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# Challenges to processed foods and solutions to improve their quality

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## FOOD IS WHAT WE EAT AND WHAT POTENTIALLY CAN "EAT" US

According to the European definition in Article 2 of regulation (EC) No.178/2002 of the European Parliament and of the Council (28 January 2002), "food" (or "foodstuff") means any substance or product – whether processed, partially processed or unprocessed – intended to be, or reasonably expected to be ingested by humans. Therefore, "processed food" has become part of a legal definition of food and indeed processed food is ubiquitous, especially in the modern western diet.

There are several ways to define processed foods. The strict definition refers to any food that is changed from its natural, raw state. For example, the whole apple is food, but a sliced or peeled apple would be considered a processed food. By this definition, humans have been eating processed food since the dawn of time. In more practical terms, processed food is defined as food that is chemically altered through additives such as flavors, flavor enhancers, binders, colors, fillers, preservatives, stabilizers, emulsifiers, or food that has been manufactured through combination methods, e.g. pasteurizing, cooking, frying, lyophilizing or spray drying. Practical food processing goes back to the prehistoric times when crude methods incorporated fermenting, sun drying, preserving with salt, roasting, smoking or steaming.

Some of the ancient methods were rendered obsolete and some that are still around are considered unhealthy, such as smoked food, which may taste great but is loaded with carcinogens. Smoked fish, meat, and charcoal-broiled steaks contain polycyclic aromatic hydrocarbons (PAHs). A number of PAHs, such as benzo[a]pyrene, are carcinogenic and mutagenic, and are widely believed to

contribute to increased incidence of a cancer in humans. PAHs of which benzo[a]pyrene is the most commonly studied and measured, are formed when fat drips onto the hot charcoal and combusts to form polycyclic aromatic hydrocarbons, which rise with the smoke to deposit on the meat (1). In addition, prolonged cooking at high temperatures results in the formation of PAHs, which adhere to the surface of the food (2). Charred surfaces of meat and fish may contain heterocyclic amines (HAs), an additional class of carcinogens, which are formed from creatine or creatinine and sugars (3).

Food processing, in addition to producing harmful byproducts, can also deteriorate nutritional quality of food ingredients. Foods like the following require little or no processing to be served and eaten with great health benefits: sweet potato (carotenoids, vitamin C, potassium and fiber), tomatoes (lycopene, vitamin C and vitamin A, and fiber), milk (calcium, vitamins, whey protein and essential fatty acids), broccoli (vitamin C, carotenoids, and folic acid and fiber), salmon (omega-3 fats), brown rice, wheat berry (vitamin B-6, vitamin E, magnesium, zinc, iron), and kale and spinach (vitamins A, C, and K, folate, potassium, magnesium, iron, lutein, and phytochemicals).

However, the same foods commonly subject to food technology to enhance their taste and appeal will result in poor nutritional value. An average half-cup serving of ice cream provides half of the daily allowance for saturated fat and a third of the cholesterol to potentially clog artery walls and contribute 300 calories to the fat cells. Ordering an Italian entrée like a very tasty homemade lasagna, lightly breaded chicken parmigiana, or creamy fettucine alfredo comes with a whopping 1,450 calories (2000 calories is the

### ABSTRACT

*Food technology and processed foods are indispensable to modern nutrition, however, it is increasingly apparent that the technology and ingredients used may pose major health risks contributing to cardiovascular disease, obesity, diabetes type 2, chronic degenerative conditions, e.g. osteoarthritis, and chronic neurodegenerative conditions, e.g. Alzheimer's disease. The science behind food processing is relatively young and controversial and it will be explored in this article.*

average daily intake), 33 g of saturated fat (recommended 10% of daily calorie intake), and 3,830 mg of sodium (the amount of sodium necessary for good health is 500 mg/day). The tasty chipotle chicken burrito consisting of tortilla, rice, pinto beans, cheese, chicken, sour cream, and salsa will set you back 970 calories and 17.5 grams of saturated fat and 2,200 mg of sodium. Traditional canned vegetable soups are loaded with salt: half a can averages more than half of a person's daily quota of salt. In addition, despite great flavor the soup's vegetables are often depleted of nutritional value due to the process of prolonged cooking that may convert nutrients into anti-nutrients with mutagenic properties.

In summary, the processed foods need to be scrutinized for their health risks to avoid food that we eat that can potentially "eat" us by causing or contributing to chronic and degenerative health conditions.

## PROCESSED FOOD, CHALLENGES

Although food additives in processed foods must be approved as safe by the national regulatory body in each country, the outcome of final food compositions is a tradeoff between consumer appeal and the nutritional and health values. Despite strict limits placed on the amount and types of ingredients in commercial foods, often it is the long list of **inadequately** researched and developed ingredients to improve taste and enhance the appearance of food that are called into question. In addition, there is no regulatory consensus on food additives worldwide therefore additives allowed in one country may be banned in another country. The controversial food additives and preservatives are natural and synthetic, some derived from natural compounds, e.g. transfat, others synthesized based on natural compounds, e.g. plant phenolics.

### Sodium Chloride - Table Salt

The "all-natural" table salt, sodium chloride, is the most common food additive and preservative, with approximately 75% of sodium in Western diets derived from processed foods. Sodium chloride is very stable and it cannot be removed from foods that have been processed and canned. A vegetable containing only a few milligrams of sodium per 100 g on the vine, may contain up to 310 times that amount after canning. There is strong evidence that our current consumption of salt is the major factor increasing blood pressure (BP) which accounts for 62% of strokes and 49% of coronary heart disease, and the risk starts at a systolic BP 115 mm Hg.

Increasing evidence also suggests that salt intake is related to obesity through soft drink consumption, associated with renal stones and osteoporosis and is probably a major cause of stomach cancer (4).

### Sodium Nitrite

One of the most controversial food additives is sodium nitrite. This compound is commonly used to preserve freshness, color and flavor of meat products and to prevent growth of bacteria, especially *Clostridium botulinum*, the microorganism responsible for botulism. Blended with food, sodium nitrite transforms into carcinogenic compounds, nitrosamines, which may be found in salted, pickled, smoked and grilled foods, e.g. bacon, ham, smoked fish, meat, sausages, hot dogs, corned beef and in the production of beer and whiskey (5). Epidemiological data suggest that nitrosamines are found more frequently and at higher concentration in Asian foods than in Western foods (6).

In the early 1970s, there were outbreaks of liver disorders, including cancer, in various farm animals in Norway. The investigation revealed that all of the affected animals had consumed feed containing herring meal, which had been preserved by the addition of relatively large amounts of sodium nitrite. Further investigation showed that the herring meal contained dimethylnitrosamine, one of the major nitrosamine compounds reported as a strong liver carcinogen nearly a decade earlier (7). It was determined that dimethylnitrosamine was formed in the fish meal as a result of a chemical reaction between dimethylamine, a commonly occurring amine in fish meal, and a nitrosating agent (nitrous anhydride) that was formed from the sodium nitrite.

### Synthetic Phenolics

Another example of questionable food preservation is in the form of synthetic phenolic antioxidants, butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT), which are used to prevent fats going rancid in cereals, chewing gum, potato chips, and vegetable oils. Both BHA and BHT are modeled on natural phenolic antioxidants however, these synthetic compounds do not act like most phenolic antioxidants; derived from nature. Of specific concern is that BHA and BHT compounds may create oxidized molecules in the process of quenching free radicals which will persist and which may act as mutagens or cancer promoters (8). Propyl gallate is another synthetic antioxidant based on natural phenolics and utilized as a preservative in meat products, chicken soup base, and chewing gum. Propyl gallate, especially when combined with sodium nitrate, has been

linked to gastrointestinal cancer in animal experiments (9).

### Transfat

Transfat may contribute to the great taste of fried foods but is proven to cause cardiovascular disease including heart disease, stroke, kidney failure, peripheral vascular disease (PVD) and chronic degenerative conditions, as well as contributing to the growing problem of obesity.

Most of the naturally-occurring unsaturated fats are composed of fatty acids with hydrocarbon chain double bonds in the "cis" configuration with the hydrogen atoms on the same side of the double bond. The industrial hydrogenation of plant oils reconfigures most of the "cis" double bonds into the "trans" configuration, orienting the hydrogen atoms on the opposite side of the double bond. Transfat has different chemical, physical and biological properties as compared to cis fat, in particular a higher melting point and resistance to rancidity, which makes it especially appropriate for cooking, processing, and storing food. Foods containing artificial transfat formed by partial hydrogenation of, for example, soy oil may contain up to 45% transfat compared to their total fat, e.g. baking shortenings generally contain 30% of trans-fat, while natural transfat in dairy products may be up to 4% as a percentage of total fat content.

Transfat, unlike cis fat, cannot be utilized properly by the body, provides no known benefit to human health and is more detrimental to one's health than saturated fat. Both saturated and transfat increase levels of LDL cholesterol or "bad" cholesterol but transfat also decreases the HDL cholesterol or "good" cholesterol levels (10) and increases levels of proinflammatory C-reactive protein (CRP) (11). The transfat cannot be easily metabolized by the human body because the metabolizing enzyme, lipase, has specificity for the cis configuration. Transfat may interfere with delta-6 desaturase, an enzyme involved in converting essential fatty acids to arachidonic acid and prostaglandins, both critically important in maintaining body homeostasis (12). The United States Departments of Agriculture (USDA) and Health and Human Services (HHS) Services recommend dietary cholesterol for healthy adults to be less than 10% of their total calories. They also suggest keeping transfat intake as low as possible. The American Heart Association has set an upper limit for transfat of no more than 1% of one's total daily calories, approximately 2 grams a day.

### Sweeteners

Natural and artificial sweeteners constitute a growing food additive category that is

simultaneously dynamic and controversial. The constantly conflicting reports on health impact of various sweeteners exemplify the conundrum in the search for healthy food solutions. Artificial sweeteners are often the subject of stories presented in the popular press claiming that they cause a variety of health problems, including cancer. However, according to the National Cancer Institute (NCI) there is no scientific evidence that any of the artificial sweeteners approved for use in the United States cause cancer.

Aspartame, also known by the brand names Nutrasweet and Equal, is a sweetener found in diet foods such as low-calorie desserts, gelatins, drink mixes and soft drinks and in individual packages used in place of common sugar. Aspartame is the methyl ester of two amino acids: phenylalanine and aspartic acid. Based on hundreds of scientific studies the U.S. Food and Drug Administration (FDA) and the World Health Organization (WHO) indicated that the additive is safe. However, the Center for Science in the Public Interest gave Aspartame their lowest ranking in safety, quoting animal studies in 2007, which suggest that there is a link between aspartame and cancer (13). Aspartame should be avoided by those with the disease phenylketonuria (PKD), an enzyme disorder, because it contains phenylalanine which cannot be metabolized by individuals afflicted with PKD.

Saccharin (Sweet'N Low, Sugar Twin) is an artificial sweetener with the chemical name benzoic sulfimide, and it is used as a high intensity sweetener in drinks, candies, medicines and toothpaste. Nutritional and food use of saccharin in populations of India and Argentina has been linked with increased rate of bladder cancer (14,15).

Sucralose (Splenda) is comprised of the high-potency artificial sweetener sucralose (manufactured by the selective chlorination of sucrose, table sugar) and the fillers maltodextrin and glucose. Evidence indicates that a 12-week administration of Splenda exerted numerous adverse effects, including reduction in beneficial fecal microflora, increased fecal pH, and enhanced expression of the P-glycoprotein, and phase 1 drug metabolizing enzymes CYP3A4, and CYP2D1, which are known to limit the bioavailability of orally administered drugs (16).

Acesulfame-K (Sunett, Sweet One), which is considered 200 times sweeter than sugar, is an artificial sweetener (the potassium salt of oxathiazine), approved by the U.S. Food and Drug Administration in 1998 for use in soft drinks. It is also found in baked goods, chewing gum, and

gelatin desserts. There is a general concern that testing on this product has been scant. Some studies showed a potential for mutagenic activity and therefore additional research is needed to conclude whether or not acesulfame-K is harmful (17).

Natural sweeteners are just as controversial as their synthetic counterparts. Sucrose or table sugar is built up from fructose and glucose monosugars, and it is a carbohydrate that occurs naturally in every fruit and vegetable. It is the major product of photosynthesis, the process by which plants transform the sun's energy into food. Sugar occurs in greatest quantities in sugar cane and sugar beets from which it is separated for commercial use. The National Health and Nutrition Examination Survey indicates that the population in the United States has increased its proportion of energy consumption from carbohydrates and decreased its proportion from total fat while obesity has increased. This implies, along with the United Nations report cited below, that obesity may correlate more accurately with sugar consumption than with fat consumption, and that reducing fat consumption while increasing sugar consumption actually increases the level of obesity. Experimental animals fed a high sucrose diet had significantly increased visceral fat, serum levels of lipids, glucose, insulin, and uric acid, insulin resistance and blood pressure. Sucrose is an example and standard for a high glycemic index food additive. Recent research data links high sucrose intake with increased risk of cancer (18).

### Food Coloring

Artificial colors are still popular in food coloring despite the fact that research data on the safe use of these colorants is lacking. Color Blue 1 or Brilliant Blue FCF, a dye derived from coal tar, is found in ice cream, tinned processed peas, dairy products, sweets, and drinks despite the fact that the Hyperactive Children's Support Group and the Feingold Association recommends elimination of this colorant from the diet of children, and Blue 1 was linked to inducing cancer in experimental animals (19).

Color Red 3, or erythrosine, is a fluorone dye used to impart color to cherries, fruit cocktail, candy and baked goods, despite being shown to cause thyroid tumors in rats (20). The evidence that this dye caused thyroid tumors in rats was convincing, according to a 1983 review committee report requested by the FDA. Red 3 has been replaced by the less controversial Red 40 or Allura Red azo dye obtained from petroleum and used in soda pop, candy, gelatin desserts, pastries, pet food and sausage. However, azo dyes

may be mutagenic and carcinogenic and cause acceleration of tumor formation in experimental animals (21).

Cochineal extract is a coloring obtained from the cochineal insect, which lives on cactus plants in Peru, the Canary Islands and elsewhere. Carmine is a more purified coloring made from cochineal, but in both cases, carminic acid actually provides the red color. These colorings, which are extremely stable, are used in some red, pink or purple candy, yogurt, ice cream, beverages, and other foods, as well as in drugs and cosmetics. A small number of people have been found to have allergies to carmine, ranging from mild cases of hives to atrial fibrillation and anaphylactic shock, and asthma. Cochineal is one of the colors that the Hyperactive Children's Support Group recommends be eliminated from the diet of hyperactive children (22).

The widely used Sunset-yellow or Yellow 6 is a synthetic coal tar and azo yellow dye useful in fermented food, orange squash, orange jelly, marzipan, Swiss roll, apricot jam, some brands of peach yogurt, citrus marmalade, lemon curd, sweets, fortune cookies, hot chocolate mix, packet soups, trifle mix, breadcrumbs and cheese sauce mix and soft drinks. Yellow 6 can also be found in over-the-counter medicines, e.g. DayQuil and Tylenol. Sunset-yellow is also combined with Amaranth dye, in order to produce a brown coloring in both chocolates and caramel.

Sunset Yellow may be responsible for causing allergic reactions in people with aspirin intolerance, and it may result in various symptoms including gastric upset, diarrhea, vomiting, nettle rash (urticaria) and swelling of the skin (angioedema) (23,24). The coloring has also been linked to hyperactivity in children (25).

### Taste Enhancer Monosodium Glutamate

Commonly associated with Asian foods is the flavor enhancer monosodium glutamate (MSG), an amino acid derivative added to soups, salad dressings, frozen entrees and restaurant food. MSG may be found in Blue Diamond Almonds brand, spicy flavors such as Jalapeño Smokehouse and Wasabi flavor, Cheez-It snack crackers and BBQ-flavored Potato Chips.

MSG is produced through a fermentation process using starch, sugar beets, sugar cane or molasses. In 1968 the monosodium glutamate symptom complex, also known as the Chinese restaurant syndrome, was first described. MSG Symptom Complex can involve symptoms such as numbness, burning sensation, tingling, facial pressure or tightness, chest pain, headache, nausea, rapid heartbeat, drowsiness, and

weakness. Asthmatics may experience these symptoms as well as difficulty in breathing.

MSG can potentially be an excitotoxin. Excitotoxins are molecules, such as glutamate and aspartate, that act as excitatory neurotransmitters, and can lead to neurotoxicity when used in excess. In 1992 the FDA contracted with the Federation of American Societies for Experimental Biology (FASEB), an independent group of scientists, to complete the most comprehensive review of available scientific data on glutamate safety to date. The 1995 FASEB report reaffirmed the safety of MSG when it is consumed at usual levels by the general population, and found no evidence of any connection between MSG and any serious long-term reactions. The report indicated that no evidence exists to suggest that dietary MSG or glutamate contributes to Alzheimer's disease, Huntington's disease, or any other long-term or chronic diseases. There was also no evidence suggesting that dietary MSG or glutamate causes brain lesions or damage to nerve cells in humans.

A number of anecdotal reports and small number of clinical studies have attributed a variety of symptoms to the dietary ingestion of MSG. Fibromyalgia is a common rheumatologic disorder that is often difficult to treat effectively. In one study a group of patients had complete, or nearly complete, resolution of their fibromyalgia symptoms within months after eliminating monosodium glutamate or MSG plus aspartame from their diet. All had a recurrence of symptoms whenever MSG had been ingested. The authors of the study suggested that elimination of MSG and other excitotoxins from the diets of patients with fibromyalgia may be an effective therapy of the condition (26).

## HEALTHY FOOD SOLUTIONS

Food processing and technology is with us to stay and to improve. With science based technology and new or improved ingredients, processed food can actually acquire additional health qualities in form of functional foods, e.g. plant sterol enriched butter spread to lower cholesterol levels or an increased amount of antioxidant lycopene in tomatoes processed into tomato paste.

Food ingredients come from many different sources, however the trend is to derive them from natural sources without chemical alterations. Fruits and vegetables are a common source of food additives. For example, thickening agents are increasingly extracted from seeds, fruits and seaweeds while tartaric acid taken from fruits is used to make some foods more acidic and improve their stability.

Even for the most accepted and safe synthetic food additives such as ascorbic acid (Vitamin C) and tocopherol (Vitamin E), both used to keep foods from becoming rancid, the trend is to obtain them in natural forms or nature-derived substitutes, e.g. plant phenolics. Similarly, edible oils and their mixtures are examples of natural substances used as emulsifiers to stop foods from separating and which are now developed into natural substitutes for trans fats. In place of chemically modified starches and cellulose used as thickening agents, a broad range of natural gums, oleoresins and hydrocolloids – water soluble fibers – are currently being tested and re-discovered as safe and healthy substitutes. The natural colors obtained from tomatoes – lycopene – and sweeteners – inulin from chicory – with added nutritional values, antioxidant and low glycemic index respectively, are in increasing demand in food industry. The technology in processing natural raw materials into natural food ingredients is changing in direction to use water and ethyl alcohol instead of other organic solvents. The new technology also utilizes solvent free and environmentally friendly extraction of natural additives from their respective raw materials with CO<sub>2</sub> or supercritical extraction process. This process is effectively applied in obtaining a spice ginger oleoresin as a food additive as well as antioxidant carotenoids, e.g. asthaxanthin from seaweed.

### Natural Food Preservatives

In 1970s it was discovered that ascorbic acid inhibits nitrosamine formation which further paved way for use of antioxidants as food preservatives. It was found that ascorbic acid is oxidized to dehydroascorbic acid and in the process a potent nitrosating agent formed from sodium nitrite, nitrous anhydride, is reduced to nitric oxide, which is not a nitrosating agent. The addition of 550 ppm of ascorbic acid is used in the manufacture of cured meat in the U.S., but most cured meat manufacturers add erythorbic acid (an isomer of ascorbic acid) rather than ascorbic acid, which is as effective as ascorbic acid in inhibiting nitrosamine formation and is also cheaper than vitamin C. Other antioxidants like alpha-tocopherol (vitamin E) are also used with cured meats to inhibit nitrosamine formation. Thanks to the use of these antioxidants there are now significantly lower levels of nitrosamines in fried bacon and other cured meats than there were some years ago.

Recently plant phenolics, a large family of botanical antioxidants, have been successfully tested as safe and healthy food preservatives. The *Curcuma longa* vern. turmeric extract is

standardized for curcumin and its derivatives demethoxycurcumin and bisdemethoxycurcumin, collectively known as curcuminoids. Turmeric is one of the oldest and most widely-used botanicals in human nutrition, preserving food from spoilage as well as improving its organoleptic value – it is a major component of a curry blend.

Curcuminoids can prevent deterioration of food caused by cooking, preventing pyrolysis, i.e. high temperature and free-radical fueled process of nutrient deterioration (27). Curcuminoids interact with dimers, a free radical species generated from the pyrolysis, terminating the dimer in its initial stages. Unlike synthetic phenolics (BHT, BHA) which in oxidized form can act as pro-oxidants and mutagens, curcuminoids disintegrate upon neutralizing the free radicals and transform into derivative compounds, e.g. vanillin, ferulic acid, and a dimer of curcumin. Curcuminoids possess a broad antioxidant action described as Bioprotectant (Badmaev V., Majeed M 1998) action, i.e. they can prevent free radical formation as in preventing food rancidity, and intervene to disable free radicals as in quenching existing free radicals. Curcuminoids can also prevent toxicity of nitrosamine, dimethylnitrosamine by inducing enzyme heme oxygenase-1, an important antioxidant enzyme that plays a pivotal role in cytoprotection against noxious stimuli of both endogenous and exogenous origin (28).

*Rosmarinus officinalis* vern. rosemary extract is the source of phenolic antioxidants that are as versatile as curcuminoids, also used as a traditional and modern food preservative. Rosemary extract is standardized for rosmarinic acid, carnosic acid and carnosol. Rosemary extract can inhibit benzo(a)pyrene- or aflatoxin B1-induced DNA adduct formation by strongly inhibiting CYP450 metabolizing enzyme activities and inducing the expression of internal anti-oxidant glutathione S-transferase (29).

*Zingiber officinalis* vern. ginger extract standardized for gingerols and shogaols is one of the best recognized food preservatives and additives. In experimental conditions, ginger administered with parabens or esters of para-hydroxybenzoic acid, controversial food preservatives implicated in breast cancer, could prevent paraben-induced lipid peroxidation. Ginger also increased significantly the activities of internal antioxidants, i.e. superoxide dismutase, glutathione peroxidase, catalase and ascorbic acid (30).

In addition to versatile antioxidant food preservative action, curcuminoids, rosemary and ginger have antimicrobial

properties against gram positive, gram negative bacteria and yeasts. In one study, 5% concentration of ginger and curcuminoids extract was effective in inhibiting growth of a broad range of histamine-producing bacteria including *Vibrio parahaemolyticus*, *Bacillus cereus*, *Pseudomonas aeruginosa* and *Proteus mirabilis* (31). In one study Ginger extract was effective in inhibiting growth of *Clostridium botulinum* (32).

The addition of a combination or a stand-alone curcuminoids, rosemary and ginger extracts to soup mixes, canned soups, canned food, cooked, broiled, fried foods, ground meats, cured meats, dairy products (cheese, yogurt, smoothie juices) is recommended to improve nutritional value, prevent bacterial overgrowth and protect against chemical and biological carcinogens and toxins. All three extracts have a long-standing history of culinary use and have been proven in many recipes, especially in Asian and European food preparation. The science behind three ingredients confirms practical values of these ingredients as food preservatives derived from ages, if not millennia, experience in various cultures.

### Transfat Replacement and Transfat Lowering Additives

As a result of scientific and epidemiological findings, many foods have been modified to reduce the amount of transfat, and the manufacturers are required to label transfat amounts on the product label. However, many restaurants and fast food chains still serve foods rich in transfat, including the "must-have" French fries. Therefore finding a substitute for transfat that would be acceptable to consumers and economically feasible is a pressing matter, and one of the leading themes in food technology science. Currently there is no single solution that would work in every food category.

A diet enriched in plant-derived sterols can prevent absorption of transfat. Phytosterols, referred to as plant sterols and stanol esters, are a group of naturally-occurring compounds found in plant cell membranes in nuts, seeds, fruits and vegetables. Because phytosterols are structurally similar to the cholesterol, when they are consumed they compete with fatty acids in micelles for absorption in the digestive system. The 6-month and 1-year consumption of 1.5 and 1.6 g/day respectively of microcrystalline sterols did not have any obvious adverse effects in hypercholesterolemic or healthy subjects. Foods enriched with sterol or stanol esters can reduce blood cholesterol levels by 10 to 15% (33).

The transfat can also be replaced in foods with new fat products based on

technology called interesterification. Interesterification is a chemical or enzymatic process that switches out undesirable fatty acids. Soybean oil, for example, naturally contains a mixture of saturated, mono- and polyunsaturated fatty acids. Through interesterification, saturated fatty acids can be replaced with healthier fatty acids – and the resulting product is turned into a product that can be baked into cakes, bread, crackers and other foods. However, some studies have shown that these novel fats may be harmful by decreasing insulin sensitivity, increasing blood sugar levels, as well as adversely affecting good cholesterol.

In the interim there are several viable alternatives to transfat. Frying chicken in canola or soybean oil instead of partially hydrogenated transfat shortening is an easy switch. These oils, their stability, shelf-life and health benefits, can be further enhanced with deodorized rosemary extract standardized for rosmarinic acid.

The cholesterol and transfat lowering composition may consist of chia seed extract, xanthan gum, locust bean gum and sesame seed. This composition containing phytosterols, essential fatty acids omega-3 and dietary fiber is aimed at blending with animal fats, such as butter or lard, or tropical oils such as palm or coconut oil to keep the taste, and prevent saturated fat and trans fat from gastrointestinal absorption. This formula does not interfere with a taste profile, enhances the texture and improves functionality. This composition is formulated to provide at least 2 g of sterols per day in final food formulations. This amount has been shown to reduce cholesterol and transfat absorption.

### Natural Sweeteners with Low-Glycemic Index Properties

The need for sweeteners in the food industry and ongoing health concerns with both natural and synthetic substitutes brings focus on the category of sweet tasting soluble fiber. Soluble fiber like oligosaccharides is found in oats, peas, beans, apples, citrus fruits, carrots, chicory, barley and psyllium. Soluble fiber can help lower blood glucose levels and offers good glycemic index as well as the desired sweet taste.

The low-glycemic botanicals are an important growing category in view of epidemic proportions of diabetes type 2 and the metabolic syndrome condition. The common sense definition of low-glycemic foods is carbohydrate-containing foods that produce relatively small changes in blood glucose. In more scientific language, foods with a "glycemic index" of less than 50 produce less than half the area-under-the-curve elevation of blood glucose compared to a reference

amount of ingested glucose. Low Glycemic Index foods – GI less than 55, Medium Glycemic Index foods – GI index between 55 and 70, High Glycemic Index foods – GI more than 70.

The GI is young science and the authorities may have a difficult time in regulating the proper use of term "low-glycemic" index. For example, fruit does not equal fruit. An Apple has GI –34, but depending on what kind of apple and its ripeness the value of GI may be higher. Lentils may have GI-40, but GI for baked beans may jump to 69. Slow cooked oatmeal has GI-70, but one-minute oatmeal may have GI-87. Potato does not equal potato. Sweet potato is considered low glycemic food, GI-54, but regular boiled/mashed potato has GI-104 and French fries have GI-107. Despite obvious challenges, the term glycemic index with proper education could become a practical guide for people with diabetes and those seeking a healthy life style. The glycemic index is also scientifically sound, and it has been found that reducing dietary GI improved glucose and lipid metabolism and normalized fibrinolytic activity in type 2 diabetics. The concept of glycemic index foods is particularly important in the United States in the next 50 years because it is projected that the percentage of adults with type 2 diabetes will exceed 30%, with the vast majority older than 65 years. Although few data are available regarding the optimal nutritional regimen for the elderly with type 2 diabetes, as a general rule, the use of nutrient-dense, low glycemic index, high-dietary fiber foods with possibly higher protein intake is recommended.

Water extract of chicory devoid of bitter flavor contains inulin, an example of natural low-glycemic index sweetener which could be used as a standalone, in combination with other sugar or combined with hydrocolloid gums and resins as a fat substitute for margarine, baked goods, fillings, dairy foods, frozen desserts, salad dressing. Inulins are a group of naturally occurring oligosaccharides (several simple sugars linked together) produced by many types of plants. They belong to a class of carbohydrates known as fructans, which are fructose-containing polymers that occur in common foods, such as Jerusalem artichokes, plums, agave, raisins, chicory root and wheat.

Inulin also enhances mouthfeel and taste in beverages, yogurt, soups, sauces, spreads and intermediate moisture foods through its unique textural properties. It also performs well in cooking and baking applications. Inulin provides an easy way to add additional fiber to the diet through foods and drinks.

Inulin doesn't raise blood sugar levels, so it may help people with diabetes. It

also stimulates the growth of friendly bacteria in the large intestine, acting as pre-biotic or food for pro-biotics (good bacteria) and lowers blood cholesterol.

### Natural Food Colorants

Fruit- and vegetable-derived carotenoids exemplify safe, versatile and healthy red coloring which can easily replace controversial Color Red 3. Tomato extract yields a cherry-red color and meets the consumer demand for non-synthetic color of non-animal origin, with the health benefits of tomato lycopene and other carotenoids. The most abundant carotenoid in tomato is lycopene, followed by phytoene, phytofluene, zeta-carotene, gamma-carotene, beta-carotene, neurosporene, and lutein. Tomato extracted cherry red is effective and stable over a wide range of temperatures exhibiting no signs of color shift. Available oleoresin offers manufacturers liquid coloring choices in shades of yellow, Sunset yellow through blood orange. Tomato cherry-red is an ideal colorant for beverages. It also works in dairy, bakery, confectionery, sauces and condiments, and a variety of other applications. Tomato extract is approved as a food colorant in the US, Europe and Japan.

Spirulina, a microalga, is a source of food with a broad range of antioxidant and regenerative properties attributed to chromophore phycocyanin (phycocyanobilin), an intense navy blue coloring compound. The biological mechanism of phycocyanin is similar to superoxide dismutase (SOD), both compounds acting as potent inhibitors of NADPH oxidase, an enzyme which is a source of excessive oxidant stress in a disease, especially inflammatory disease. The synergistic mechanism of SOD and phycocyanin is utilized combining them in functional food colorant compositions which besides imparting navy blue color may play a role in supporting internal antioxidant systems against disease. The blue color is water soluble and stable in a broad range of pH and temperatures with neutral taste and can be incorporated into a broad range of foods and drinks including fruit juices and "smoothies".

The food spice and preservative turmeric is a source of curcumin, and its derivatives demethoxycurcumin and bisdemethoxycurcumin, collectively known as curcuminoids, yield a radiant, sun-yellow pigment. Curcuminoids are fat soluble and, therefore, their coloring applications have been limited to certain type of foods. In addition it has been well recognized that, due to physical and chemical properties, curcuminoids are poorly bioavailable for its biological functions. Recently a new form of nanocurcuminoids preparation has been developed that provides safe and

effective delivery of the intact phenolic compounds with foods and drinks. The nano formula allows up to 30 times better bioavailability than standard curcuminoid extract. The nano curcuminoids' yellow color is stable in a broad range of pH, temperatures, and it has neutral taste.

### Monosodium Glutamate Substitute

Umami is the term derived from Japanese language and food culture that identifies brothy, meaty taste that makes a variety of foods palatable. Umami is defined by substances such as L-glutamate salts, which were discovered by Ikeda in 1908 and became a basis for a synthetic food additive monosodium glutamate (MSG). How it adds flavor to other foods is not fully understood, though scientists believe that when someone ingests MSG it reacts with glutamate receptors on the tongue to enhance meat-like taste.

Due to previously discussed health concerns, there is a need to substitute MSG by natural food compositions which would contain glutamate and 5'-ribonucleotides such as inosinate and guanylate, without adverse effects on human health. The safe Umami flavor enhancer is especially needed since it is now very popular worldwide, added to a variety of restaurant and fast-foods, canned vegetables, soups and processed meats. Glutamic acid is a major constituent of food proteins and is present in most foods, such as meat, poultry, seafood and vegetables. Two ribonucleotides that contribute most to the umami taste, 5'-inosinate and 5'-guanylate, are also present in many foods: inosinate primarily in meats, whereas guanylate is abundant in plants. Another ribonucleotide, 5'-adenylate, is abundant in fish and shellfish. Kelp is an example of a vegetable which can impart the umami taste, especially when soaked in soup or water. In addition the substitute for MSG may include brown seaweed, microalgae (blue-green algae), its component alginate as well as xanthan and guar gums. The extract of *Emblica officinalis* (Amla) can be added to Umami compositions to further enhance the desired taste.

### Versatile Food Substitutes: Gums from Past for the Future

New technologies allow removal from foods of potentially unhealthy ingredients like gluten present in, e.g. wheat bran or avoiding wheat all together. Gluten is a protein causing gastrointestinal inflammation leading to poor nutrient absorption and gradual deterioration of general health. However, removal of wheat flour and gluten requires a wheat flour substitute for bakery and other

foods. The substitute should include swelling-control, starch-like material to improve the bread-making ability, the palatability, and the taste and texture of resulting foods.

Natural gums are plant-derived polysaccharides that are increasingly used in the food industry in gluten-free products. They are used to thicken foods, prevent sugar crystals from forming in candy, stabilize beer foam, form a gel in pudding (furcelleran), encapsulate flavor oils in powdered drink mixes, or keep oil and water mixed together in salad dressings. Gums are often used to replace fat in low-fat ice cream, baked goods, and salad dressings.

Guar gum is extracted from the guar bean and chemically is a galactomannan composed of the sugars galactose and mannose. Guar gum shows viscosity synergy with xanthan gum. Xanthan gum is also used in gluten-free baking. Xanthan gum is used to give the dough or batter a "stickiness" that would otherwise be achieved with the gluten. In addition it also helps thicken commercial egg substitutes made from egg whites, to replace the fat and emulsifiers found in yolks. Polysaccharides derived from marine plants including carrageenans and agar are widely used for their ability to form gels and act as thickeners, emulsifiers and stabilizers in a variety of foods. Carrageenans are a family of sulphated polysaccharides that are extracted from red seaweeds. Agar or agar agar is a gelatinous substance derived from seaweed.

A complementary addition to gluten-free food compositions is fiber-rich chia seed powder; it improves texture and helps prevent moisture migration in frozen products. Chia powder absorbs 12 times its weight in water and helps prevent staling in food processing. Chia powder can be used as a partial or total substitute for wheat flour.

The use of gums as food is not a new idea. The Biblical manna (Exodus 16:14) exemplifies food material utilized in modern food technology. The Biblical manna inspired the name of the polysaccharide mannan that is a polymer of sugar mannose and is generally found in yeast, bacteria and plants.

Manna according to the Bible, was eaten by the Israelites during their travels in the desert as food, keeping them alive. In the Book of Exodus, manna is described as being available six mornings a week, after the dew had evaporated. It is described in the Book of Numbers as arriving with the dew during night. Israelites ground it up and it pounded into cakes, which were then baked, resulting in something that tasted like cakes baked with oil. Exodus states that raw manna tasted like wafers that had

been made with honey.

While there is no science available to exactly determine the nature of Biblical food, manna may symbolize an important lesson from the past: food that we need may be with us waiting for re-discovery.

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## NutraCos news

### CYVEX NUTRITION ANNOUNCES RESEARCH PARTNERSHIP WITH THE SALK INSTITUTE FOR BIOLOGICAL STUDIES

Cyvox Nutrition announced that it has entered into a R&D partnership with the Salk Institute for Biological Studies to examine the effects of vinpocetine, as *BioVince*® from Cyvox Nutrition, and fisetin, separately and in combination, on cognitive function. Three *in vitro* assays relevant to cognitive function and memory will be conducted to determine if these compounds work synergistically and if further testing is warranted. *BioVince*, a proprietary extract of the periwinkle plant, has been shown to support brain functions such as concentration and memory due to its overall neuroprotective properties, as well as its ability to enhance cerebral blood flow. Fisetin, a naturally occurring flavonoid found in strawberries and other fruits and vegetables, has been shown to

stimulate the signaling pathways that enhance long-term memory. Cyvox will supply both compounds for testing.

### LIPID NUTRITION INTRODUCES HIGH CONCENTRATED STABLE OMEGA-3 EMULSION

MARINOL® OMEGA-3 EMULSION, SUPERIOR TASTE, SUPERIOR STABILITY  
Lipid Nutrition introduces *Marinol*® Omega-3 Emulsion worldwide. This highly concentrated fish oil emulsion with superior stability creates better opportunities for food companies to fortify food application with omega-3 fatty acids and create a great tasted healthy food product. *Marinol*® Omega-3 Emulsion contains high concentration of the two of the most important long-chain polyunsaturated fatty acids (LC-PUFAs): eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The superior stability of the emulsion prevents the formation of notorious smell and taste of fish. Therefore it increases the applicability of

EPA and DHA in food products, such as milk.

"Lipid Nutrition realized that the challenge for any food or dietary supplement manufacture has been to find a way to incorporate omega-3 fatty acids into their products without compromising taste and stability," said MIRIAM VAN WANROIJ, Application Manager for **Lipid Nutrition**. "With this new emulsion there is a solution to create a more stable and tasteful product without compromising of the fortified Omega-3 concentration." People are increasingly looking for food products and ingredients that will help them live longer, healthier lives. One of such ingredients that consumers know about and are very interested in is omega-3 fatty acids. This new Emulsion will be added to the product range of *Marinol*®, highly concentrated, oils and powders that offer different EPA and/or DHA ratios to provide specific health benefits. The highly versatile application properties and concentrations make it easier to give everyone the optimum amounts of EPA and/or DHA they need.