

New herbal health ingredients and their functional applications: A review

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INTRODUCTION

Herbal applications are becoming a fast enlarging market. In the past five years, there has been a surge of herbal products, claiming one or more health benefits, in the market.

Currently, these products are classified into various segments such as functional foods/beverages, nutraceuticals, cosmeceuticals, fortified foods, antioxidants and health ingredients.

Nutraceuticals are positioned at the interface of food and drugs, and provide medical as well as health benefits. Since nutraceuticals are associated with one or more body function, they are also termed as functional foods. Most of the new herbal ingredients that are being marketed belong to this category. Some of the latest discoveries include benecol (plant stanol that reduce absorption of cholesterol from food), xylitol (sugar free alcohol for sweetener from birch trees, which also prevents tooth decay), beta-glucan (natural fibre of oat that controls serum cholesterol, improve bowel functions; new applications of β -glucan are high beta-glucan biscuits and vegetable burgers), preventive health ingredients like hibiscus flower extracts against heart disease, lutein from marigold flowers against Age related Macular Disorders (AMD), polyphenols from apple skin and grape seed as antioxidants, phytosterols, lycopene, tocopherol, lutein, zeaxanthin, canthaxanthin, astaxanthin, polyphenols etc.

Another major area in which herbal ingredients are finding increased acceptance is the **Cosmeceutical** segment. These are cosmetic products having therapeutic effects. Some of the examples of this category include skin lotions with herbals added to counter

ageing, creams containing antioxidants to fight environmental damage, health and beauty products of herbal base (aloe, curcumin-creams, green tea-body sprays) etc.

Functional beverages is another new application that has gained good market momentum. The functional beverage market offers a lot of scope for future expansion as well. These beverages are generally cocktails of herbs such as caffeine, taurine, guarana, glucuronolactone etc., and their consumption have gone up by 11% in the last 5 years. This occupies around 6% of the total soft drink market, in terms of value, in the last 6 years. New-age beverages have strong potential for future growth across Europe, with Switzerland positioned as the biggest market. To cite a few popular botanical ingredients for health drinks are ginseng, balm, comomile, ginko, kombucha, echinacea, schizandra, and wolfery. Simple green teas are slowly disappearing from the western market and newer and newer tea formulations containing less of tea and more of other body stimulants are occupying the place of green tea. These beverages are based on tea but contain vitamins or immune enhancing ingredients. Most popularly used herbals in such drinks are echinacea, milk thistle, ginseng, kava kava, red clover, ginko biloba, st. John's wort and valerian, which are preferred mostly during winter. In many cases, Vitamins C and B are also mixed in such teas. The after tastes of herbals are hidden generally by strong flavours of mint, menthol, citrus, fennel, peach, strawberry ginger, honey eucalyptus and cinnamon. Flavour laden whole ingredients such as stevia leaves, toasted chicory, rose buds, orange peel, toasted barley malt, licorice, lemon grass, rose hips, catnip, lavender flowers, star anise, hawthorn berries, hops and cayenne pepper are also used to enhance the

flavour profile. Mixing green and black tea to add colour and flavour has also become popular. These changes in the green tea market might be for good as more and more people would be attracted towards these drinks having a tea base. On the other hand, it could lead to a situation wherein the volume of green tea extract used could be replaced by other ingredients.

Fortified foods are the largest of the functional food segment, and are projected to show a dramatic growth over the next decade due to preventive health care, relationship between diet and disease and self-sufficiency. Industrial R&D works related to fortified foods have identified new role for carbohydrates in the diet. For example, natural saccharine like glycans from onions, leek, garlic, chicory, artichoke, bananas, wheat are being used as functional ingredients. Similarly, low calorie sweeteners like polyols (sorbitol, lactitol, mannitol, maltitol, isomalt, and xylitol), fat replacers and dietary fibres are taking prominent place in the dietary preferences of the western world. Few examples to show the future R&D directions would be novelose from maize, litesse, fibrex from sugar beet pulp, inulin and oligofructose from chicory taproot, fibregum from acacia tree. The recent introduction of natural lycopene-tomato fibres standardized for lycopene content – for use as food colourant and functional ingredient - shows the importance of functional herbal ingredients. Another example is that of avocado oil, which is extracted from pressing of avocado, which contains low saturated fat, high mono-unsaturated fats, and is cholesterol-free and rich in betasitosterol. Naturally-infused avocado oils with garlic, chilly and lemon are also finding their place in the market of herbal applications.

REGULATORY HURDLES

Before finding their way to the product shelf in the market, new applications need to go through the hurdle of regulatory approval. This is tough indeed, more because the laws and regulations of different countries are varied. The United States, the largest consumer of nutraceutical food and beverages, has been evolving regulatory strategies to counter false claims, at the same time minimizing the infrastructural delays. FDA regulates food products depending on how they are classified. There are two categories under the FDA directive, the conventional foods, which are consumed for aroma, taste and nutrition; and the dietary supplements, which are consumed for health benefits. The FDA does not have a regulatory category for functional foods however, so these foods have to be marketed as either of the above. FDA has categorized new products having qualified or unqualified health claims. The qualified new products should have greater number of studies supporting the health claim, which are not likely to be reversed by future studies. Examples of products having qualified health claims are folate, folic acid, omega-3 fatty acids, phosphatidylserine, antioxidant vitamins etc. The unqualified products are those who have potential health benefits based on "significant scientific agreement". Examples being calcium for osteoporosis, dietary fat and cancer, fibre containing vegetable and cancer, plant sterols and plant stanol and heart disease. The labelling should ensure that the classified claims are depicted correctly.

PRE-BIOTIC AND PRO-BIOTIC BEVERAGES

The pre- and pro-biotic beverage sector has performed exceptionally well in the market in 2004-05. Japanese consumers especially, have been historically aware of the use of pre-biotic ingredients along with pro-biotic bacteria in their diet. The pro-biotic beverage, *Yakult*, originated in Japan around 70 years ago, now has become a truly global brand. Such beverages promote the growth of friendly bacteria and decrease harmful bacteria in the intestinal environment. The pre-biotic concept was first commercially implemented twenty years back when fructo oligosaccharides were sold as a bifidus factor to enhance the growth of friendly bifid bacteria in the intestinal tract.

Maintaining a healthy

gastrointestinal system is a priority for good health. Especially when new medical systems use antibiotics for a variety of health conditions, it becomes very important to replenish the bacterial flora in the gut, and for this, pro-biotic bacteria are the best solution. The best example of such a drink is the aloe vera yogurt with pieces of crunchy aloe vera leaf added as the pre-biotic ingredient. There are more than 70 FOSHU (Food for Specialised Health Use) gut regulation products containing dietary fibre as the functional ingredient, and more than 60 FOSHU products using an oligosaccharide to support a gut health claim. Most popular functional ingredient in the pre-biotic fibre category include dextrin, psyllium seed husk, poly-dextrose, partially hydrolysed guar gum, wheat bran, raffinose and beer yeast fibre. The major incentive for development of new pro-biotic ingredients is a concern for diabetes and obesity and the role of dietary fibre related to insulin sensitivity and glucose response.

FUNCTIONAL FOODS

The term functional foods was introduced in 1980s, and refers to processed foods containing ingredients that aid specific bodily functions, in addition to being nutritious. To date, Japan is the only country that has formulated a specific regulatory approval process for functional foods. Known as Foods for Specified Health Use (FOSHU), these foods are eligible to bear a seal of approval from the Japanese Ministry of Health and Welfare. Currently, 100 products are licensed as FOSHU foods in Japan.

In the United States, the functional foods category is not recognized legally. Irrespective of this, many organizations have proposed definitions for this new and emerging area of the food and nutrition sciences. The Institute of Medicine's Food and Nutrition Board defined functional foods as "any food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains." Health-conscious baby boomers have made functional foods the leading trend in the U.S. food industry. Estimates of the magnitude of this market vary significantly, as there is no consensus on what constitutes a functional food. Decision Resources, Inc. estimates the current market value of functional foods at \$ 30 billion. More significant, perhaps, is the potential of functional foods to mitigate disease, promote health, and reduce health care costs.

Overwhelming evidence from epidemiological, *in vivo*, *in vitro*, and clinical trial data indicates that a plant-based diet can reduce the risk of chronic disease, particularly cancer. In 1992, a review of 200 epidemiological studies showed that cancer risk in people consuming diets high in fruits and vegetables was only one-half that in those consuming few of these foods. It is now clear that there are components in a plant-based diet other than traditional nutrients that can reduce cancer risk. More than a dozen classes of these biologically active plant chemicals are identified now, which are known as phytochemicals. Some established examples are outlined here.

Oats

Oat products are a widely studied dietary source of the cholesterol-lowering soluble fibre, β -glucan. There is now significant scientific agreement that consumption of this particular plant food can reduce total and low-density lipoprotein (LDL) cholesterol, thereby reducing the risk of coronary heart disease (CHD). The Food and Drug Administration (FDA) awarded the first food-specific health claim for β -glucan in January 1997. The award was based on finding of a series of studies which revealed statistically significant reductions in total and LDL-cholesterol in hypercholesterolemic subjects consuming either a typical American diet or a low fat diet. In February of 1998, the soluble fibre health claim was extended to include *psyllium fibre*.

Soy

Soy has been in the attention of scientific researchers since 1990s. It is a high quality protein, as assessed by the FDA's "Protein Digestibility Corrected Amino Acid Score" method. Studies are claiming preventive and therapeutic roles in cardiovascular disease (CVD), cancer, osteoporosis, and the alleviation of menopausal symptoms. The cholesterol-lowering effect of soy is well documented. A meta-analysis of 38 separate studies found that the consumption of soy protein resulted in significant reductions in total cholesterol (9.3%), LDL cholesterol (12.9%), and triglycerides (10.5%), with a small but insignificant increase (2.4%) in high-density lipoprotein (HDL) cholesterol. Regarding the specific component responsible for the cholesterol-lowering effect of soy, attention has focused on the isoflavones. The exact mechanism by which soy exerts its hypocholesterolemic effect, however, has not been fully elucidated yet.

Several classes of anti-carcinogens

have been identified in soybeans, including protease inhibitors, phytosterols, saponins, phenolic acids, phytic acid, and isoflavones. Soybeans are the only significant dietary source of isoflavones (genistein and daidzein). Isoflavones are heterocyclic phenols structurally similar to the estrogenic steroids. Because they are weak estrogens, isoflavones may act as anti-estrogen by competing with the more potent, naturally occurring endogenous estrogens (e.g., 17 β -estradiol) for binding to the oestrogen receptor. However, the epidemiological data on soy intake and cancer risk are inconsistent at present.

Flaxseed

Among the major seed oils, flaxseed oil contains the most (approx. 57%) of the omega-3 fatty acid, α -linolenic acid. More recently, studies have revealed that fibre-associated compounds known as lignans (like enterodiol and its oxidation product, enterolactone), are formed in the intestinal tract by bacterial action on plant lignan precursors. Flaxseed is the richest source of mammalian lignan precursors. Because enterodiol and enterolactone are structurally similar to both naturally occurring and synthetic oestrogen, and have been shown to possess weak oestrogenic and anti-oestrogenic activities, they may play a role in the prevention of oestrogen-dependent cancers. However, there are no epidemiological data and relatively few animal studies to support this hypothesis. Consumption of flaxseed has also been shown to reduce total and LDL cholesterol as well as platelet aggregation.

Tomatoes

"Eating well" magazine, in 1997, selected tomato as the "vegetable of the year". Tomatoes have received significant attention in the past five years because of interest in lycopene, the primary carotenoid found in this fruit and its role in reduction of cancer risk.

Lycopene is the most abundant carotenoid in the prostate gland. In a study involving around 50,000 men, it was found that those who consumed tomato products ten or more times per week had less than one-half the risk of developing advanced prostate cancer. Other cancer types whose risk have been inversely associated with serum or tissue levels of lycopene include breast, digestive tract, cervix, bladder, and skin. Proposed mechanisms by which lycopene could influence cancer risk are related to its antioxidant function.

Lycopene is the most efficient quencher of singlet oxygen in biological systems.

Garlic

Garlic (*Allium sativum*) could probably be the herb most repeatedly quoted in the literature for medicinal properties. Thus, it is not surprising that garlic has been ranked as the second best selling herb in the United States in the late nineties. The purported health benefits of garlic are numerous, which include cancer chemo-preventive, antibiotic, anti-hypertensive, and cholesterol-lowering properties.

The characteristic flavour and pungency of garlic are due to oil- and water-soluble, sulphur-containing elements, which are also responsible for the various medicinal effects ascribed to this plant. However, intact, undisturbed bulbs of garlic contain only a few medicinally active components. The intact garlic bulb contains an odourless amino acid, alliin, which is converted enzymatically by allinase into allicin when the garlic cloves are crushed. Allicin is responsible for the characteristic odour of fresh garlic, which spontaneously decomposes to form numerous sulphur-containing compounds.

Several epidemiologic studies show that garlic may be effective in reducing human cancer risk. Recently, in a study of more than 40,000 postmenopausal women, garlic consumption was associated with nearly a 50% reduction in colon cancer risk. Not all epidemiological studies, however, have shown garlic to be protective against carcinogenesis. In a meta-analysis of placebo-controlled clinical trials involving 410 patients showed that an average of 900 mg garlic/day (as little as one-half to one clove of garlic) could decrease total serum cholesterol levels by approximately 9%. However, it is to be noted that there are methodological shortcomings, including the fact that dietary intake, weight, and/or exogenous garlic ingestion was not always well controlled in such studies.

Broccoli and Other Cruciferous Vegetables

Epidemiological evidence shows that frequent consumption of cruciferous vegetables decrease cancer risk. This was demonstrated in a recent review of 87 case-control studies. The percentages of case-control studies showing an inverse association between consumption of cabbage, broccoli, cauliflower, and Brussels sprouts and cancer risk were 70, 56, 67, and 29%, respectively. The anti carcinogenic properties of cruciferous vegetables

were assigned to their relatively high content of glucosinolates. Glucosinolates are a group of glycosides that are stored within cell vacuoles of all cruciferous vegetables. Myrosinase, an enzyme found in plant cells, catalyzes these compounds to different hydrolysis products, including isothiocyanates and indoles. Indole-3 carbinol (I3C) is currently under investigation for its cancer chemopreventive properties, particularly of the mammary gland.

Although wide varieties of naturally occurring and synthetic isothiocyanates have been shown to prevent cancer in animals, attention has been focused on a particular isothiocyanate isolated from broccoli, known as sulforaphane. Sulforaphane has been shown to be the principal inducer of a particular type of Phase II enzyme, quinone reductase. However, in view of the importance of an overall dietary pattern in cancer risk reduction, the clinical implications of a single phytochemical in isolation have been widely questioned.

Citrus Fruits

Several epidemiological studies have shown that citrus fruits are protective against a variety of human cancers. Although oranges, lemons, limes, and grapefruits are principal sources of important nutrients like Vitamin C, folate, and fibre, it was suggested that another component is responsible for the anticancer activity.

Citrus fruits are particularly high in a class of phytochemicals known as the limonoids. These compounds were effective against a variety of spontaneous as well as chemically-induced tumours in rodents. Based on these observations, and because it has little or no toxicity in humans, limonene has been suggested as a good candidate for human clinical chemoprevention trial evaluation.

Cranberry

Cranberry juice has been recognized as efficacious in the treatment of urinary tract infections since 1914. It was reported that this benzoic acid-rich fruit caused acidification of the urine. Recent investigations have focused on the ability of cranberry juice to inhibit the adherence of *Escherichia coli* to uroepithelial cells. This phenomenon has been attributed to two compounds: fructose and a non-dialyzable polymeric compound. The latter compound, subsequently isolated from cranberry and blueberry juices, was found to inhibit adhesions present on the pili of the surface of certain pathogenic *E. coli*.

In a study, one hundred and fifty three elderly women consuming 300 ml

cranberry beverage per day had significantly reduced incidence of bacteriuria with pyuria compared to the control group after six months. Based on the results of these studies, prevailing beliefs about the benefits of cranberry juice on the urinary tract appear to be justified.

Tea

Tea is second only to water as the most widely consumed beverage in the world. A great deal of attention has been directed to the polyphenolic constituents of tea, particularly green tea. Polyphenols comprise up to 30% of the total dry weight of fresh tea leaves. Catechins are the predominant and most significant of all tea polyphenols. The four major green tea catechins are epigallocatechin-3-gallate, epigallocatechin, epicatechin-3-gallate, and epicatechin.

In recent years, there has been a great deal of interest in pharmacological effects of tea. By far, most research on health benefits of tea has focused on its cancer chemopreventive effects, although the epidemiological studies are inconclusive now. Review of epidemiological studies shows that approximately 2/3 of the studies found no relationship between tea consumption and cancer risk, while 20 found a positive relationship and only 14 studies found that tea consumption reduced cancer risk. A more recent review, however, suggests that benefits from tea consumption are restricted to high intakes in high-risk populations. In contrast to the inconclusive results from epidemiological studies, research findings in laboratory animals clearly support a cancer chemopreventive effect of tea components. There is also some evidence that tea consumption may also reduce the risk of cardiovascular disease (CVD). It was reported that tea was the major source of flavonoids in a population of elderly men in the Netherlands. Intake of five flavonoids (quercetin, kaempferol, myricetin, apigenin, and luteolin), the majority of which was derived from tea consumption, was inversely associated with mortality from coronary heart disease (CHD) in this population. Although several other prospective studies have demonstrated a substantial reduction in CVD risk with tea consumption, the evidence is not presently conclusive.

Wine and Grapes

There is growing evidence that wine, particularly red wine, can reduce the risk of CVD. Investigations are now

focusing on the non-alcohol components of wine, in particular, the flavonoids.

The high phenolic content of red wine, which is about 20-50 times higher than white wine, is due to the incorporation of the grape skins into the fermenting grape juice during production. The black seedless grapes and red wines contain high concentrations of phenolics while green Thomson grapes contain lower phenolic levels. The positive benefits of red wine was attributed to the ability of phenolic substances to prevent the oxidation of LDL, a critical event in the process of atherogenesis. Moderate wine consumption has also been associated with a decreased risk of age-related macular degeneration (AMD)

Those who desire health benefits of wine without potential risk of alcohol consider alcohol-free wine, which has been shown to increase total plasma antioxidant capacity. Furthermore, commercial grape juice is effective in inhibiting the oxidation of LDL isolated from human subjects. Red wine is also a significant source of trans-resveratrol, a phytoalexin found in grape skins. Resveratrol has also been shown to have estrogenic properties, which may explain in part the cardiovascular benefits of wine drinking, and it has been shown to inhibit carcinogenesis *in vivo*.

DIETARY FIBRE

Dietary fibre is described as the proportion of plant foods not digested in the human small intestine. Among the various kinds of pectin, apple pectin exerts a bacteriostatic action and therefore may change the composition of the intestinal flora. The diet supplemented with 20% apple pectin significantly decreases the number and the incidence of colon tumors in rats, according to studies. The prostaglandin E2 (PGE2) level in the distal colonic mucosa and blood of portal vein was lower in rats fed with 20% pectin than those fed the basal diet. Rats fed apple pectin showed a significantly lower incidence of hepatic metastasis than those fed the basal diet. Apple pectic oligosaccharides with small molecular weights showed highly inhibitory effects on hypoxanthin-xanthin oxidase and ferrous sulphate-hydrogen peroxide. The scavenging activity of apple pectic oligosaccharides was suitable and accelerated at high temperatures (120°C, 30 min.). Apple pectin and *Lactobacillus* have a scavenger effect in the intestinal digestion and portal

circulation system as an anti-inflammatory food and have very important function for the prevention of hepatic metastasis.

ANTIOXIDANTS

Antioxidants are dietary supplements, which act as scavengers of nascent oxygen in blood, thereby preventing the deleterious effects of nascent oxygen on cells. In addition to the established antioxidants in the market, numerous new molecules have been isolated from new herbal sources. Some of them are included here.

Acerola (*Malpighi glabra*) or caribbean cherry is a natural source of Vitamin C. It also contains bioflavonoids and is often used as a mixture with orange juice.

Rosehips (*Rosa moschata*, *R. rubiginosa*, *R. canina*) is popular for its high Vitamin C content, and is used in teas and dietary supplements as natural source of Vitamin C. The seeds are popularly used as a topical antioxidant and it contains essential fatty acids, Vitamin E and retinol.

Quercetin and Rutin (*Dimorphandra gardenariana*, *D. mollis* – indigenous to South America) are extracts from the pods. Rutin has circulatory properties, while quercetin is used against allergy remedies and immune support products.

Grape seed and grape skin extracts (*Vitis vinifera*) are also generous source of antioxidants. The active ingredients such as OPCs, resveratrol and polyphenols are used for different formulations. Health benefits of antioxidants are not a selling point as immediate or even long term effects are not felt by the consumers, and the market is already crowded with many varieties of antioxidants.

Cocoa extracts (*Theobroma cacao*) exhibit many antioxidant health benefits, contrary to the popular notion. There is a good health side too for chocolates. It contains high amount of polyphenols similar to grape seed/skin extracts. A good amount of research is being conducted aiming at the cardiovascular benefits of dark, polyphenol-rich cocoa extracts and chocolate.

Acai (*Euterpe oleracea*) is a palm fruit found in Brazil and Northern Amazon. It contains high amount of polyphenols, essential fatty acids, dietary minerals, and high anthocyanin colour. It is being used now by mixing with guarana as an energy tonic, and a rich source of water as well as oil soluble antioxidants.

Buriti (*Mauritia vinifera*, *M. flexuosa*) is a

palm fruit found in Brazil. The pulp contains high amount of carotenoids. Research is on to ascertain it as source of viable and delicious antioxidants. Pitanga (*Eugenia uniflora* – Surinam cherry) pulp and juice provide a wonderful balance of antioxidants and other nutrients, carotenoids and Vitamin C, B and minerals, especially magnesium. Jaboticaba (*Myrciaria cauliflora*, *M. trunciflora*) is a tree growing in South America, which contains high amount of polyphenols especially anthocyanins.

Ellagic Acid is a naturally occurring polyphenolic constituent found at least in 46 different fruits and nuts, such as pomegranate, red raspberry, strawberry, blueberry and walnuts. It is a nutraceutical containing a naturally occurring phenolic compound that has been claimed to have very strong antioxidant properties. This phenol is a potent anti-carcinogen, and has the ability to inhibit mutations within a cell's DNA. It is also considered a cancer inhibitor, which has the ability to cause apoptosis or normal cell death in cancer cells. In addition, research has found that ellagic acid has antibacterial and anti-viral properties. Clinical studies are showing that ellagic acid may be one of the most potent ways to prevent cancer, inhibit the growth of cancer cells, and arrest the growth of cancer in subjects with a genetic predisposition for the disease.

Ellagic acid is usually made from red raspberries. Most of the studies on ellagic acid have been conducted on this source of ellagic acid that has been tested as a cancer alternative. The Hollings Cancer Institute at the University of South Carolina, USA is doing a double blind study on a large group of 500 cervical cancer patients using ellagic acid from red raspberries. Nine years of study have shown that ellagic acid is causing G-arrest within 48 hours (inhibiting and stopping g-phase of mitosis), and apoptosis (normal cell death) within 72 hours, for breast, pancreas, esophageal, skin, colon and prostate cancer cells. Clinical tests also show that ellagic acid prevents the destruction of the p53 gene by cancer cells. One of the mechanisms by which ellagic acid inhibits mutagenesis and carcinogenesis is by forming adducts with DNA, thus masking binding sites to be occupied by the mutagen or carcinogen. Ellagic acid itself is not naturally present in plants. Instead, polymers of gallic acid and hexahydroxydiphenyl (HHDP) are linked to glucose centers to form the class of compounds known as ellagitannins.

When two gallic acid groups become linked side-by-side within a tannin molecule, an HHDP group is formed. Ellagic acid is the result when the HHDP group is cleaved from the tannin molecule and spontaneously rearranges. It is the ellagitannins that are present in red raspberries. Availability of ellagic acid to the body from dietary sources has only been confirmed with red raspberries. Other foods such as strawberries, pomegranates, and walnuts contain far lesser amounts of ellagic acid yet the bioavailability has not been confirmed.

The compound curcumin, derived from turmeric, inhibits phosphorylase kinase and, by doing so, exhibits a number of physiological effects related to the control of inflammation and cellular proliferation. Recently a colourless standardized turmeric root extract, **Tetrahydrocurcuminoid**, was developed which is claimed to have applications for dietary supplements as well as cosmeceuticals. This patented standardized turmeric root extract, Curcumin C3 Complex[®], is a patented bioprotectant and multipurpose antioxidant, yet its topical applications are limited due to its staining effect. It can also present difficulties in a manufacturing environment because of its intense colour. To overcome these difficulties a new colourless extract was developed from this by a proprietary extraction process involving the parent curcuminoids resulting in the formation of tetrahydrocurcuminoids (THC). Equally important to the off-white colour material is the fact that all of the biological properties are preserved to yield a minimum 95% curcuminoids content. There is some evidence that the white tetrahydrocurcuminoids may be 4-5 times more potent than yellow curcuminoids, meaning a lower dosage is required. Research is ongoing to explore and validate this theory.

EYE HEALTH INGREDIENTS

The cornea of the eye behaves like a lens cover, diverging light through pupil at the centre of iris, which function like the aperture of a camera. The lens focuses the rays to the retina of the eye, which functions like the film. The lens is part of the eye that can become cloudy and is removed during cataract surgery. The retina is membranous containing photoreceptor nerve cells, which changes light rays into electrical impulses and send them through optic nerve to the brain where the image is perceived. The centre of

the retina is called macula and is sensitive to ageing.

Correlation of eye health and nutrition is age old with xerophthalmia and night blindness having been associated with Vitamin A for many decades. It is reported that blindness or low vision affects 3.3 million Americans over 40, and this goes up with age. The most common of the age related eye diseases are AMD, glaucoma, cataracts and diabetic retinopathy. The AMD is the leading cause of blindness and is estimated to affect more than 10 million Americans and Europeans each. Macular degeneration is caused by oxidative stress due to high consumption of oxygen by retina, high content of polyunsaturated fatty acids and exposure to light. Cataract, formed when the eye lens becomes cloudy by blocking some light from reaching retina, is believed to affect 20 million Americans over 40. Diabetic retinopathy, on the other hand affects 4 million Americans over 40 while glaucoma affects 2 million Americans of 40 plus.

Oxidative damage to the retina has been recognized as a potential risk for AMD and other associated vision loss. Antioxidants are believed to interact with free radicals produced in the process of light absorption, and prevent cellular damage in the retina. Results of a study called Age-Related Eye Disease Study (AREDS) sponsored by the Federal Government's National Eye Institute (NEI), MD, USA showed that taking high levels of antioxidants and zinc could reduce the risk of advanced AMD by about 25%. The results suggested that nutritional supplements can delay end-stage AMD, but had no effect on cataract. Another recent study examined the role of specific carotenoids like alpha-, beta-carotenes, beta-crypto xanthenes, lycopene, lutein, zeaxanthin to glaucoma risk and found no direct evidence.

The most biologically plausible micronutrients reported to have a protective role in AMD are the carotenoids **lutein** and **zeaxanthin**, which are present abundantly in the retina and macula. They are commonly found in leafy vegetables (spinach, broccoli, and Brussels sprout) and egg yolk. They are oxygen-containing carotenoids known as xanthophylls. Observational studies point to their association with reduced risk of AMD and Cataract by protecting against oxidative damage and as harmful (blue light) filters. Low plasma lutein and zeaxanthin concentrations or dietary intake is associated with low macular pigment density, and there is a growing

body of evidence suggesting a relationship between AMD and low levels of macular pigment. In a test tube experiment, both lutein and zeaxanthin were shown to protect human lens epithelial cells against UV light insult. For a commercial point of view it is important to note that animal toxicology studies have established the safety of lutein as a nutrient, and it is also generally recognized as safe (GRAS) for use in foods and beverages.

Zeaxanthins are yellow coloured lipid soluble xanthophylls, which are also oxidized hydroxyl derivatives of beta-carotene. They are found in highest concentration in the macular region of the eyes along with lutein, where they are believed to help filter out damaging blue light and prevent free radical damage of the delicate structures in the back of the eye. It cannot be synthesized by humans and must be obtained from the diet.

In the human blood stream, high-density lipoprotein is the major carrier of lutein and zeaxanthin. In the mammalian eye, it has been reported that retinal tubulin binds macular carotenoids, possibly as a site for passive deposition in the tissue. Recently, xanthophyll-binding proteins were partially purified and isolated from the human macula and retina and it was shown that lutein zeaxanthin bind specifically to these proteins. Such *in vitro* studies suggest that if adipose tissue and liver compete with the retina for dietary lutein in human subjects, macular pigment may be more effectively increased through supplementation with zeaxanthin than with lutein. Dietary lutein may serve as a precursor for the very high concentration of zeaxanthin found in the primate fovea, and conversion of lutein to mesoxanthin has been suggested.

Bilberry extracts are found to enhance night vision acuity, while *Gingko biloba* extracts were found to be effective against long distance visual acuity. Bilberry extracts have been used in ophthalmology for their properties in enhancing night vision acuity. This property was first reported in World War II when pilots at the British royal air force who ate bilberry jam experienced an improvement in nighttime visual acuity, faster adjustment to darkness, faster restoration of visual acuity after exposure to glare. Likewise, improvement in visual acuity of patients of macular degeneration after consumption of *G. biloba* extracts were also reported.

MARKET PERFORMANCE OF HERBAL PRODUCTS AND CONSUMER AWARENESS

In 2004, herbal health ingredient industry performed well with a growth index increase of 20%, far ahead of the Dow Jones industrial average performance of 3.6%. This index had been compiled by Adam Ismail, Business development analyst of Cargill health and food technologies, Minneapolis, USA. The index combines market capitalization of 35 natural product companies in the fields of personal care, dietary supplement, natural foods, organic foods, and functional foods. The top performer in the above list for 2004 was Hansen Natural Corporation with 340% gain due to growth and diversification in the energy beverage market.

Amongst all countries, Japan is showing higher growth in health food products. A recent study outlines that Japan will be spending its current budget worth on health care in 12 years time from now. There are three main categories of health foods in Japan, namely food supplements (vitamins, minerals, fish oils etc.), prevention foods (for life style related diseases – glucosamine, royal jelly, chlorella etc.), food for beauty (fibre, collagen, amino acids, garcenia, cambogia etc). The main challenge for new herbal products in achieving the market penetration is the lack of any direct evidence of scientific linkage of active ingredients with a specific health benefit. In case of antioxidants, differentiation between the products focusing on a particular health condition will have to be a key for selling. Sale of antioxidants grew 6-8% in 2003 and 2004, with Vitamin C, E CoQ10, Vitamin A / beta-carotene, lutein, green tea and soy isoflavones consuming the major shares.

Consumer awareness with regard to physiological or health effects of herbal products has grown considerably in the recent years. Natural Marketing Institute, Harleysville, USA have trended the antioxidant market data and come out with a Health and Wellness report, which indicates that consumers are associating antioxidants with health issues like cancer prevention (30%), immune support (20%), heart health (20%). Their report has also split such data into specific antioxidants such as green tea (20%), Vitamin C (18%), garlic (17%), Vitamin E (13%), soy (10%) and lycopene (9%). This high consumer awareness is a positive sign for the market; however, confusion in the antioxidant category when comparing one antioxidant to another for the same

effect has to be cleared (For e.g. green tea Vs grape seed). Studies have pointed out that the nutrient contents like Vitamin C, calcium, iron and phytochemicals in the fruits and vegetables grown now has a depleted content than those grown 50 years ago. It is logical to think that when the yield increases 10-fold, the nutrient content can be compromised. This aspect has been capitalised by many companies for selling their herbal products in the market.

Though a flurry of products reach the market, very few sustain the pressure to stay on. Even the well-established ingredients have been drawn to controversy by fresh research data or studies. A classic example is the "Vitamin E debacle" that hit the nutraceutical headlines recently. The issue was triggered by a report of studies published in the *Annals of Internal medicine*. A meta-analysis of 19 Vitamin E studies investigating the impact of this antioxidant on chronic diseases like cardiovascular diseases, cancer, AMD, Parkinson's and Alzheimer's disease, revealed that the vitamin is harmful to those having these diseases. Furious by the studies' outcome, the Council for Responsible Nutrition (CRN), Washington DC, USA contented that the conclusions were unscientifically extrapolated from a combination of studies on some people already at grave risk with existing diseases to the entire population. Other institutions followed the CRN suite to rescue the Vitamin E. Such issues however, have underlined the importance of safe and effective nutraceuticals, and consumers are increasingly asking questions on the effectiveness and safety aspects before deciding on the health benefits.

Companies are trying to exploit the 'nutrient gaps' in the regular diets, and are offering various solutions like multiple servings of fruits and vegetables per tablet, capsule, 8-ounce beverage or 50 g bar. The fruit/vegetable equivalency is a major selling point for many of the new products. The consumers are often advised to calculate the nutraceutical equivalent of certain amount of fruits and vegetables rather than looking at the product as nutraceutical. However, scientists are of the opinion that though the ingredients can be delivered in many forms, there exists a beneficial synergistic effect when the combination of phytochemicals with nutraceutical activity are delivered together as in natural, whole food. This aspect might be a crucial decider, and might save the traditional/natural food habits of people around the world.