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# ADDING VALUE TO PETFOOD BY UTILIZING NOVEL INGREDIENTS AND DEVELOPMENTS IN APPLIED NUTRITION

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# Adding Value to Petfood by Utilizing Novel Ingredients and Developments in Applied Nutrition

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## Introduction:

Adding value to pet food today requires more than ever before a two-fold approach. One is about improving the actual nutrition of the pet for a longer healthier life and the other is about using nutrition so that is perceived by the owner as being health providing, nutritional effects that can be seen. Whilst there is almost a never ending supply of knowledge in terms of biochemistry, nutrition and biotechnology to fuel this, the terms and understanding that is required of the pet owning public in order to induce the response of increased purchases or price paid is at present lacking (Baker, 2002), hence the need for at least one aspect of the nutritional improvement to be "seen" to be present.

This lack of understanding remains despite the best efforts of manufacturers and veterinarians to educate the pet owner. Self-help is also limited as many of the functional ingredients or nutrients are not in the majority of the text books or in a format or context that is appropriate. As a consequence many pet owners will not have heard of them before. The result is a huge uphill marketing struggle to get awareness as to the benefits that may be insurmountable in the short term.

The primary motivator for many is to have their pets live in youthful mental and physical agility even when at a chronologically aged state. It is suggested that pets are now living longer, probably through improvements in veterinary medicine and nutrition (Reid and Peterson, 2000; Watson, 1996, Edney ***pers comm***; Michell***, pers comm***). However they are also suffering the challenges of modern life and pollution and the chronic diseases of ageing are beginning to become more prevalent (Machlin, 1996).

Our expectations and desires as to what can be achieved through nutrition have also changed. We live as we desire for our pets in youthful mental and physical agility at a chronologically aged state is. We seek a life of convenience and are reluctant to suffer for our health, yet are not proactive about preventative medicine, but are happy to imbibe supplements and functional foods that will provide health benefits (Baker, 2002) (Figure 1).

Food is a central part of our lives. We all consider ourselves as food experts yet evidence from home made diets and meals for humans and pets indicates that we are not as good as we think (Nestle Family Monitor 2001, Streiff *et al* 2001). The types of food we eat typify our age, nationality and social class, with the motivation for ABC1's and high earners being simple, easy to buy, convenient and time sparing foods with health implications. These factors impinge upon our pet food preferences also.

Such attitudes provide yet more opportunity for the pet food industry to apply biotechnological developments and change in nutrient levels to what is currently thought of as nutraceutical but in future should be considered, in my opinion, as progress in nutritional biochemistry or perhaps better defined as optimum nutrition.

However in order to present added value to the pet owner in this way there still needs to be a progression from considering nutraceuticals as a legislative dilemma over additives and supplemental nutrient levels in diets to the all embracing concept of in-built nutrition for health and well being as standard.

Should such a change become established then it is likely that their remains a huge market potential for the products of biotechnology, based on the fact that our understanding and knowledge in nutrition is constantly developing and increasing. This offers the opportunity for added value from both sides of petfood, improving the margin for the manufacturer, improving the "value" for the pet owner and from the pet's own perspective providing a better quality of life.

## Opportunities from novel approaches to Applied Nutrition:

Hippocrates of Cos (c460BC-c370BC, Greek Physician) is reported to have said, "let food be your medicine and medicine be your food". There is no doubt that dietary components play a crucial role in the health of companion animals especially, we are now aware, when life presents increased stress, toxin or free radical loading.

In times past many animal owners and nutritionists were aware, even if the biology or biochemical modes of action were unknown, that certain "foods" helped to prevent certain conditions and provided better nutrition than others. These concepts and ideas still apply and form part of the basis of Chinese and other similar medicine philosophies (Schoen and Wynn, 1998).

Further man's evolutionary progress, away from hunter-gatherers through farmers into the industrial age has reduced the variety in the diet. The domestication of dogs and other animals has similarly changed their diet and we may now be missing many of the nutrients and "nutraceuticals" that we once ate. Fish oil is a classical example; we now talk of them as if they were a new gospel whereas we are actually only replacing what we always used to eat and the diseases associated with their absence (CHD, extensive cartilage damage) have only increased in the last few hundreds of years. As hunter-gatherers we would have had a much wider and varied diet than as the farmers we became. Both man and his animals would have enjoyed scores of species with all sorts of components and "nutrients", whereas modern diets tend to be based on limited species of plants and animals. Even in recent times both farmed plants and diets for animals have not been based on their biochemistry for long term health but on yield and succulence.

Throughout our evolution we appear to have gone from a wide ranging diet, yet dying from pharmacological impoverishment, lack of medical intervention and other challenges, through to a state of improved medicine yet a deterioration in dietary range even to wide spread malnutrition even as late as the 1940's and 1950's.

Where opportunities now lie, I believe, is in the application of the nutrients that we are "rediscovering" and the new roles for the nutrients that we already take for granted. These have been labeled as functional foods and nutraceuticals derived from developments and improvements in our knowledge of nutritional biochemistry. This is probably driven by the changes in the way in which the various divisions of biology studies now interact, with cross fertilization of ideas and comparative species studies.

We are now at the stage of benefiting from comparative nutrition across the species and comparative studies across disciplines. Together these lead us on to the steep slope of opportunity to apply nutrition to the health and well being of pets for the future.

Such thoughts have led us to apply existing nutrients to other species for example:

Taurine from essentiality in cats and to beneficial in humans to dogs
Vitamin C from essentiality in humans to conditionally essential in dogs and cats
Long chain polyunsaturated ω-3 fatty acids, DHA and EPA (from fish), originally in the diet of man and dogs, lost during evolution, now being reintroduced as essential nutrients
Phytochemicals, antioxiant properties originally in the diet of man and dogs, lost during evolution, now being reintroduced as essential nutrients.
Application of carotenoids for eye health in man to similar studies in aging dogs
Vitamin D metabolite (Hy-D™) shown to be beneficial in poultry to have a useful role in young dogs and cats and those with impaired liver function.
Phyto oestrogens (from flax and soya): inappropriate in dogs for osteoporosis but possible anti cancer applications.
Chelated minerals and organic selenium, found as natural mineral sources and now being substituted for the inorganics as data begin to indicate benefits over and above the actual mineral supply level.
Increased levels of supplemental dietary vitamins and carotenoids, shown to not just overcome classical deficiencies but have a positive effect on long term health, gene expression and cell signaling, for example enhanced immune facilitation in young dogs and cats.
Yucca shidegera extract: an antifoaming agent and flavour in popular human drinks, now used in dog and cat foods as flavours, feacal aroma reducer and possible antibacterial.

They have also led to the introduction of specific nutrients and feed ingredients for benefit to long term health or biochemical function:

FOS, MOS, β-glucans: gut health and immune function
Chondroitin and glucosamine: joint condition and cartilage remodelling
Nucleotides: immune function
MSM: orgainic sulphur source a deficiency of which is involved in a myriad of disorders
Creatine: for muscle metabolism
Carnitine: fat metabolism
Glutamine: immunity and antioxidant status
Tea Polyphenols: oral hygiene and antioxidant status
Glycomacropeptide: oral hygiene
Polyols: oral hygiene, liver function, bile production, sweetener, humectant
Enzymes: as production aids and as digestion aids
Chromium: anti diabetes
Lipoic acid: antioxidant.
Herbs and botanicals: various applications
Carotenoids: (lycopene, lutein, zeaxanthin) as antioxidants and immune facilitators

Nowadays we are beginning to recognize the evidence and clinical observations that strongly suggest that the risk of developing many of the chronic or degenerative diseases (that speed up the onset of aging for example) are reduced by the consumption of some of the previously so called dispensable nutrients and even non-nutrient components (as currently defined) of food. In addition beneficial effects on the quality of life, activity levels and disease resistance have been observed with high intakes of some essential nutrients (Harper, 2000). This has raised questions and encouraged the nutritional biochemist to rethink both the classification of nutrients and food components and the amounts that should be fed to avoid “deficiencies”.

Thus before we establish what level of a nutrient is required in the diet to overcome a deficiency we must first define and identify the condition to which the nutrient deficiency would be associated with (Figure 3). This is well illustrated by Se, where intakes to overcome classical deficiency are well below those that are now known to be supportive of a reduced incidence of cancer.

We now look for optimum level where health and biochemical markers are optimized. In this way nutraceutical levels of today may become the allowances of tomorrow as we redefine the concept of deficiency.

Examination of the geriatric dog or cat (Hoskins, 1995) indicates that they rarely suffer from a single disease or body system problem, thus adjustment to a combination of nutrients to achieve a response is more likely to be effective than a single increase in one nutrient.

## The Application of Novel Ingredients:

I would suggest that the opportunities for adding value by the addition of certain functional foods and nutraceuticals is there, but that there is a greater reward to be had by in addition changing from a pure additive standpoint to one of the diet being in possession of inbuilt progress in nutritional biochemistry.

This then I believe becomes the basis and the driver for added value in modern pet foods. Some pet food companies already address this approach by not indicating the nutraceutical component, but suggesting that you will see the benefits from its inbuilt matrix of key nutrients. It also means that one can keep on developing and improving the perceived sales value to the pet owner for as long as nutritional science progresses.

Rarely do any of the nutrients or feed ingredients have only a single role in the diet. Whilst many of the biotechnology products that we are aware of have started life with a single, itemized benefit it is now becoming more and more apparent as to how they fit into and are almost essential constraints in dietary formulation of the complete picture of optimizing the pet's long-term quality of life.

Some examples of the importance of this can be illustrated with antioxidants. Many now think that aging, immunity, mental alertness and some diseases are a consequence of the cumulative injurious effects of free radicals (Baskin and Salem, 1997). Most free radicals are generated as part of the body's normal metabolic processes but certain conditions both from within and without the animal increase their occurrence. The animal has a complex and elaborate system of antioxidant defense to deal with such onslaughts. However, evidence is increasing to indicate benefits from additional dietary antioxidants to support the bodies own systems., further that the addition of more than one antioxidant has a synergistic effect on the outcome.

The inclusion of the antioxidant vitamins, such as vitamin E and C has changed dramatically over the years.
Vitamin E was considered, in isolation, in 1962 by the National Research Council, subcommittee on dog nutrition (NRC, 1962) as follows:

"although it has not been proved definitely, there is evidence that the dog requires vitamin E for normal reproduction and lactation".

They concluded that 22 $mg.kg^{-1}$ would be adequate, but bearing in mind the losses due to the oxidation of dietary fat an amount of 44 $mg.kg^{-1}$ is suggested for diets for growth and presumably thus for all life stages.

By 1985 the subcommittee (NRC, 1985) acknowledged the requirements for vitamin E but also indicated its involvement with selenium (Se) and its role in conjunction with glutathione peroxidase (GSHPx), though recognized that since the determination of Se as “essential” few of the vitamin E studies with dogs have taken this factor into account. The discussion then further expands on the requirement for vitamin E being dependent upon the poly-unsaturated fatty acid (PUFA) content of cell membranes that are directly influenced by the dietary concentration of PUFA. It is suggested that as much as 100mg.kg$^{-1}$ diet of vitamin E may be insufficient. They suggest that a vitamin E (expressed as α-tocopherol) to PUFA ratio of 0.6:1 should be considered a minimum and thus conclude that with a diet containing 1% linoleic acid and ≥0.1mg.kg$^{-1}$ of Se then 20mg.kg$^{-1}$ of vitamin E in a die with 3300kcal which is approximately equivalent to 1.2iu.kg$^{-1}$ body weight. If the PUFA content was increased then the vitamin E should be increased in order to maintain a ratio of 0.5:1.

By the time the American Association of Feed Control Officials (AAFCO, 1990) concluded their deliberations in the early 1990’s the level had become 50mg.kg$^{-1}$

Inclusion levels rose again based on advice and studies from the leading vitamin houses and pet food companies and were in the region of 80-120 mg.kg$^{-1}$ by end 1990’s.

A review of vitamin inclusion in pet food (Roche, 2001) of some 95 canine and 8 feline diets showed wide variation in the use of vitamin E ranging from 14-400 mg.kg$^{-1}$ of diet all corrected to 400 kcal.100g$^{-1}$ indicating that some at least were aware of the benefits of higher levels.

More recent studies, indicate that improvements in total antioxidant capacity of the dog can be achieved with levels of 200mg.kg$^{-1}$ (Lowe and Braunton, unpublished data) and with inclusions of in excess of 500 mg.kg$^{-1}$ to reduce serum circulating alkenals (Jewell *et al* 2000) and as part of a mixture of other antioxidants, immune status (Harper, 2001).

Similar changes in approach to inclusion rates can be seen with vitamin C, though subtle differences exist here due to the change in approach from a dispensable nutrient, due to natural synthesis in the dog, to one of conditional essentiality:

In 1962 the NRC concluded that “ the dog generally does not need vitamin C in the diet”. Whilst by 1985 they recognized the difference between possible effects from pharmacological doses (that 600mg. 2x.day$^{-1}$ aggravated skeletal disease) though maintained the statement about the lack of need; concluding that “ there is no adequate evidence to justify recommendation of routine vitamin C additions to the diet of the normal dog, however dogs with hepatic dysfunction may have lowered plasma concentrations of ascorbic acid”.

Today vitamin C is included in diets not necessarily because there is evidence for a classical deficiency *per se* but its role in protection and regeneration of other antioxidant capacity components and thus the global picture of increased total antioxidant status and the management of the chronic diseases with this.

Thus we see increases both in the inclusion of specific vitamins and we see inclusions of these vitamins in strict ratio to the energy in the diet, as it is about daily intake rather than percentage inclusion and in relationship to each other as well as the inclusion of previously unconsidered vitamins such as the carotenoids.

Antioxidants have a variety of functions with the body, all of which are involved with the reduction in oxidative damage. The many antioxidants in the animal, from vitamins to endogenous enzymes can be grouped according to their role in the prevention and reduction of oxidation reactions, redox potential and relative concentrations of the surrounding molecules, with the vitamins acting primarily as free radical scavengers.

For example based on their relative free radical quenching activity lycopene > β-carotene >lutein ≈ zeaxanthin (both have similar structures) > α-carotene > canthaxanthin ≈ astaxanthin (Miller *et al* 1996). Although data exists for the absorption in the cat and dog of these various carotenoids their relative bioavailability remains under discussion. The strength behind the carotenoids is not only in their ability to scavenge radicals and act as chain breaking antioxidants but also to act through the formation of radical adducts that in themselves are highly stable and act to terminate radical reactions.

Further the antioxidant vitamins typically have secondary or alternative roles within the biochemistry of the animal, often unrelated related to their antioxidant chemistry. For example: vitamin E; which has an inhibitory effect on cell proliferation and protein kinase C activity (Ricciarelli *et al* 2001) or the distinguishable difference of the antioxidant capacity of all-*tans*-retinal from its role in rhodopsin and vision. The role of Vitamin C however, in addition to its direct antioxidant effect, when involved in collagen synthesis uses its electron donating chemistry to maintain iron in its reduced state ($Fe^{2+}$) and thus catalytic activity in the iron dependent enzyme proline monooxygenase which converts proline residues into hydroxyproline. A similar role for ascorbic acid occurs in the synthesis of the neurotransmitters, norepinephrine and epinephrine where it is involved in the maintenance of Cu in the cuprous ($Cu^{+}$) state for the copper / $B_6$ dependent enzyme dopadecarboxylase.

The action of the carotenoids in terms of enhancing immune function appears to be through several modes of action; increased proliferation of lymphocytes, T-helper cells and up regulation of interleukin-2 whilst depressing prostaglandin $E_2$ resulting in an overall elevation of humoral response. It is also thought that the integrity of immune cell membranes is enhanced by the antioxidant systems.

A similar dual role for plant extracts of the yucca schidigera exists, in that its inclusion in dogs and cat diets has been shown to ameliorate faecal aroma intensity and alter faecal volatiles (Lowe and Kershaw 1997, Lowe *et al* 1997l) However there is also information as to its effectiveness in reducing inflammation and arthritis in humans (Bingham 1975). Further as steroidal saponins are reported to reduce cholesterol levels (Bingham *et al* 1978) and induce cancer cell apoptosis (Sakagami *et al* 2001) their presence in the yucca shidegera may thus be of additional benefit to the dog.

## Conclusions:

Adding value to pet foods through novel ingredients or nutrients has to be seen from all sides, improving the margin for the manufacturer and improving the "value" for the pet owner and from the pet's own perspective a better quality of life.

It is also about understanding that many of these components have more than one application and are rarely fully effective when considered in isolation. Almost all of them require other supporting nutrients to optimize their functionality.

Many of the available biotechnology products now offer at least one and in many cases all of these requirements to be fulfilled through individual identifiable sales benefits and through their involvement in the fuller picture of complete nutrition.

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