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CHALLENGES IN FORMULATING FOODS TO SPECIFIC NUTRITIONAL PROFILES

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Abstract
There is currently enormous pressure on food companies to improve the nutritional profile of their products and this area was very much a "hot topic" at the 18th International Congress of Nutrition held in Durban, South Africa in September 2005. Much of this pressure comes from consumer groups and others within the nutritional activist community who have very little knowledge of food science & technology and thus lack understanding of the practical technical and cost implications of formulating foods to give improved nutritional profiles. It was clear from observations at the Durban Congress that many of the more vociferous nutritionists adopt a highly simplistic view of what can and cannot be done in this area and interpret any lack of progress as being driven exclusively by financial considerations, often advocating unrealistic regulatory measures to force food companies to amend nutritional profiles. While financial considerations are indeed highly relevant, technical constraints usually have a greater role to play in determining the feasibility or otherwise of developing particular nutritional profiles. This paper will therefore outline some of the practical considerations that have to be considered when attempting to either develop a new product with a particular nutritional profile or reformulate an existing product with the objective of imparting a more nutritionally desirable profile. Aspects such as availability and cost of ingredients, ease of processing, impact on shelf life and product safety will be considered. It will be demonstrated that, at least in the context of current food science and technology knowledge, it will be difficult to meet many of the likely expectations, from both nutritional activists and food companies anxious to present a more nutritionally favourable face to consumers. Ways in which a greater sense of realism can be effectively communicated in this regard by the food science and technology community will be discussed.

Introduction

The food science and technology communities are currently facing the huge challenge posed by the global obesity issue. It is an issue that confronts all food companies and both their technical and commercial functions. It is widely acknowledged that the problem is a multi-faceted one encompassing not only eating practices and food composition but also issues relating to marketing practices and broader societal changes such as reduced physical activity and the tendency for developing countries to progressively adopt westernised lifestyles and associated dietary practices.

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However it is common for the nutritional quality of processed foods to be deemed as the principle cause of the obesity issue by the more outspoken members of the nutritional activist community.

This phenomenon was strongly in evidence at the 18th International Congress of Nutrition that was held in Durban, South Africa in September 2005. Numerous speakers criticised the nutritional quality of processed foods and called for far reaching measures to improve the quality of dietary intake. Derek Yach of the Yale School of Public Health stated: "…we face an intellectual challenge of developing the optimal mix of regulatory, fiscal and other policy measures that would make markets work more effectively to promote chronic disease prevention"(Yach, 2005). Marion Nestle of the University of New York, a well-known critic of the food industry, called for "…policy changes that promote more healthful food choices and that also make it easier for people to exercise informed personal responsibility"(Nestle, 2005). These statements give a broad perspective of the issues at stake but somewhat alarmingly do not appear to exclude endorsement of a more heavy-handed and prescriptive regulatory approach. In a similar vein, Geoffrey Cannon of the World Health Policy Forum commented that: "…nutrition advice has been distorted by trade groups protecting the interests of milk, baked goods, soft drinks, sugar and salt, with massive budgets spent on lobbying legislators; and also by national and global nutrition foundations controlled or influenced by those sectors of industry whose products are energy-dense, high in fat, sugar or salt". He also states, with seemingly great indignation, that "…industry now lists some chemical constituents on standardised 'nutrition' labels"(Cannon, 2005).

While respecting the passion of these critics and their genuine desire to highlight a major issue that affects all of us in the food community, what was disappointing in all the pronouncements made in Durban was the lack of any practical science driven solutions or understanding of consumer behaviour. One certainly questions whether any of the these vociferous critics has ever been exposed to practical food product development or sat in a market research session and heard consumers stating that they will not buy the latest prospective low kilojoule or reduced sugar offering because it compares unfavourably to its standard counterpart in terms of taste or texture and, for good measure, stating that they will not pay a cost premium for it even if taste and texture were acceptable. There are however some signs of realism from a perhaps unexpected quarter. In a recent report on nutritional practices in large food companies, the Centre for Food Policy at City University in London states "…some companies are reviewing their product ranges in the light of the new heath agenda, which is welcome. The majority are not". They however temper this by also stating "…the reformulation of food products without endangering market share is a real difficulty but should not be an excuse for inaction"(Lang et al 2006).
These latter sentiments put a more realistic perspective to the challenges facing anyone attempting to formulate products with desirable nutritional profiles or reformulate existing products to improve their nutritional quality. It is however important to take a realistic view of what can be achieved within the constraints of current food science and technology capability.

The Practical Challenges
Typically, the areas in which it may be possible for the food scientist or technologist to enhance the nutritional characteristics of food products are:

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•Kilojoule reduction
•Fat reduction
•Sucrose reduction
•Salt reduction
•Modification of fat components
•Modification of carbohydrate components
•Micronutrient fortification
•Macronutrient fortification

Each of these areas brings with it practical challenges in terms of the impact of nutritional modification on:

•Palatability and consumer acceptability
•Cost of the product
•Factors influencing product safety
•Shelf life
•Processing characteristics that can in turn affect product cost

The resulting matrix is a complex one and extensive information is available on each and every one of the permutations of individual nutritional enhancement opportunities versus the effect of each of these on product characteristics. However it is desirable that food scientists and technologists have at their disposal a broad-based summary of these that can be used as a "toolkit" when communicating with nutritionists and other stakeholders in the food community who may lack detailed understanding of the practical implications of nutritional enhancement.

Kilojoule Reduction
The most common means of achieving kilojoule reduction are:

- Reducing fat content with corresponding increase in other macronutrients
- Adding water to the product
- Adding air to the product

Each of these approaches presents particular challenges. Fat has a strong tendency to enhance palatability by improving texture and mouthfeel of products and palatability will tend to decrease if it is removed, however cost and shelf life may be improved. Addition of water to the product is a simplistic but sometimes effective approach however the increased moisture content of the product will almost certainly affect both shelf life and product safety, the latter due to the increased water activity and greater potential for microbiological spoilage. An even more simplistic approach is to incorporate gas into the product by means of suitable aeration technology – this will not reduce the energy content of the product but, if correctly applied, can reduce serving weight while still imparting the same product volume. Apart from the ethics of this approach, it is a technology with only limited application, often requiring sophisticated technology and complex processing that can in turn impact on product stability.

Broadly speaking it can be stated that kilojoule reduction will normally result in products with lower consumer acceptance, equivalent cost to standard products but potentially reduced safety and shelf life.

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Fat Reduction
The most common means of achieving fat reduction are:
•Replace with protein
•Replace with carbohydrate
•Replace with non-metabolised lipid
•Replace with water
•Replace with air

The substitution of fat with protein and carbohydrate based "fat replacers" has been a major area of activity for the food ingredients industry over the last fifteen years, largely brought about by the need for fat and kilojoule reduction. Results have been mixed with a fair degree of success achieved in areas such as baked goods and certain categories of dairy products. However the functional characteristics of fat are such that replacement of fat with protein and carbohydrate in those products where its physical characteristics contribute fundamentally to the texture and processing characteristics of the product, such as fried products, biscuits and chocolate, is not technically feasible. Furthermore the use of carbohydrate and protein fat replacers often also entails the addition of moisture to the product, which may be acceptable in products such as acidic dairy products or short shelf life baked goods but will not be acceptable in low moisture products such as dry powders. Cost of the replacers is often also higher than that of the fats being replaced.

Much was expected of the non-metabolised lipid fat replacers developed in recent years and in particular Olestra. However consumer acceptance has been poor, the issue of whether or not their use results in undesirable side effects for the consumer remain contentious and regulatory and cost issues remain a barrier. While their functionality is generally good and product safety and shelf life are acceptable, their usage remains limited.
In summary, fat replacement is a well-established technology but cost and functionality limit its potential application.

Sucrose Reduction
The most common means of achieving sucrose reduction are:
•Use of artificial sweeteners
•Use of other carbohydrates of similar functionality

The use of artificial sweeteners is so widespread that comment is almost superfluous. However their use is effectively limited to applications where sucrose functionality is not an issue or where its functionality can be simulated by such applications as the use of gums to impart sucrose like mouthfeel in beverages. Certain artificial sweeteners are also becoming unacceptable to consumers in terms of their perceived safety, may be more expensive than sucrose in certain markets in terms of cost per unit of sweetening power and may also affect product shelf life.

The use of alternative carbohydrate based sweeteners is also a complex matrix. If kilojoule reduction is also desired, one is limited to specialised materials such as polydextrose, which has good functionality but is expensive and can influence processing characteristics. If kilojoule reduction is not required, sucrose replacement with specialised polyols may be possible but comes at the expense of higher cost and

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potential impact on processing and finished product characteristics. High fructose corn syrup is an obvious further alternative but its applications are largely limited to liquid applications.

Sucrose reduction is thus an area where considerable success can be achieved but with cost and functional constraints in many applications.

Salt Reduction

The most common means of achieving salt reduction are:

- Use of salt replacers
- Enhancement of flavour by other formulation modifications

It is well known that it has to date proved virtually impossible to match the flavour characteristics of salt, both in absolute terms and also in terms of its ability to enhance other flavours within a food system. The use of potassium chloride is well established but its flavour is not always acceptable and often imparts bitter notes to the food in which it is used, as well as being significantly more expensive than salt. More fundamental modifications to flavour systems are also possible but invariably require more complex and expensive ingredients.

The challenges in this field are such that, if salt reduction is desired, it is probably a more desirable solution to progressively reduce the amount of salt in processed food in stages and educating the consumer to accept lower salt levels.

Modification of Fat Composition

The most common activities in this area are:

- Reduction of saturated fat
- Reduction or removal of trans fat
- Increase in mono-unsaturated and poly-unsaturated fats

An enormous amount of technical resource has gone into this area in recent years and considerable successes have been achieved. Some of the side effects have however been increased cost (one multinational is on record as stating that implementation of a trans-fat free policy in their North American operation is costing them over $10m annually in increased raw material costs). Shelf life has also been impacted to some extent by the use of more highly unsaturated fats with reduced resistance to oxidative rancidity. It is also of concern that in some cases trans fats have been partially replaced by saturated fats in order to retain essential functional characteristics in complex fat blends. However exciting developments in plant breeding, using both traditional and genetic modification techniques offer the possibility of plant oils with enhanced fatty acid compositions, minimising the need for hydrogenation. It should however be remembered that replacement of saturated fat in those products where the fats can only be of animal origin is simply impossible. It may be that genetic modification can in the longer term have an impact in this area but such are the ethical issues relating to the potential genetic modification of animals that it is difficult to see any likelihood of progress in this area for the foreseeable future.

Fat composition modification is thus one of the most promising areas for nutritional enhancement, with sizeable but by no means insurmountable challenges.

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Carbohydrate Composition Modification

The most common activities in this area are:

•Reduction in simple carbohydrate (mono & disaccharides)
•Increases in polysaccharides and fibre
•Reduction in sucrose

There has been considerable activity in this area in recent years due to efforts to reduce sucrose contents and the greater awareness of the role of fibre in nutrition as well as the emergence of the glycemic index as a measure used to assess the nutritional desirability of foods. Putting aside sucrose reduction, which has already been discussed, the challenges in this area relate largely to the impact of poly-saccharide and fibre inclusion in products with high levels of carbohydrate. While much effort has been put into the development of palatable high fibre inclusions by the food ingredients industry, it has to be said that results have been mixed.

Palatability is the main issue with addition of high fibre ingredients often resulting in flavour and texture characteristics unacceptable to the consumer. Mention should however be made of the successes achieved by the starch industry in using plant breeding to develop specialty resistant starches that impart fibre like characteristics to baked goods. While modifications of this sort do not typically impact on product safety or shelf life, both cost and processing requirements can be negatively affected.

Carbohydrate composition modification is thus generally less advanced than its counterpart in fat composition and arguably presents greater challenges in terms of cost and technical feasibiity.

Fortification

Having considered the modification of existing nutritional characteristics as a means of nutritional enhancement, it is appropriate here to also consider the other major field of nutritional enhancement, namely that of food fortification. While this has traditionally been primarily considered as a means of overcoming nutritional deficiencies in both developed and less sophisticated parts of the world, it is also a tool used by marketers to improve consumer acceptance of their products. Leaving aside the ethical questions as to whether or not fortification is desirable for target markets where no deficiencies of the chosen fortificants exist or whether micronutrient fortification of products with poor macronutrient profiles should be permitted, the key areas for fortification are:

•Vitamins
•Minerals
•Protein addition
•Protein quality enhancement
•Fibre addition

The use of vitamin fortification is viewed favourably by consumers. However its practical application requires considerable technical expertise as flavour and appearance of finished products can be affected and issues such as vitamin lability, even distribution of vitamins throughout the food concerned and the potential toxicity of certain vitamins in high doses need to be addressed. Cost of fortification can also be a significant factor for certain vitamins such as vitamin E and biotin.

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Mineral fortification also presents challenges due to the difficulty of adding certain minerals to particular foods in sufficient dosages without affecting palatability and also the tendency of certain minerals to affect product shelf life. Iron fortification presents particular challenges in both these areas. A further issue relates to the bioavailability of the mineral in different forms where the most suitable methods for inclusion of the mineral may result in poor utilisation of the mineral concerned.

In the field of macronutrient fortification, the addition of fibre has already been discussed but protein fortification is also undertaken in certain specialised food categories. The main technical issues relate to palatability and cost with many applications requiring the use of expensive concentrated protein sources if flavour is not to be negatively impacted. A more specialised area relates to protein quality enhancement, a little known area for food applications and more commonly associated with the animal feeds industry but one that may become more important as the regulatory environment focuses increasingly on both quality and quantity of protein in fortified products. Expertise is required in the selection of proteins with desirable amino acid profiles, as these tend to be expensive and addition of free amino acids brings challenges in the areas of both palatability and cost.

The field of fortification is thus a complex one with substantial technical and cost implications in most areas.

Summary and Conclusions

From the above, it can be seen that almost every single area of nutritional enhancement brings with it major constraints in one or more of the areas of palatability, cost, safety, shelf life and processing complexity. It is essential that food scientists and technologists clearly explain these challenges and constraints to those who wish to challenge the current nutritional status of processed foods. This will include the nutritional activist community along with dieticians and nutritionists who are bombarded by the public with demands for quick fix solutions to obesity and other nutrition related concerns that may well result from factors other than food composition but for whom changes in nutritional composition are seen as a quick and easy “magic bullet”. However pressure on food scientists and technologists can also be expected from the commercial arms of food companies who, under pressure from nutritional activists, governments and sometimes shareholders, are looking for a similar quick fix as well as for the marketing opportunities presented by nutritionally enhanced products. Both groups need to be faced with a reality check, which however needs to be presented in a rational manner. The reality is that, while some significant scientific advances have been made in the area of enhanced nutritional composition of both staple and value added foods, these alone will not solve the obesity problem, coming as they do with significant potentially negative practical implications, not least that of increased cost to the consumer. The food science and technology community therefore needs to promote a balanced approach in which nutritional enhancement is seen as one of a number of components to the solution, others being:

- Greater focus on reduced pack and portion sizes. This will not always be well received by volume driven food companies but is unavoidable.

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- A holistic approach to obesity that highlights the issues relating to both sides of the energy equation.
- Acknowledgement that much of the problem relates to behavioural issues and that these need to be addressed by all parties including food manufacturers.
- Better liaison between the food science & technology and nutrition communities.

The last two are perhaps the most telling issues of them all. A well-known statistic from the FDA estimates that 64% of American adults are overweight and 30% are clinically obese. A lesser-known statistic from an AP Ipsos research survey conducted in the USA in May and June this year indicated that 44% of adults would continue to buy so-called "bad" foods after checking nutritional labels.

Finally, if we are to work successfully with the nutrition community, both communication issues and the food science and technology capability of nutritionists must be addressed. It is a telling factor that Volume 8 number 6(A) of the Journal of Public Health Nutrition, published at the time of last year's International Congress of Nutrition, and in which many of the adverse comments on food composition were included, contained:

- One hundred and thirty seven pages
- Fourteen papers
- A mere two paragraphs, each of of seven lines, in one of the fourteen papers on the subject of food technology in relation to nutrition and not a single mention of food science.

It is truly frightening that the disciplines that can arguably do the most to resolve the problems highlighted by the nutritionists are virtually ignored by them. It appears we face a communication as well as a scientific challenge and, as professional food scientists and technologists, we must rise to the challenge.

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