take account of the broad nutritional dimensions of food in the development of designer foods or food analogues is evident through a consideration of the non-nutrient components of food. There are also opportunities for extended therapeutic uses over and above those of the present.

One thing is clear, namely that the state of food and nutrition science is one of increasing sophistication, stimulating new product development. Awareness of the non-nutrient composition and function of food is an imperative for nutritional literacy of a new order – one that must exceed what our traditional cultures have taught us. Not to be literate in this way will stratify society in new ways, as has computer and informatics literacy, but this time with implications for personal and social health. □

Literature references (50) supportive of this article are available from the author at Monash Medical Centre, 246 Clayton Road, Melbourne, Victoria 3168, Australia.

FOOD TECHNOLOGY INTERNATIONAL
EUROPE
1994

Editor: Alan Turner

Cover: Karlshamns, a Swedish-based specialist in the research, development and production of vegetable-based speciality oils and fats, and other lipid-derived products, conducts Karlshamns Oils & Fats Academy. The academy offers customer-designed training programmes for the food industry and also sponsors technical seminars.

Published by Sterling Publications Limited – a subsidiary of Sterling Publishing Group PLC
Garfield House, 86-88 Edgware Road, London W2 2YW. Tel: 071-915 9600

ABC ANNUALS

ISSN 0950 4435

Printed in Singapore and Malaysia by Khai Wah-Ferco Pte Limited