FOOD ADDITIVES

by
Nancy Borgeson
with
Stefan Müller
and
Akihiro Kishi

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (concluded)

SUMMARY

The term *food additive* applies broadly to chemicals that are added to food, either intentionally or indirectly, to facilitate processing, maintain product consistency, extend shelf life, ensure microbiological safety, improve or maintain nutritional value, or enhance the organoleptic qualities (flavor, color and texture) of the finished products. This report covers nine major product categories of food additives including thickeners and stabilizers, alternative sweeteners, colors, fat substitutes, enzymes, vitamins, antioxidants, preservatives, and emulsifiers. A tenth product category—an emerging one—nutraceutical additives, is included for the second time in the report. Information on flavors, fats and oils, and acidulants, and more information on certain food additives covered in this report, can be found in the Chemical Economics Handbook (CEH) Program's *Amino Acids*, *Citric Acid*, *Fats and Oils Industry Overview*, *Food Processing Industry Overview*, *Sorbitol*, *High-Intensity Sweeteners* and *Water-Soluble Polymers* marketing research reports; *Aroma Chemicals and the Flavor and Fragrance Industry* and *Lactic Acid* product reviews; and *Malic Acid—United States* and *Tartaric Acid—United States* data summaries; and the SCUP *Flavors and Fragrances* and *Water-Soluble Polymers* reports.

The food additive industry as a whole is highly fragmented, with a plethora of products and participants serving a common end-use market—the food industry. Additives manufacturers vary greatly in size and product/market focus. However, with a few exceptions (the most notable being Danisco), producers typically supply additives in a limited number of product categories (e.g., colors, enzymes, vitamins) or service-selected food sectors (e.g., dairy-based products, meats, bakery products). Downsizing and consolidation in the food industry have over the last five or so years had considerable impact on traditional customer-supplier relations. Food additive manufacturers are required to provide more technical service and formulation expertise and to compete more aggressively for a smaller number of large accounts. Distribution is typically direct from additive producer to food processor for large-volume sales, with distributors playing an important role in servicing/supplying regional and/or smaller accounts.

Consumption of major food additives for 1998 and 2001, and forecast growth ranges to 2006 in the major developed and consuming regions of the world are summarized in Table 1. In 2001, the value of food additive consumption of the product areas covered in this report (excluding nutraceuticals in the United States and Europe where available data do not appear reliable) reached *data removed* and is projected to grow at an average annual rate of *data removed* (fixed price dollar basis) per year, reaching an estimated *data removed* by 2006. Changes in pricing, particularly in those segments tarnished by price-fixing or where China has become a significant competitive factor, and foreign exchange rates may cause some of the category growth rates to appear somewhat contradictory in terms of value.

While there are many differences in food tastes and preferences among the three world regions, the major trends driving the food additives industry appear to be very similar in all regions—concern over health and nutrition, food safety and health consciousness, desire for convenience, the concept of value added and the high costs associated with R&D, and new product commercialization. Growing concern regarding of the connection between diet and major diseases such as cancer and heart disease has caused consumers to reexamine their diets and lifestyles and seek healthier alternatives. The consumer desire for healthier, more nutritious foods will favor natural additives and ingredients as well as those that reduce calories, sodium, cholesterol and the overall fat in foods. Fortification with the "right" level of vitamins, amino acids, and minerals will be important, and additives that sound natural (e.g., pectin, vitamin C, enzymes) versus chemical (e.g., potassium benzoate, butylated hydroxyanisole) will have a more favorable consumer image. Bioactive additives and ingredients—like PUFAs (polyunsaturated fatty acids), plant sterols, pre- and probiotics—will also receive increasing attention from both consumers and food manufacturers.

Table 1

Consumption of Food Additives by Major Region
(millions of dollars)

	United States			Western Europe[a]			Japan[b]		
	1998	**2001**	**Average Annual Growth Rate, 2001-2006[c] (percent)**	**1998**	**2001**	**Average Annual Growth Rate, 2001-2006[c] (percent)**	**1998**	**2001**	**Average Annual Growth Rate, 2001-2006[c] (percent)**
Thickeners and Stabilizers	1,31		Data Removed						
High-Intensity Sweeteners	520-52								
Alternative Sweeteners[d]	136								
Colorants	24								
Fat Replacers	355								
Enzymes	185-18								
Vitamins	208-215								
Antioxidants	69								
Preservatives	153								
Emulsifiers	350								
Nutraceuticals	na								
Total	3,535-3,549								

a. Value in U.S. dollars was calculated throughout this report using a currency exchange rate for Western Europe of DM1.85 per dollar for 1998 and 1.13 euros per dollar for 2001.

b. Value in U.S. dollars was calculated throughout this report using a currency exchange rate for Japan of ¥131 per dollar for 1998 and ¥121.5 per dollar for 2001.

c. Average annual growth rates were computed from unrounded data.

d. Nutritive specialty sweeteners, such as sorbitol, mannitol, xylitol, and (for Europe and Japan) crystalline fructose. Does not include commodities such as sucrose, high fructose corn syrup, dextrose, lactose, etc., and (for the United States) crystalline fructose.

SOURCE: SRI Consulting.

In addition to the traditional processed food products, a new food segment known as *nutraceuticals* or *functional foods* could dramatically change food markets during the next decade. A nutraceutical can be broadly defined as any substance that may be considered food or part of a food that provides medical and health benefits, including the prevention and treatment of disease. (In the section on nutraceutical additives in this report, we define the term *nutraceutical* to mean the emerging category of nonessential bioactive substances that can be or are used as additives or ingredients in foods and beverages and that are considered to provide positive physiological or therapeutic effects. We exclude vitamins and minerals for which Reference Daily Intakes (RDIs) have been established, fat substitutes and high-intensity sweeteners from the nutraceuticals category where other publications may not. A large volume of research has been devoted to the alleged favorable effects on health of such ingredients as dietary fiber, various carotenoids, oligosaccharides and omega-3 fatty acids. Among other food additive categories, vitamins, antioxidants, gums, plant extracts and certain carbohydrates may benefit from this new force. Phytochemicals (plant-derived substances such as phenolics, flavonoids or indoles that are considered nutritionally, physiologically and/or medically highly active) will clearly be a growth area and are emerging as a possibility for enhancing traditional products. In the United States, nutraceuticals will have to be better conceived, better priced, and their benefits better communicated before these products can gain large markets. In contrast, in Japan and several countries in Europe the concept of nutraceuticals or functional foods is well established, in terms of regulation as well as consumer acceptance.

As a result of this trend toward healthier lifestyles and foods, alternative sweeteners and (with the exception of Japan) fat substitutes are among the fastest growing categories in the industry and are expected to show good growth during 2001-2006. While calorie reduction has been dominated by nonnutritive sweeteners, market growth for this category will slacken in the United States and Japan as competition from alternative sweeteners, particularly polyols, increases.

While fat replacement is still very important to consumers in the United States, over the last several years the interest in low- and no-fat products has weakened. Even the advent of olestra in snack food products and the introduction of some other “true” fat substitutes like salatrim and caprenin have not provided the solution. Still, the fastest growth for fat substitute–containing products is expected to be in the United States, where diets have historically been higher in fat and sugar and consumers appear to have more problems with obesity/weight control and associated diseases. In Europe, consumer preference for low-fat, low-calorie foods perceived as natural, rather than artificial, has tended to limit gains for fat replacers. And as in the United States, European consumers are looking for an indulgent quality in low-fat foods. On the regulatory side, fat substitutes face more daunting approval challenges in Europe than do other types of additives. In Japan, the market for fat substitutes is currently very small. Even with the increase in fat and oil consumption that has followed westernization of diet and lifestyle and the recognition that excessive fat/oil intake can be a health problem, interest in fat replacement is not expected to drive significant usage growth in the next five years.

The safety of the food supply continues to receive a great deal of attention from the press, public and governments. In 1993, an outbreak of food poisoning in the United States, eventually traced to undercooked beef, caused fundamental changes in regulatory policies and demonstrated to food processors the need for increased caution against food pathogens. The European outbreaks of mad cow disease, or bovine spongiform encephalopathy (BSE), have created serious concerns about cattle-derived food products, including some dietary supplements and personal-care products.

Fast-paced lifestyles will continue to drive the demand for savory, high-quality convenience foods in all three regions. Microwavable and shelf-stable products that are tasty and healthy require additives such as specialized flavors, colors and stabilizers to enhance and maintain quality, which will result in continuing growth of these additives. The concept of value-added products is also of great interest to food processors, since foods with added value, or at least perceived added value (e.g., reduced-fat, low-calorie, vitamin-enriched, more convenient form or package, perceived prevention of particular diseases), particularly in light of increased consumer price sensitivities, garner higher margins. Therefore, consumption of additives that can aid in adding value to processed foods will continue to grow during the next several years.

Following trends in the United States, the European market is showing increased interest in ethnic foods and meatless foods. The motivation in both cases is to promote health. Also, more products are being introduced that are aimed at very specific groups, including children, teenagers, women and in particular the growing population of elderly persons.

Another issue affecting the growth and broadening of the food additives industry is increasing government regulatory activity. In the United States, in the early and mid-1990s, there was great debate regarding labeling requirements for food products with regard to nutrition, ingredients, serving/portion size, product descriptors and health statements on food labels, as well as potential changes in government diet recommendations. The debate over health claims for foods and health statements (structure/function statements) on dietary supplements continues. The advent of the Common Market brought about much discussion regarding the harmonization of regulation in the European food industry sector. In 1994 and 1995, directives dealing with sweeteners, colors and other additives were put in place along with some subsequent amendments. In 1997 a directive regarding novel foods and food ingredients was adopted, followed in 2000 by a directive addressing labeling of foodstuffs and ingredients containing additives that have been genetically modified or produced from genetically modified organisms. Japan made a major change in its food additives regulation in 1995, bringing under MHW's purview natural-based food additives for the first time, so long as they are new substances. Prior to 1995, only synthetic substances for use as food additives were regulated.

Genetic modification of foodstuffs or the raw materials from which many additives are derived is an issue on which the major regional markets have significant disagreement. In the United States, there is no requirement that food ingredients or additives derived from GMO sources be labeled as such on finished food products. In Europe, where suspicion of biotechnology is much more entrenched, regulation requires that foods and food ingredients wholly or partly derived from genetically modified soybeans and corn must be labeled accordingly. Currently there is discussion as to whether there should be a minimum threshold for the presence of GMOs in food below which specific labeling would not be compulsory. The European Union is hesitating between 1% and 2% maximum for traces of DNA or protein resulting from genetic modification. Differences in regulations concerning GMO-derived additives among countries not only present trade barriers to transnational additive suppliers but can result in companies' having to bear the costs surrounding offering both GMO and non-GMO (or IPO—identity-preserved) materials.

R&D for food additives can be quite costly, with R&D expenditures as a percent of sales ranging from 1% or less for average products such as preservatives to 5% or higher for more technically oriented products such as fat substitutes and natural colors, and 5-10% for flavors. These costs, coupled with the time and money needed to perfect, gain approval for and successfully market a new food additive product, may make new product development unattractive for many additive producers. Volumes of some additives used by the food industry are quite small and pricing is highly competitive, so potential sales are not large enough to warrant extensive R&D.

The food additives industry has been consolidating over the last ten years, and this trend is expected to continue in the future as a result of increasing R&D costs, regulatory constraints and competition among producers. More and more, food manufacturers are looking to additive suppliers to carry out new product development efforts. Strong working relationships between food processors and food additive suppliers will continue to develop. Larger additive producers with focused R&D programs, adequate financial and technical resources, and strong patent positions appear to be in the best position for developing new products in the future.

While there may be some minor differences among regions, major key factors for success remain the same in all regions:

- In-depth knowledge of food industry sectors and a basic understanding of consumer needs
  - Current products in use and their attributes/problems
  - Trends affecting the sector

- Manufacturing/application expertise
  - Strong procurement position for natural ingredients from foreign sources
  - Economical production and raw material sourcing
  - In-house product development and formulation expertise
  - Custom tailoring of products
  - Production of quality products and meeting strict specifications
  - Thorough knowledge of food product process requirements

- Technically trained/specialized sales force
  - Ability to solve customers' technical questions/problems
  - Service orientation

- Competitive price/performance

- Strong commitment to R&D
  - Adequate financial and technical resources for product development and regulatory approval process
  - Focused R&D programs
  - Strong patent position
  - Ability to carry out clinical trials for bioactive/nutraceutical additives

- Willingness to assume risk and ability to operate in a highly regulated industry
  - Risk of unfavorable regulatory actions for existing additives
  - Constant awareness of impending threats or possible regulatory actions
  - Adequate finances to cover potential liability and legal expenses

- Good reputation for product quality, service and delivery
  - Established distribution network
  - Adequate manufacturing capacity and procurement channels to provide customers with a steady product supply

INTRODUCTION

The broadest practical definition of a food additive is “any substance that becomes part of a food product, either directly or indirectly, during some phase of processing, storage or packaging.” Direct food additives, which are discussed in this report, are those that have been intentionally added to food for a functional purpose, in controlled amounts, usually at low levels (from parts per million to 1-2% by weight).

Indirect additives, on the other hand, are those entering into food products in small quantities as a result of growing, processing or packaging. Examples of these are lubricating oils from processing equipment or components of a packaging material that migrate into the food before consumption.

Direct food additives are used in foods for six main reasons:

- To ensure microbial safety
- To maintain product consistency
- To improve or maintain nutritional value
- To extend shelf life
- To facilitate food processing (e.g., provide leavening or control acidity or alkalinity)
- To enhance flavor or texture, or impart desired color

In the United States, substances that come under the general definition of direct food additives number in the thousands and include both inorganic and organic chemicals, natural products, and modified natural and synthetic or artificial materials. Most food additives have a long history of use; others are the result of recent research and development to fill particular requirements of modern food processing. Some are common chemicals used in industry that have their purity upgraded to allow their use in food. Many direct additives find specialized use in food applications, but they are not true specialty chemicals—as evidenced by their multiple uses, sheer volume, lack of differentiation, or low value. Some of these types of products are included in this report to complete coverage of a food additive category.

The food additive business comprises more than twenty segments. Major categories of food additives include functional products such as preservatives, colorants, antioxidants, thickeners and stabilizers, emulsifiers, acidulants and buffers, enzymes, flavors and flavor enhancers, and sweeteners. Examples of major products in each category are shown in Table 2. Basic foodstuffs and chance contaminants are excluded from the definition, although ingredients added to foods (e.g., high-fructose corn syrup [HFCS], flavor enhancers [MSG] and protein concentrates) are often included in estimates of the food additives market. With well over 2,300 food additives currently approved for use in the United States (and more petitioning for approval), it would be impossible in a report such as this to discuss each and every substance.

Table 2

Major Products by Additive Category[a]

Product Category	Additive
Thickeners and Gums	Casein, modified starches, gelatin, xanthan gum, alginates, carrageenan, pectin, carboxymethylcellulose, guar gum, gum arabic
Sweeteners and Bulking Agents	Aspartame, acesulfame-K, sucralose, polyols, polydextrose, lactose
Colors	Certified and natural food colors
Fat Substitutes	Partially or fully nonmetabolizable lipids, gums, carbohydrate and protein-based materials, emulsifiers
Enzymes	Rennet, proteases, lactase, starch and pectic enzymes
Vitamins	Vitamin A, B, C, D, E, carotenoids
Antioxidants	Vitamin C and E, TBHQ, BHA, BHT, erythorbates, sulfites, tocopherols
Preservatives	Benzoates, sorbates, propionates
Emulsifiers	Mono- and diglycerides, lecithin, polysorbates

a. Only those food sectors that represent major outlets for the additive category are listed.

SOURCE: SRI Consulting.

Included in the overall food additive category are

- Inorganic chemicals (e.g., phosphates, sulfites, calcium carbonate)
- Synthetic organic chemicals (e.g., dyes, benzoates, BHA, natural vitamin A)
- Extraction products from and derivatives of natural sources (e.g., pectin, cellulose, vitamin E)
- Fermentation-derived products (e.g., enzymes, citric acid, biogums)

The following nine major product categories are included in this report: thickeners and stabilizers, sweeteners, colors, fat substitutes, enzymes, vitamins, antioxidants, preservatives and emulsifiers. A tenth category is continued in this revision—nutraceutical additives. Nutraceutical additives include substances added to foods for their health preserving or enhancing effect and/or for disease prevention. Examples of additives classified as nutraceuticals are pre- and probiotics like *lactobacillus*, stanol esters that reduce serum cholesterol, and isoflavones that may reduce menopausal symptoms and protect against heart disease. This is a new and growing category not as yet recognized as such by the FDA regulation. In Japan, such additives are commonly characterized as FOSHU additives.

There is much discussion about whether a food additive or food product is natural or synthetic, since this classification, in many instances, has become somewhat arbitrary. Many food additives synthesized in chemical laboratories are also found naturally occurring in normal food. Monosodium glutamate, a flavor-enhancing food additive, for instance, is the sodium salt of glutamic acid, an amino acid found in many foods such as mushrooms and tomatoes and metabolized by the human body using the same biochemical pathways of digestion. Vitamin C (ascorbic acid) and its isomer, erythorbic acid, are the same chemicals that are found in oranges. Similarly, citric acid, which is today produced commercially by enzymatic fermentation of sugars, is the same chemically as the naturally occurring chemical that has been found to make lemons and limes tart.

Direct food additives serve several major functions in foods. Many additives, in fact, are multifunctional. The basic functions are as follows:

- **Preservation.** Food preservation techniques have advanced in the past hundred years and now include thermal processing, concentration and drying, refrigeration and freezing, modified atmosphere and irradiation. However, chemical preservatives frequently augment these basic preservation techniques and represent the most economical way for food manufacturers to ensure a reasonable shelf life for a product. Antioxidants and antimicrobial agents perform some of these functions as well.

- **Processing.** Food processors are increasingly using food additives to ensure the integrity and appeal of finished products. Emulsifiers maintain mixtures and improve texture in breads, dressings and other foods. They are used in ice cream when smoothness is desired, in breads to increase shelf life and volume and to distribute the shortening, and in cake mixes to achieve batter consistency. Stabilizers and thickeners assist in presenting an appealing, consistent-textured product. Sorbitol, a humectant and sweetener, is used to retain moisture and enhance flavor. With the removal of sugar from many foods for dietetic reasons, use of a substitute bulking agent has become important.

- **Appeal and Convenience.** The changing eating habits of consumers, partly brought about by the large increase in the percentage of women who work outside the home, has created a huge demand for convenience foods. In many of these types of foods, it is essential that a variety of additives be used to provide the taste, color, texture, body and general acceptability that is required. This need for convenience, along with aesthetic appeal and taste, is now extremely important. Most food additives, such as gums, flavoring agents, colorants and sweeteners, are included by food processors because consumers in the developed countries demand that food look and taste good as well as be easy and safe to serve.

- **Nutrition.** There have been tremendous advances in knowledge of human nutrition, and consumers are increasingly aware of the value of good nutrition. Vitamins, antioxidants, proteins and minerals are added to foods and beverages in an attempt to ensure proper nutrition for those who do not eat a well-balanced diet. In addition, additives such as antioxidants are often used to prevent deterioration of natural nutrients during processing. Recently, more importance has been attributed to disease prevention through proper nutrition, as well as to increasing performance through sports nutrition and energy enhancing products. On the other hand, the medically based desire for good nutrition through a balanced diet may adversely affect consumer demand for some food additives such as fat substitutes.

The legal definition of a food additive is complex and often the subject of controversial interpretation; it is addressed in the **Government Regulations** sections of this report.

The practice of adding chemicals (e.g., salt, spices, herbs, vinegar, smoke) to food dates back many centuries. In recent years, however, the ubiquitousness of chemical additives in processed foods has attracted much attention and public concern over the long-term safety of additives to humans. Although the safety issue is far from subsiding, there is scientific consensus that food additives are indispensable in the production, processing and marketing of many food products, and that the judicious use of chemical additives—typically in the range of a few parts per million (ppm) to less than 1% by weight of the finished food—contributes to the abundance, variety, stability, microbiological safety, flavor and appearance of the food supply. While food additives offer a major contribution to the palatability and appeal of a wide variety of foods, their level of use is relatively insignificant in the total human diet.

Examples of food additives and their functions are presented in Table 3.

Table 3

Food Additives and Their Functions

	Nutritional Value	Preservation, Protection	Production Improvement	Appeal Modification
Thickeners and Stabilizers	X			X
Sweeteners	X	X	X	X
Colors				X
Fat Substitutes	X			X
Enzymes	X		X	X
Vitamins	X	X		
Antioxidants	X	X		X
Preservatives		X		
Emulsifiers		X	X	X
Nutraceuticals	X			

SOURCE: SRI Consulting.

In Japan, the term *food additives* has historically been legally and also generally defined as made up of two separate categories—synthetic food additives and natural food additives. Under the Japanese Food Sanitation Law, synthetic substances are not permitted to be used as food additives unless approved; today, 350 items are listed as approved synthetic food additives. On the other hand, until 1995 there was no legal restriction on natural food additives. The 1995 amendment to the Food Sanitation Law requires that any new substances—synthetic or natural-based—be verified as safe and be approved by MHW before use as a food additive. In this report, covered Japanese food additives include both additives whose listing is required by law and natural additives in use prior to 1995.

OVERVIEW OF THE FOOD ADDITIVES INDUSTRY

UNITED STATES

Market Size and Growth

The volume and value of food additive consumption in the United States are summarized in Table 4.

Table 4

U.S. Consumption of Food Additives

	1998		2001		2006		Average Annual Volume Growth Rate, 2001-2006[a] (percent)
	Thousands of Metric Tons	Millions of Dollars	Thousands of Metric Tons	Millions of Dollars	Thousands of Metric Tons	Millions of Dollars	
Thickeners and Stabilizers				Data Removed			
High-Intensity Sweeteners							
Alternative Sweeteners[b]							
Colorants[c]							
Fat Replacers[d]							
Enzymes[d]							
Vitamins							
Antioxidants							
Preservatives							
Emulsifiers							
Total							

Note: Value column data have been rounded from data in various additive sections.

a. Average annual growth rates calculated from unrounded data.

b. Includes nutritive specialty sweeteners, such as polyols. Commodities, such as sugar, HFCS, dextrose and lactose, are not included.

c. Noncertified colors are not included in quantity calculations.

d. Quantity figures are not meaningful for these products.

e. Value basis.

SOURCE: SRI Consulting.

These figures differ from those shown in the **SUMMARY** section in one major respect: the growth projections presented above generally reflect volume increases while those in the **SUMMARY** section reflect category value. For categories where the product mix is expected to shift toward higher-unit-value additives over time (e.g., as in high-intensity sweeteners with the growth in usage of acesulfame-K and sucralose, the highest-priced high-intensity sweeteners), future growth on a value basis would be higher than on a volume basis. Also, note that the projected growth rate shown in the table for all food additives on a combined basis excludes enzymes and fat replacers for which volume data are not available.

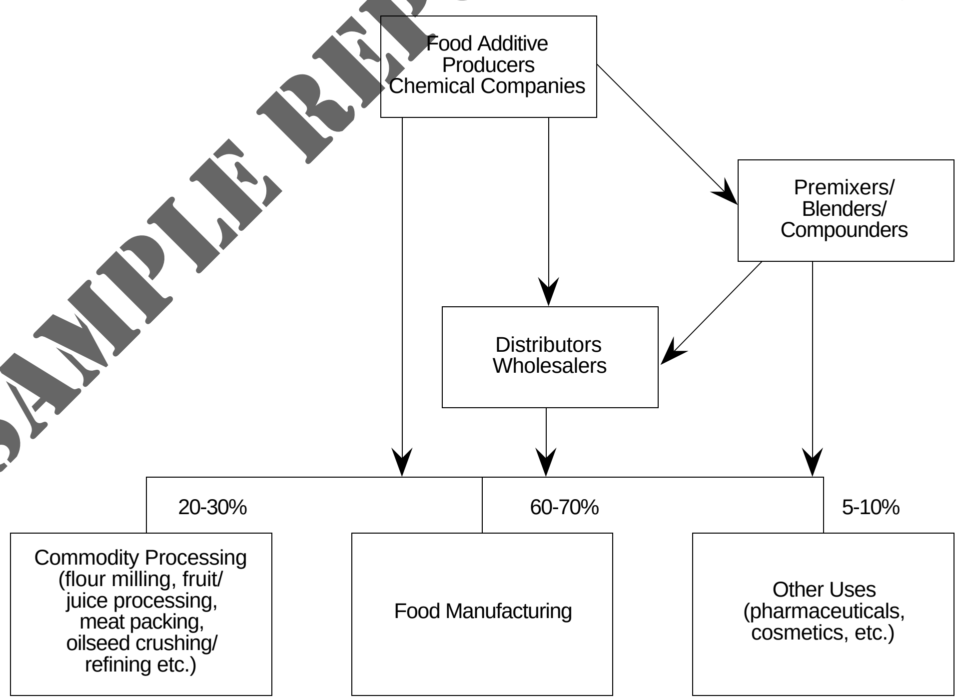
Also, nutraceuticals are not listed in the table above. We had intended to do so and gathered what information was available on the value of nutraceutical ingredients/additives and decided that these estimates (which put the 2001 value of nutraceutical ingredients/additives at about 10% of the value of functional food retail sales or $1.8 billion) were not reasonable. Data from the U.S. Census of Manufactures for 1997 demonstrate that the value of all ingredients/additives consumed in food manufacturing is generally a low percentage of the value of manufacturers' shipments (e.g., about 12% for breakfast cereals, 15% for cookies and crackers, 23% for soft drinks, 29% for ice cream and frozen desserts). Thus it would be highly unlikely that the value of nutraceutical ingredients/additives like vitamins, minerals, active cultures, insoluble fiber, soy isolate, etc., added into most functional foods would contribute 10% of product costs, let alone retail price. The other issue is, of course, the fact that at present a significant portion of nutraceutical additives are vitamins, which are already accounted for in the vitamin category.

Industry Structure

Food additive suppliers are an important part of the U.S. food manufacturing system, supplying products to both commodity processors and food processors.

Figure 1 depicts the food additives industry structure and flow of products. Some 60-70% of food additives are used in the manufacturing of foods, while 20-30% are used in commodity processing operations such as flour milling, meat packing, oilseed crushing/refining, fruit and vegetable preservation, pet food manufacture and fruit/juice processing; the remaining 5-10% are used in such other areas as pharmaceuticals and cosmetics. The difference between food ingredients and additives is mainly that of the quantity used in any given formulation. Food additives are used in small quantities (usually less than 2%) relative to the total composition, but they nonetheless play a large part in the production of desirable and safe food products.

FIGURE 1
Structure and Flow of Products in the U.S. Food Additives Industry



Practically every food manufacturing operation depends in some degree on the use of food additives, but the range of additives necessary for the formulation varies. As shown in Table 5, the manufacture of carbonated beverages, dry beverage mixes, ice cream and frozen desserts, breakfast cereals, salad dressings, snack foods, cookies and crackers, dietetic products and confections requires high use of food additives.

Table 5

Relative Use of Food Additives in U.S. Food Manufacturing by Industry Sector[a]

Processed and Cured Meat, Poultry and Fish	+
Dairy Products	
Fluid, Condensed and Dry Milk	+
Cultured and Formulated Dairy Products	++
Butter	+
Cheese	++
Ice Cream and Frozen Desserts	+++
Preserved Fruits and Vegetables	
Canned, Frozen and Dried Fruits and Vegetables	+
Fruit and Vegetable Juice	+
Jams and Jellies	++
Pickles and Sauces	++
Grain Mill Products	
Prepared Flour Mixes and Dough	++
Pasta and Macaroni	+
Breakfast Foods and Cereals	+++
Baked Products	
Bread and Cakes	++
Refrigerated and Frozen Bakery Products	++
Cookies and Crackers	+++
Confections	
Candy	+++
Chewing Gum	+++
Chocolate and Cocoa Products	++
Fats and Oils	
Refined Fats and Oils	+
Margarine and Shortenings	+
Mayonnaise, Salad Dressing, Peanut Butter	+++
Beverages	
Beer and Malt Beverages	++
Wine, Brandy and Spirits	+
Distilled and Blended Liquors	++
Carbonated Soft Drinks	+++
Still Drinks	++
Dry Beverage Mixes	+++
Coffee and Tea	+

Table 5 (concluded)

Relative Use of Food Additives in U.S. Food Manufacturing by Industry Sector[a]

Specialty Foods	
Savory Snacks, Chips, Popcorn, Nuts	+++
Dinner and Dessert Ready Mixes	+++
Canned/Aseptic “Shelf-Stable” Food Preparations	++
Frozen/Refrigerated Food Preparations	++
Pet Foods	+++
Spices and Condiments	+
Dietetic Products and Nutritional Supplements	+++
Tabletop Sweeteners	+++

a. + = low; ++ = medium; +++ = high.

SOURCE: SRI Consulting.

The food additives business includes numerous market segments, with ten major product categories—thickeners and stabilizers, sweeteners, colors, fat substitutes, enzymes, vitamins, antioxidants, preservatives, emulsifiers, and nutraceuticals—included in this report (flavors and acidulants are covered in other reports; see the **SUMMARY** for further information). In terms of products, the business is as diverse as the differentiated needs of the many food industry sectors served (e.g., beverages, dairy, cereals, confections, snacks), as shown in Table 6. Even within the same category, products may belong to several chemical classes and offer specialized functionality (e.g., water- and oil-soluble antioxidants that include ascorbic acid and hindered phenols, respectively; water-soluble azo dyes and water-dispersible carotenoids as food colors).

Table 6

Selected U.S. Food Additives and Their Major Uses

	Processed/ Cured Meats	Dairy Products	Cheese	Ice Cream	Jams/ Jellies	Pickles/ Sauces	Breakfast Cereals	Cookies/ Crackers
Thickeners and Stabilizers	Data Removed							
Sweeteners								
Colors								
Fat Substitutes								
Enzymes								
Vitamins								
Antioxidants								
Preservatives								
Emulsifiers								
Nutraceuticals								

Table 6 (concluded)

Selected U.S. Food Additives and Their Major Uses

	Baked Goods	**Candy**	**Chocolate**	**Chewing Gum**	**Mayonnaise/ Dressings**	**Carbonated Beverages**	**Still Beverages**
Thickeners and Stabilizers	Data Removed						
Sweeteners							
Colors							
Fat Substitutes							
Enzymes							
Vitamins							
Antioxidants							
Preservatives							
Emulsifiers							
Nutraceuticals							

	Dry Beverage Bases	**Tabletop Sweeteners**	**Snacks/ Chips**	**Dessert Mixes**	**Frozen Entrees**	**Dietetic Products**	**Fats/ Oils**	**Margarine**	**Essential Oils**
Thickeners and Stabilizers	Data Removed								
Sweeteners									
Colors									
Fat Substitutes									
Enzymes									
Vitamins									
Antioxidants									
Preservatives									
Emulsifiers									
Nutraceuticals									

SOURCE: SRI Consulting.

Overall, the U.S. food additives industry is highly fragmented, consisting of more than 400 companies supplying a variety of chemically and functionally different products that serve a common end-use market—the food industry. However, suppliers tend to be either highly specialized participants in the major product categories (e.g., Novozymes with enzymes; Warner-Jenkinson with food colors) or large chemical companies that offer food-grade versions of a few industrial products (e.g., Dow’s Methocel). Manufacturers are typically involved in supplying additives in a limited number of product categories (e.g., colors, vitamins, enzymes) or servicing selected food sectors (e.g., processed meats, dairy-based products, bakery products). While a company or group of companies may tend to dominate sales in each of the specific categories (e.g., Novozymes in enzymes, Roche and BASF in vitamins), no single company or small group of companies dominates the entire food additive industry.

There are signs, however, that this might be changing. The 1999 merger of Danisco AS and Cultor Corporation marked the creation of what some see as a potential functional food additives giant. The combined companies, which includes Cultor’s stake in Genencor, is a major player in enzymes, emulsifiers, and flavors, and will have a significant presence in antioxidants, alternative sweeteners and bulking agents, texturizers, fat substitutes and functional systems. Danisco USA has estimated annual sales in excess of $1 billion.

Thirty years ago it was relatively easy and lucrative for chemical companies to stumble into the role of food additive supplier and reap profits by upgrading the purity and quality of chemicals originally developed for other industrial markets. Today, however, the long time and high costs associated with gaining FDA approval (estimated to be five to ten years and $15-40 million) have removed the incentive to commercialize products from basic research. As a result, food additives represent only a minor portion of large chemical companies' overall business. Most large U.S. chemical companies that supply food additives, such as FMC Corporation, Hercules and Eastman Chemical, have diversified chemical operations with perhaps only 5% or less of total sales generated by food additives.

In addition to basic additive producers, the U.S. food additives industry includes companies that specialize in compounding functional additive blends or in premixing nutrients, and national and local distributors.

Specialty compounders formulate mixed products for the food industry such as dairy ingredients, baker's mixes, curing blends, thickener/emulsifier blends, cheese aids, ethnic flavors, total seasoning packages, vitamin and mineral premixes and spice blends. They are generally very knowledgeable about additive and ingredient properties and are experienced in food technology overall. Compounding companies are often relatively small, sell directly to a food processor, are highly service-oriented and market product lines that have a high level of perceived differentiation. Their formulations offer convenience and enjoy higher gross profit margins than single food additive sales. Several examples of these specialty premixers, blenders and compounders in the food industry are given in Table 7.

Table 7

Selected U.S. Blenders and Compounders of Specialty Additives and Ingredients—2001

Company and Headquarters	Expertise
ADM-Arkady Olathe, KS	Bakery blends
Chr. Hansen, Inc. Milwaukee, WI	Flavor blends, especially dairy
Continental Custom Ingredients, Inc. West Chicago, IL	Dairy products
David Michael & Co., Inc. Philadelphia, PA	Blends of flavorings; stabilizers
Erie Foods International, Inc. Erie, IL	Caseinate and hydrocolloid blends and cheese premixes
Fortitech, Inc. Schenectady, NY	Vitamin and mineral premixes
Germantown (USA) (Danisco) West Chester, PA	Stabilizer/emulsifier systems
Griffith Laboratories, Inc. Alsip, IL	Flavor systems, seasoning blends
Gumix International, Inc. Fort Lee, NJ	Stabilizer systems

Table 7 (concluded)

Selected U.S. Blenders and Compounders of Specialty Additives and Ingredients—2001

Company and Headquarters	Expertise
Kalsec, Inc. Kalamazoo, MI	Spices, flavor blends, and natural food colors
Kerry Inc. Beloit, WI	Dairy ingredients and protein blends, flavoring blends
Kraft Food Ingredients Corp. Memphis, TN	Cheese and meat ingredient systems
Land O'Lakes, Inc. Food Ingredients Division Minneapolis, MN	Dairy blends
Meer Corporation North Bergen, NJ	Flavor enhancers and stabilizers
TIC Gums Inc. Belcamp, MD	Food gums and stabilizers, emulsifiers, colloids
Watson Foods, Inc. West Haven, CT	Nutrient systems, bakery bases
Wright Group Crowley, LA	Custom nutritional blends

SOURCE: SRI Consulting.

Distributors also play an important role in the distribution of food additives. Additive producers typically use distributors to service their smaller accounts or for warehousing and servicing of geographically dispersed accounts that the producers cannot cover effectively or economically.

Overall, the U.S. food processing industry is concentrated in terms of food sales, with the top twenty food companies accounting for over $250 billion of the estimated $434 billion of industry product shipments in 2000. In other aspects, however, the food industry is fragmented with some 47 recognized subsectors (each classified by a Standard Industrial Classification [SIC] code) and with over 50,000 manufacturing establishments. Food producers as a whole are a rather conservative group, traditionally slow in reacting to technological change and reluctant to be drawn into the controversy surrounding food chemicals. Since reducing or discontinuing the use of additives is a socially acceptable way of defusing public outcry and of minimizing problems of compliance with U.S. FDA regulations, food manufacturers have opted out of chemical additives unless precluded from doing so by the technical requirements and process economics of modern food manufacturing practices.

The twenty leading U.S. food companies ranked by food and beverage sales are listed in Table 8.

FOOD ADDITIVES

Table 8

Leading U.S. Food and Beverage Companies—2000
(millions of dollars)

Company	Food Sales
Philip Morris Cos. Inc.	
ConAgra, Inc.	
Coca-Cola Co.	
PepsiCo, Inc.	
Cargill Inc.	
IBP Inc.	
Mars	
Anheuser-Busch Inc.	
Archer Daniels Midland Co.	
H. J. Heinz Co.	
Bestfoods Co.	
Nestlé USA Inc.	
Sara Lee Corp.	
Dairy Farmers of America	
Tyson Foods	
Kellogg Co.	
General Mills	
Campbell Soup Company	
The Pillsbury Company	
Land O'Lakes Inc.	

SOURCE: *Food Processing Magazine*, May 2001.

Operating Characteristics

Research and development

Because of so many dissimilar and unconnected segments of the food additives industry, the participating companies exhibit different approaches to R&D. Many stress applications research to uncover new niches for existing additives or modifications of current FDA-approved additives. Some emphasize innovative research or new, high-value products, but these are very few because of the cost and time required for basic research, development, U.S. FDA approval and market acceptance of a new food additive product. For example, NutraSweet's aspartame product took over eleven years for FDA approval; acesulfame-K took six years for FDA approval and a total of 21 years since development began. The total costs of research, development and approval for aspartame were close to $25 million.

Procter & Gamble's olestra was in R&D for twenty years, and was not submitted to the FDA until June 1987. After spending over $200 million in development costs and waiting over eight years for FDA approval, Procter & Gamble received approval for the fat substitute in January 1996. P&G invested in a new production facility, extensively test marketed olestra-containing products (as did Frito-Lay). Olestra's success to date has been far less than what P&G had hoped for, in large part as a result of product performance and the mandatory product labeling. (FDA requires that olestra-containing products must be labeled with the following: "This product contains Olestra. Olestra may cause abdominal cramping and loose stools. Olestra inhibits the absorption of some vitamins and other nutrients. Vitamins A, D, E and K have been added.")

In general, only large, well-financed companies can afford the R&D efforts necessary to develop a food additive product to its optimum potential. Small companies simply are unable to deal with the complexity and the cost and time requirements.

Expenditure on R&D of food additives varies significantly. Because data on the food additives business of most U.S. producing companies are not reported separately, only estimates can be made. The range is from close to zero for a company that produces and markets grandfathered food additives, to 5-6% for companies with more technically demanding products, to about 12% of sales for research-oriented companies such as Novozymes.

Manufacturing

Manufacturing processes for food additives vary widely in their nature and technological sophistication. Some of the specific processes for the more important food additives are described in later sections of this report.

A common characteristic of all food additives manufacture, however, is that the products must be made to a high degree of purity and under sanitary conditions similar to those required for food processing plants. Production equipment must be dedicated to food additive products and cannot be used for other industrial production. Plants producing food additives are subject to periodic inspection by the FDA. Typically, chemical additives made by synthesis (e.g., BHT, saccharin) or by fermentation (e.g., microbial enzymes, xanthan and gellan gums) require a high level of capital investment. The former additives have industrial uses and are likely to share their basic production costs with the industrial-grade material; a small portion of the total production is then upgraded and purified to food-grade quality in separate, dedicated plant units. Accurate long-term market forecasts for products are essential in order to minimize the risk associated with capital investment decisions in single-purpose plants. Other participants in the food additives business that are not involved in chemical production on a large scale for the extraction and purification of natural products, for small-scale synthesis of aromatic chemicals, and for flavor and ingredient compounding have much lower capital requirements.

Profitability

Public companies do not provide financial breakdowns of their food additives operations, thereby making it difficult to accurately pinpoint profitability for the industry as a whole. However, gross profit as a percentage of net sales for food additive products has typically ranged from less than 15% to as high as 35%. The relative ranking over the last five to ten years of the food additive categories discussed in this report is shown in Table 9.

Table 9

Relative Profitability of U.S. Food Additives
(percent of sales)

Category	Typical Range
Biogums	35%
Nonnutritive Sweeteners (on patent)	
Colors	
Enzymes	
Hydrocolloids	
Nutraceuticals	
Vitamins	
Antioxidants	
Bulking Agents	
Fat Substitutes	
Emulsifiers	
Preservatives	15%

SOURCE: SRI Consulting.

There has been significant slippage in the profitability of certain additives in recent years in large part because of patent expiration, China's huge progress in production and export, and the fallout from major price fixing investigations. Additives like xanthan, vitamin C, and aspartame that were highly profitable for many years have run afoul of competition, overcapacity and commoditization. Additive companies have also been under pressure by food manufacturers whose consolidation has created intense competition and whose size and buying power can force price reductions and service increases. In addition, the number of new food products brought to market has dropped by 15% over the past few years because of the smaller number of players and the economic downturn. New products tend to be the growth areas for additives, particularly new ones.

The profitability picture is somewhat brighter for specialty compounders and flavor houses that are able to extract added value from differentiated products that are formulated to provide convenience of use or to satisfy specialized technical needs in food processing. It is not unusual, for instance, for these custom-service specialty blenders and compounders to have a 10-25% markup over cost on the sale of a single ingredient and up to a 100% markup over raw material costs for the blended, finished mix of ingredients.

For the most part, the combination of limited profits and limited market size discourages the introduction of new additives because of the substantial investment at risk prior to obtaining FDA approval.

Government Regulations

The U.S. Food and Drug Administration (FDA) is the principal U.S. regulatory body controlling the use of food additives. It does so through the 1958 Food Additives Amendment to the Food, Drug & Cosmetic (FD&C) Act of 1938. The amendment was enacted with the threefold purpose of (1) protecting public health by requiring proof of safety before a substance could be added to food, (2) advancing food technology and (3) improving the food supply by permitting the use of substances in food that are safe at the levels of intended use. According to the legal definition, food additives that are subject to the amendment include "any substance the intended use of which results or may reasonably be expected to result directly or indirectly in its becoming a component or otherwise affecting the characteristics of any food." This definition includes any substance used in the production, processing, treatment, packaging, transportation or storage of food.

If a substance is added to a food for a specific purpose, it is referred to as a direct additive. For example, the low-calorie sweetener aspartame, which is used in beverages, puddings, yogurt, chewing gum and other foods, is considered a direct additive. Indirect food additives are those that become part of the food in trace amounts as a result of its packaging, storage or other handling. For example, minute amounts of packaging substances may find their way into foods during storage. Therefore, food packaging manufacturers must prove to the FDA that all materials coming in contact with food are safe before they are permitted for use.

For regulatory purposes, all food additives fall into one of three categories: (1) generally recognized as safe (GRAS) substances, (2) prior-sanctioned substances or (3) regulated direct/indirect additives. GRAS substances (of which there are approximately 700 in all) are a group of additives regarded by qualified experts as "generally recognized as safe" because extensive past use has not shown any harmful effects. Prior-sanctioned substances (approximately 1,400) are products that already were in use in foods prior to the 1958 Food Additives Amendment to the federal Food, Drug & Cosmetic Act, and are therefore considered exempt from the approval process. Some prior-sanctioned substances also appear on the GRAS list. This is the grandfather clause of the amendment. The FDA is involved in an ongoing review of the GRAS and prior-sanctioned lists to ensure that these substances are tested by the latest scientific methods. Likewise, the FDA also reviews substances that are not currently included on the GRAS list to determine whether they should be added.

All other additives are regulated, meaning that a specific food additive petition must be filed with the FDA, requesting approval for use of the additive in any application not previously approved. A food or color additive petition must provide convincing evidence that the proposed additive performs as it is intended. Animal studies using large doses of the additive for long periods are often necessary to show that the substance would not cause harmful effects at expected levels of human consumption.

In deciding whether an additive should be approved, the agency considers the composition and properties of the substance, the amount likely to be consumed, its probable long-term effects and various other safety factors. Absolute safety of any substance can never be proven. Therefore, the FDA must determine if the additive is safe under the proposed conditions of use, based on the best scientific knowledge available. In addition, the FDA operates an Adverse Reaction Monitoring System (ARMS) to help serve as an ongoing safety check of all additives. The system monitors and investigates all complaints by individuals or their physicians that are believed to be related to specific foods, food additives or dietary supplements.

All color additives are subject to the Color Additive Amendment of 1960. Colors permitted for use in foods are classified as either certified or exempt from certification. Certified colors are man-made, with each batch being tested by the manufacturer and the FDA (certified) to ensure that it meets strict specifications for purity. Color additives that are exempt from certification include pigments derived from natural sources. However, colors exempt from certification also must meet certain legal criteria for specifications and purity.

The FD&C Act also authorizes the establishment of reasonable standards of identity and quality for food products. The standards of identity specify in detail what may and may not be packaged under a given product name. Standards of identity exist for milk, cream, cheese, frozen desserts, bologna products, cereal products, cereal flours, pasta, canned and frozen fruits and vegetables, juices, eggs, fish, nuts, nonalcoholic beverages, margarine, sweeteners, dressings and flavorings. An approved food additive in the United States may be precluded from use in certain foods characterized by the standards of identity unless the additive is specifically required by, or is listed as an optional ingredient in, the standards. The standards of identity establish the ingredient composition of a given food, which can then be labeled by its common name. If the standard composition is not adhered to by the manufacturer, the food must be labeled “imitation.”

In the United States, the Food and Drug Administration has primary jurisdiction over food additives, although clearance for use of additives in certain products must be obtained from other government agencies as well. For example, the U.S. Department of Agriculture (USDA) through the Meat Inspection Division (MID) exercises jurisdiction over additives and ingredients for meat and poultry, and the Bureau of Alcohol, Tobacco, and Firearms (BATF) of the U.S. Department of the Treasury controls the ingredients used in alcoholic beverages.

Under FDA, USDA and BATF regulations, the ingredients of a food or beverage must be stated on the product label in decreasing order of predominance. For many direct additive categories, chemical constituents must be identified by their common names and the purpose for which they were added.

The USDA’s Food Safety & Inspection Service (FSIS) acts primarily to

- Inspect domestic and imported meat, poultry, and meat and poultry products
- Establish ingredient standards and approve recipes and labels for processed meat and poultry products
- Monitor the meat and poultry industries for violations of inspection laws

These activities are carried out under the authority of the Federal Meat Inspection Act, the Poultry Products Inspection Act and other laws. These laws are directed at ensuring that meat and poultry products sold for human food are safe, wholesome and accurately labeled, whether produced inside or outside the United States. The USDA also has established mandatory standards of composition for processed poultry and meat products.

One of the recent regulations involving the food industry as well as food additive manufacturers came with the passing of the Nutrition Labeling and Education Act of 1990 (NLEA), which amends the Federal Food, Drug & Cosmetic Act to make nutrition labeling mandatory for most FDA-regulated foods. This regulation represents the first major change in FDA nutrition labeling regulations since their origin in 1973.

The nutrition labeling regulations issued by the FDA and the FSIS required compliance by August 8, 1994. The FDA found that by the end of May 1995, more than 80% of the domestic and imported food products checked were in compliance with the regulations.

Nutrients

The FDA’s nutrition labeling regulations focus on nutrients currently accepted as significantly affecting consumer health. The serving size is the basis for reporting each food’s nutrient content. Serving sizes defined for most foods reflect the amount people actually eat and are shown in both common household and metric measures. The amounts per serving of the following nutrients are required to be included on labels: total calories, calories from total fat, total fat, saturated fat, cholesterol, total carbohydrates, complex carbohydrates, sugars, dietary fiber, protein, sodium, vitamin A, vitamin C, calcium and iron. Listing other essential vitamins and minerals, such as thiamine, riboflavin and niacin, is optional. A simplified nutrition label format is allowed for foods containing insignificant amounts of more than half the required nutrients.

The FSIS requires the same list of nutrients as in the FDA regulations, with additional nutrients required to be listed if the label makes any claims about them. A simplified format is allowed when more than half of the fifteen required nutrients are present in insignificant amounts. The minimum label includes total calories, total fat, total carbohydrates, protein and sodium.

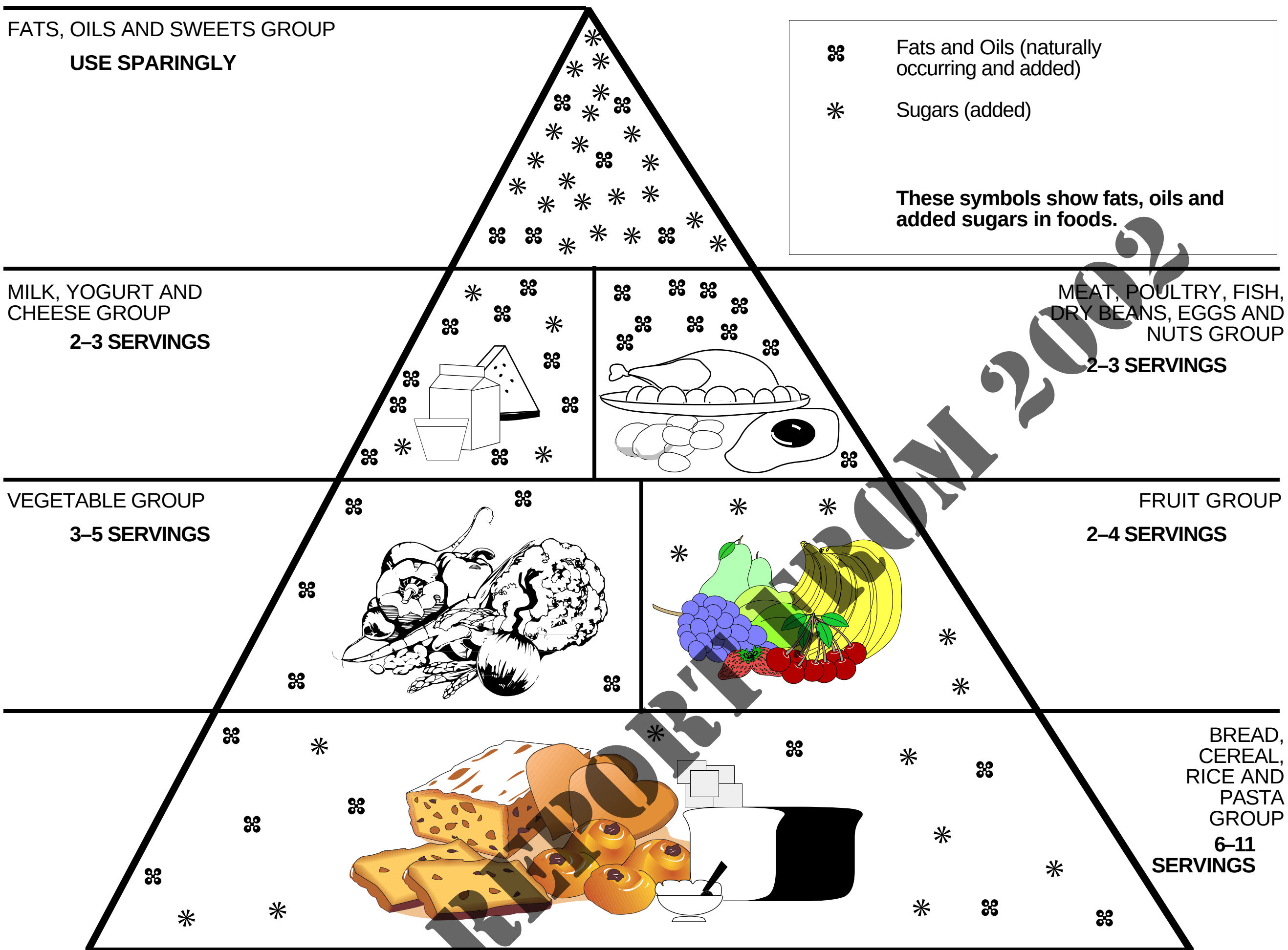
In 1999, FDA proposed a labeling change that would require labeling the trans fatty acid content of foods. The proposed rule would require food manufacturers to display the combined amount of trans fatty acids and saturated fats in their products. A separate footnote would identify the trans fat content. FDA would also impose limits on trans fat in foods that carry certain claims about their nutrient content or health benefits. Trans fat has become an issue because of recent studies that show links between trans fat consumption and higher blood levels of low-density lipoproteins (referred to as the bad cholesterol). Most trans fats are made through hydrogenation of oils; hydrogenated oils are commonly used in vegetable shortenings, margarines, crackers, cookies and snack foods.

There has been much debate with regard to advising people on what products and how much of these products to consume to maintain a healthy diet. Since 1950, the U.S. population has been taught to eat foods from the “basic four” food groups—milk, meat, fruits and vegetables, and breads and cereals. In 1984, the American Red Cross and the USDA jointly developed a graphic device (a circle in this case) to depict the important components of the 1980 Dietary Guidelines. In the circular graphic, each food group occupies a similarly sized section and the minimum number of servings per day for each group is indicated. However, with increased studies regarding the disease and diet relationship, new dietary recommendations and a new graphic symbol were introduced in the early 1990s.

The “food guide pyramid” was unveiled by the U.S. Secretary of Agriculture in April 1992. This updated version of the “eating right pyramid,” issued in 1991, is the product of a collaboration by nutritionists, communications researchers and graphic designers. Experts in the USDA and the Department of Health and Human Services adopted the new graphic because they believed it would be the most effective device to convey their advice on good nutrition to the U.S. public.

The pyramid organizes foods into six groups and conveys the essential elements of a healthy diet—the proportion of food to choose from each major food group, the variety of food selection from each food group, and moderation in consuming fats, oils and sweets.

FIGURE 2
Food Guide Pyramid—A Guide to Daily Food Choices



Ingredients

FDA regulations now require the following:

- Full ingredient labeling must be done, even if the food is covered by a standard of identity.
- Food labels must list ingredients in descending order of predominance by weight; however, the descending order does not apply for those minor components that are present in less than a 2% concentration.
- The label on beverages containing vegetable or fruit juice must state the percentage of vegetable or fruit juice in the drink.
- All FDA-certified color additives must be listed by name.
- Labels must declare protein hydrolysates and specify the sources of those additives.

- To alert consumers with allergies to milk protein and sulfites, labels must identify caseinate as a milk derivative when used in nondairy foods, such as coffee whiteners, and declare use of sulfiting agents.

Serving size

The FDA regulation requires nutrition content to be based on amounts of product customarily consumed and expressed in both common household and metric measures (e.g., “one cup” and “240 ml”). Serving size reference amounts are based on food consumption survey data on amounts of food commonly consumed per eating occasion by persons four years of age and older. Manufacturers must follow the procedures to convert the reference amounts to serving sizes appropriate for their specific products. Any package containing less than two servings is considered a single-serving container.

Descriptors

Nine terms are currently allowed by the FDA to describe a food, including *free*, *low*, *high*, *source of*, *reduced*, *light/lite*, *less* (or, for calories, *fewer*), *more* and *fresh*. Claims for cholesterol are tied to levels of saturated fat in the food. Meal-type products are not allowed to use the term *reduced*. The FSIS proposes to adopt the FDA’s definitions for descriptors. However, in the best interest of consumers, two additional descriptors unique to meat and poultry—*lean* and *extra lean*—have also been proposed.

Health claims are allowed only for the following nutrient/disease relationships:

- Calcium and osteoporosis
- Sodium and hypertension
- Dietary saturated fats and cholesterol intake and risk of cardiovascular disease
- Dietary fats and cancer
- Fiber-containing grain products, fruits, and vegetables and cancer
- Fruits, vegetables and grain products that contain fiber, particularly soluble fiber, and risk of coronary heart disease
- Fruits and vegetables and cancer
- Folic acid and neural tube defects
- Dietary sugar alcohols and dental caries
- Soluble fiber from certain foods and coronary heart disease
- Soy protein and risk of coronary heart disease
- Stanols/sterols and risk of coronary heart disease

Changing dietary recommendations and labeling requirements have affected food additive producers both positively and negatively. Products used for fat sparing or substitution (e.g., hydrocolloids, starches, other fat substitutes) and low-calorie sweeteners have generally fared well, as food manufacturers moved to lower the caloric and saturated fat content of their products. Natural colors (provided they can be substituted), as well as other natural or seemingly natural products, have enjoyed higher demand so food manufacturers have moved to provide consumers with a more healthy and nutritious product (or at least one with a more healthy-sounding label).

The FDA's Food Additives Amendment also contains what is known as the Delaney Clause, which mandates the FDA to ban any food additive found to cause cancer in humans or animals, regardless of dose level or intended use. The clause applies not only to new food additives but also to those in use prior to 1958. The Delaney Clause is totally inflexible in that it does not recognize any threshold level below which the additive might not present a health hazard. Thus, it has caused a number of problems for the food industry and for food additives manufacturers. Certain additives, such as the sweetener cyclamate and FD&C Red #2 food color, have been banned after they were found to be potential carcinogens—even though feeding tests in animals at massive dose levels may not bear any correlation to the potential risk to humans of chronic ingestion at very low levels. Were it not for a moratorium mandated by Congress, saccharin also would have been banned by the FDA in the United States, in compliance with U.S. food laws. Although congressional sentiment has been running for some time in favor of repealing the Delaney Clause, attempts to date to replace it with a more practical and realistic law have been unsuccessful.

A new substance gains approval for food use through the successful submission of a Food Additive petition that must document the following:

- Safety, including chronic feeding studies in two species of animals
- Intended use
- Efficiency data at specific levels in specified food systems
- Manufacturing details and product specifications
- Methods for analysis of the substance in food
- Environmental impact statement

Quite frequently, this process can be lengthy—up to ten years in the case of aspartame and olestra—and costly in terms of time and dollars. There is little doubt that every level of the U.S. food additives business is affected by regulations and operates with a constant awareness of the importance of FDA decisions. Not only is the introduction of a new food additive impossible without FDA approval, but also the additives in use are under constant scrutiny by the regulatory agency and remain always vulnerable to new unfavorable toxicological findings. While the barring of an additive may create opportunities for suppliers to develop new or substitute materials, nonetheless the potential market is often too small to create sufficient incentive, and the potential loss of the ingredient may raise excessive havoc within affected sectors of the food industry. For example, the ban on cyclamates, followed by the close call on saccharin, almost caused the demise of a strong diet soft drink industry. The well-recognized need for alternative safe sweeteners that would command a high price undoubtedly acted as a stimulus for G. D. Searle (next Monsanto's NutraSweet business and now the NutraSweet Company) to engage in a ten-year effort to have aspartame cleared for food use. The same is true for the manufacturers of other dietetic sweeteners, alitame (Danisco USA) and neotame (The Nutrasweet Company), some of which are still awaiting FDA approval.

Trends and Opportunities

Underlying changes in food additive trends are the changing relationship between food additive suppliers and food manufacturers; changing consumer demands, as eating habits are modified in a desire for "healthy" low-calorie, low-fat foods and premium-quality products; and increased consumption of convenience foods, particularly frozen and chilled products that are easy to prepare. Other major influences on the U.S. food additives business include the fall-out from the price-fixing scandals a few years ago and the emergence of China as a price spoiler in some product segments.

The consumer desire for healthier, safer and more nutritious foods will favor natural additives and ingredients as well as those that reduce calories, sodium, cholesterol and the overall fat in foods. Fortification with the right level of vitamins, amino acids and trace minerals will be important, and additives that sound safe and natural (e.g., pectin, vitamins) versus chemical (e.g., butylated hydroxyanisole) or (to some) suspect (e.g., gelatin) will have a more favorable image. Fast-paced lifestyles will continue to drive the demand for savory, high-quality convenience foods, such as microwavable and shelf-stable products, which require additives such as specialized flavors, colors and stabilizers to enhance or maintain quality.

Despite the strong controversy that continues in some circles, the U.S. public's concern over biotechnology and genetically modified foodstuffs appears to be abating. The United States in general has been much less suspicious of biotechnology than either Europe or Japan, but U.S. additive companies now almost as a rule are asked by their customers about the source of their raw materials. There does, however, appear to be some increasing concern over food pathogens and food security as the concept of bioterrorism penetrates the public's consciousness. The improved image of irradiation is in part a result of that.

Key issues ranging from economics to health and product safety are summarized below in Table 10.

Table 10

U.S. Food System Participants and Key Issues That Affect Consumption of Food Additives

Participant	Key Issues
Food and Commodity Processor	Process economics Processing technology/functionality Food quality Food safety (bacteriological) Shelf life Fortification/health aspects Regulations/labeling
Food Service Operator	Consumer acceptance (e.g., taste, texture) Preparation/convenience Economics Environment/waste disposal
Consumer	Food safety (free of contaminants and use of safe additives) Nutrition/health Naturalness/quality Convenience Fresher/less processed Price-value relationship

SOURCE: SRI Consulting.

While the shift away from commodity to more processed, higher-value food products should favor increased use of additives for processing, slow population growth will limit volume expansion of the total food additives category to 2.5-3.3% per year. Additives that encounter a favorable consumer perception for healthy and natural foods are likely to grow two or more times faster. Demand will be higher than average for fat replacers; alternative sweeteners; certain types of enzymes, gums, antioxidants; and nutraceuticals.

Increasingly, sales of ingredient-and-additive blends will dominate in the future. The synergistic effects that enhance the functionality of these materials while reducing the quantity needed will play an ever-more-significant role in formulated foods. Information on these blends will be scarce, because they will be developed in-house by food additive suppliers as well as food manufacturers wishing to maintain confidentiality in order to optimize exclusive commercial benefit.

In the mid- to late 1990s, China's increasing ability to produce and export acceptable-quality food additives pushed prices and profitability downward for some previously attractive additives like vitamin C, sodium erythorbate, and benzoates. Chinese competition in certain other additives like xanthan is building. The Republic of Korea and India may prove to be factors in the future as well.

In the last several years, the food ingredients/additives business has been tarnished by price-fixing scandals. Citric acid was followed by vitamins, sorbates, sodium erythorbate, and maltols, and some of the most respected companies in the food additives/ingredients business were hit by huge fines. It is difficult to say what this means for the additives industry and business as a whole, but it is likely that in some areas of the business, price increases will be hard to come by for some time.

Other issues affecting the growth and broadening of the food additives industry include increasing government regulatory activity; increasing R&D and legal expenses; and the great length of time needed to perfect, gain approval for, and market a new food additive product. Volumes of some additives used by the food industry are quite small and pricing is highly competitive, so that potential sales are not large enough to warrant extensive R&D.

Critical Factors for Success

Food additives encompass a wide variety of products and end-use markets (e.g., dairy products, processed fruits and vegetables, snacks). However, the key factors for success are generally similar regardless of product/market type. Such factors include the following:

- In-depth knowledge of food industry sectors and a basic understanding of consumer needs
  - Current products in use and their attributes/problems
  - Trends affecting the sector
- Manufacturing/application expertise
  - Strong procurement position for natural ingredients from foreign sources
  - Economical production and raw material sourcing
  - In-house product development and formulation expertise
  - Custom tailoring of products
  - Production of quality products that meet strict specifications
  - Thorough knowledge of food product process requirements

- Technically trained/specialized sales force
  - Ability to solve customers' technical questions/problems
  - Service orientation

- Competitive price/performance

- Strong commitment to R&D
  - Adequate financial and technical resources for product development and FDA approval process
  - Focused R&D program
  - Strong patent position
  - Ability to carry out clinical trials for bioactive/nutraceutical additives

- Willingness to assume risk and ability to operate in a highly regulated industry
  - Risk of unfavorable regulatory actions for existing additives
  - Constant awareness of impending threats or possible regulatory actions
  - Adequate finances to cover potential liability and legal expenses

- Good reputation for product quality, service and delivery
  - Established distribution network
  - Adequate manufacturing capacity and procurement channels, to provide customers with a steady product supply

Different suppliers have selected different strategies to succeed in the food additives business. While all strategies face the element of risk associated with future unfavorable regulatory actions affecting the food additives business, they exhibit a number of features that emphasize either the specialized product requirements of the user or the technical and manufacturing expertise of the supplier.

Some suppliers have built their successful food ingredient businesses by striving to become low-cost, large-volume producers of fermentation products that require specialized processing, separation and engineering expertise. Such companies include ADM and Cargill for citric acid and vitamins, and Novozymes and Genencor for enzymes. Experienced personnel, proprietary technical expertise for handling natural products of variable quality and a strong buying position for imported raw materials characterize the business strategy of suppliers of natural gums, flavors, hydrocolloids and colorants, such as FMC Corporation's FMC Biopolymers Division, ISP Alginates, Warner Jenkinson and Kalsec.

A few companies have developed their strategies for growth in selected niches of the food industry, around a combination of (1) ingredient processing and formulation expertise, (2) an in-depth technical knowledge of the food processing practices within the target food sector and (3) an excellent reputation for quality products and technical service. Chr. Hansen, Inc., a supplier of natural flavors, enzymes, starter cultures and colorants to the cheese industry, is one such company, and Danisco has structured its business across many food industry segments with a more-or-less one-stop-shop approach.

Several food additive suppliers enjoy the enviable position of being the sole U.S. producer of an additive, although the number of such companies is decreasing. In times when the U.S. dollar is valued lower than other countries' currencies, competition even from imports can be low. Such companies include Eastman Chemical Company, with two antioxidants—TBHQ and BHA; PMP Fermentation with sodium erythorbate; and CP Kelco with its gellan gum.

During the last decade two agricultural commodity–based companies, ADM and Cargill, emerged as important food additive suppliers, utilizing the advantage of their control over low-cost raw materials. These companies have long histories and very large capacity for processing agricultural commodities such as corn, oilseeds, rice and wheat. In recent years both acquired the necessary chemical and fermentation technologies to become major forces in the food additive market with a variety of agricultural raw material–based chemicals, such as sorbitol, citric acid, lactic acid, amino acids, vitamin E, enzymes, xanthan gum and emulsifiers.

Over the last decade, the high cost of R&D combined with requirements for doing government compliance work (e.g., food safety, labeling) has left U.S. food manufacturers and food service companies little time and few resources to devote to R&D in the additives area. Therefore, these firms have come to rely on food additive and ingredient suppliers to carry on the bulk of applications research. This trend is likely to continue.

Also to be considered are the implications of the increasing use of biologically modified products currently described as "genetically engineered" substances. A collection of biological processes and techniques such as microbial fermentation, plant and animal cell culture, and recombinant DNA promise future unique and/or lower-cost production of certain chemical additives such as flavors, thickeners, emulsifiers, enzymes, vitamins and antioxidants. Biotechnology is also the likely means for future natural preservation of food products and increased availability of scarce natural products of high value. But lingering consumer concerns over the safety of genetically modified foods and food additives may have effectively delayed this technology's capacity to make major impacts in the food additive arena to beyond the next five years.

Literally hundreds of food additive companies are successes in the development or marketing of additives for the U.S. food industry. An examination of the U.S. producer lists for each additive category in this report provides a very brief indication of just how many companies actively participate in this market. The most financially successful companies are those that are innovative, customer-oriented and opportunistic regarding new developments, trends and needs of the U.S. food industry.

WESTERN EUROPE

Market Size and Growth

The Western European food additives market is subject to strong consumer-driven pressures and offers opportunities for exceptionally high growth for some product groups. Growth of the food additives business in terms of value is higher than demographic growth on average.

Table 11 illustrates the current and future demand for food additives in Western Europe.

THICKENERS AND STABILIZERS

UNITED STATES

Products and Functions

Thickeners and stabilizers (also called hydrocolloids, gums or water-soluble polymers) provide a number of useful effects in food products. The technical base for these effects results from the ability of these materials to modify the physical properties of water. Most food and beverage products are largely water.

Water-soluble materials function as rheology modifiers, affecting the flow and feel (mouth) of food and beverage products; act as suspension agents for food products containing particulate matter; stabilize oil/water mixtures; act as binders in dry and semidry food products; and create both hard and soft gels in food products that require this physical form. During the 1990s, fat replacement (discussed in detail under **FAT SUBSTITUTES**) became a major application for modified starches and gums, since these additives provide the unique texturizing, bulking and emulsifying properties of the displaced fat. Also, natural gums are being touted as good sources of dietary fiber.

Thickeners and stabilizers are generally used in very small amounts in most food products (e.g., 0.15% in jam, 0.35% in ice cream and 1-2% in salad dressings).

Table 20 indicates the primary functions of many food thickeners.

Table 20

Major U.S. Food Thickeners and Stabilizers and Their Principal Functions

	Thickening	Emulsion Stabilization	Suspending Properties	Gelation	Crystallization Control	Water Binding
Unmodified Starches	Data Removed					
Modified Starches						
Casein						
Gelatin						
Carboxymethylcellulose						
Methyl Cellulose						
Guar Gum						
Alginates						
Xanthan Gum						
Pectin						
Locust Bean Gum						
Gum Arabic						
Carrageenan						
Agar						

Table 20 (concluded)

Major U.S. Food Thickeners and Stabilizers and Their Principal Functions

	Mouth Feel	Foam Stabilization	Flavor Fixation	Protective Film Forming	Synergistic Effect	Fat Substitution
Unmodified Starches			Data	Removed		
Modified Starches						
Casein						
Gelatin						
Carboxymethylcellulose						
Methyl Cellulose						
Guar Gum						
Alginates						
Xanthan Gum						
Pectin						
Locust Bean Gum						
Gum Arabic						
Carrageenan						
Agar						

SOURCE: SRI Consulting.

Consumption and Markets

Table 21 shows the estimated U.S. consumption of the major water-soluble thickeners/gums/stabilizers that find common usage in the food and beverage industry, and their expected growth through 2006.

Table 21

U.S. Consumption of Major Food Thickeners and Stabilizers

	1998		2001		Average Annual Volume Growth Rate, 2001-2006 (percent)
	Thousands of Metric Tons	Millions of Dollars	Thousands of Metric Tons	Millions of Dollars	
Unmodified and Modified Starches	Data Removed				
Casein					
Gelatin					
Carboxymethylcellulose					
Other Cellulosics[a]					
Guar Gum					
Alginates					
Xanthan Gum					
Pectin					
Locust Bean Gum					
Gum Arabic					
Carrageenan[b]					
Agar					
Other[c]					
Total					

a. Includes MC, HPC, HPMC and MCC.

b. Includes PNG.

c. Includes gellan, karaya and tragacanth.

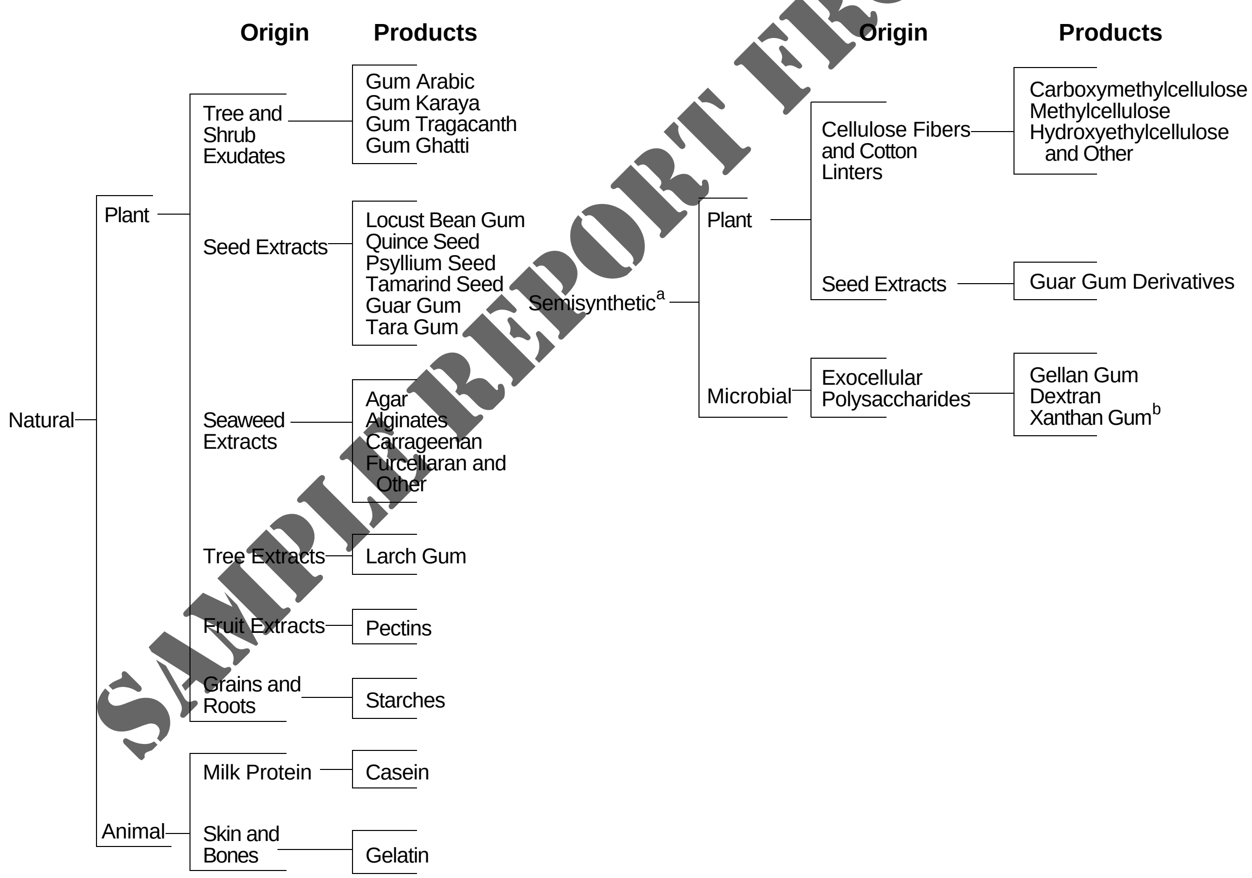
SOURCE: SRI Consulting.

Two principal classes of thickeners and stabilizers are recognized (a third class known as synthetic polymers, obtained from petroleum or natural gas precursors, is not used in food):

- Natural materials obtained from plants or animals
- Semisynthetic materials manufactured by chemical derivatization of natural organic materials, generally based on a polysaccharide, or microbial fermentation–based substances

Figure 5 shows the various hydrocolloids used by the food processing industry and their sources.

FIGURE 5
Natural and Semisynthetic Hydrocolloids Used as Food Additives



a. Natural-based, but highly derivatized.

b. Although xanthan gum is sourced from a natural product (grain), it is classified as a semisynthetic polymer because it is manufactured by fermentation in a chemical plant. Some industry sources disagree with this classification.

Source: SRI Consulting.

Unmodified starches

Unmodified or natural corn starch, produced by the wet milling of field corn, supplies the major volume of thickening material for the American food and beverage market. Other natural starches of significance include potato starch from U.S. sources, and tapioca, arrowroot and sago from foreign sources.

Unmodified corn starch, commonly called pearl starch, is widely used in the food processing industry as the base ingredient in many formulated thickening products because it is modestly priced in comparison with modified starch but even more so compared with such exotic materials as cellulose ethers, guar, xanthan and alginates. It is also a significant source of nutritional value. Its traditional growth rate has been tied largely to population growth, but in the last ten or so years unmodified starch has lost some ground because of the shift to low-calorie prepared foods and the availability of alternative modified natural and semisynthetic thickeners.

Unmodified starches are used mainly for their thickening, gelling, adhesive and film-forming properties. These characteristics, plus their low cost, availability in large quantities and easily controlled quality, have resulted in use in a variety of food products. Major use categories for unmodified starches are meat gravies, cooked puddings, cream-style sauces, pie fillings, barbecue sauces, salad dressings and baked good fillings.

In the last five plus years, a new wrinkle in unmodified starches offers food processors additional options—functional native starches that provide the process-tolerance attributes of modified starches without the word "modified" on the finished food label. These functional native starches appear to have a good fit with "label sensitive" products like yogurt, frozen dairy desserts and fresh soups. In addition, native starches from any source are considered GRAS, whereas modified starches are food additives and the limitations of their modification and use are defined in the Code of Federal Regulations.

The market for unmodified starches for food use remains fairly stable in terms of volume, generally tracing population/food industry growth. Prices tend to remain fairly constant as well. Major price and volume increases are not expected in the near future.

Modified starches

Modified starches used in food products or food processing have been modified for several reasons: (1) to extend the bodying or gelling effect of normal starches, (2) to improve resistance to acid or heat degradability and to low temperature and freeze-thaw (eliminating aggregation), (3) to improve texture, (4) to modify gelling tendencies as desired, (5) to increase viscosities at high temperature without gelling on cooling, and (6) to provide instant solubility and gelling in cold water. Modified or derivatized starches are generally designed for more selective food applications than are unmodified starches. They are used, however, in a wide variety of products including baby foods, purees, candy (e.g., bonbons and butter creams), jellies, cake mixes, doughs, various soup powders and liquids, instant noodles, puddings, pie fillings, batter mixes, gravies and sauces, salad dressings, yogurts and dairy desserts, snack foods, canned foods, and meat products such as sausages, hams and luncheon meats, where they serve as a binder as well as a thickener.

The market for modified starches is expected to grow at an average annual rate of 2-3% over the next five years.

Casein

Casein and caseinates are imported mostly from New Zealand and Ireland, although some caseinates are produced domestically from imported casein. Casein is a protein occurring naturally in, and obtained from, milk. It is the main ingredient in cheese. Casein is marketed as rennet and acid casein and as sodium, calcium, potassium or magnesium caseinate. Casein/caseinate is used in soups, sauces, puddings, bakery fillings and frostings, coffee whiteners and whipped toppings primarily for its functional benefits—its excellent thickening, whitening and whipping properties. It is also used in low-fat meat products and imitation cheese. Casein/caseinates are finding increasing application in weight loss products, sports nutrition products, and nutritional bars and drinks, primarily for their protein component. Here the competition often is domestically produced whey protein.

The future growth of casein/caseinate use for its functional properties is expected to be modest. There is much better growth potential in functional foods, meal supplements/replacements and dairy-based products where the protein component, rather than the thickening functionality, is in demand. These nutritional applications should keep total casein/caseinate consumption growing at annual average rates of 3.0-4.0% over the next five years. It is estimated that in 2001, about 30% was consumed by the food industry as casein and about 70% as caseinate.

Casein/caseinate use in the United States has not been affected in any way by concerns over BSE. There is no scientific evidence to support any link between prions linked to BSE in cattle to dairy (i.e., milk) products.

Gelatin

Demand for gelatin for use in food products has generally been relatively stable. It is obtained from pork skin and bones (Type A) or beef skin and bones (Type B) and is available from both domestic and imported sources. Type A is used mostly for confectionery products and Type B for dairy applications. Gelatin is about 97% protein, but it has no beneficial value to human nutrition. The largest food applications for gelatin are dairy products such as yogurts, confectionery products such as gummy bears, meats such as canned hams, and gelatin desserts. Gelatin is hygroscopic, capable of absorbing up to ten times its weight in water. Under refrigeration it forms a thermally reversible gel of high strength.

There appears to be little activity in the blending of gelatin with other gums to produce custom formulations. Gelatin seems to exhibit little synergy with other thickeners and stabilizers. However, there are reportedly some possible synergies with Kelco’s gellan gum.

Gelatin is a mature product with well-established applications. In recent years, it has been tarred by the brush of BSE (bovine spongiform encephalopathy) or mad cow disease. This has led food manufacturers in Europe to look for gelatin replacers. The initial spillover of these concerns into the United States prompted a number of U.S. food manufacturers to announce their intent to formulate all new products without gelatin. (Gelatin also is an issue in serving Kosher and Halal customers.) But gelatin is relatively cheap and is difficult to replace in many applications. Overall, U.S. food industry concerns over BSE appear to have faded rather quickly, with no real impact on U.S. gelatin use. The only lasting affect has been on gelatin suppliers who now regularly are called upon to provide customers with expanded documentation on gelatin source, SRM (Specified Risk Material)-free status and others. All gelatin produced in the United States is processed under USDA supervision.

Gelatin use is projected to grow 1.0-2.0% annually over the next five years.

CMC and other cellulose ethers

Carboxymethylcellulose (CMC) is the primary cellulose ether consumed in food and beverage applications. An estimated *data removed* of CMC were consumed in 2001 in the preparation of pet foods, frozen dairy products, beverages, bakers' goods, dry drink mixes, syrups, glazes, and icings and toppings. CMC, a nonnutritive substance, is also popular in diet food formulations requiring thickeners and stabilizers. CMC is widely used, easy to use and inexpensive. It suffers somewhat from having a non-natural image.

CMC is a mature product and consumption is expected to show modest growth (2-3% per year) in the next five years. However, one factor that might affect its future would be labeling changes. Currently, users of CMC can declare it as cellulose gum on the ingredient label. If food companies are required to spell out carboxymethylcellulose on the label, some potential users may be deterred from using CMC in their formulations.

Methylcellulose (MC), hydroxypropylcellulose (HPC) and hydroxymethyl propylcellulose (HPMC) are also used in specialized food and beverage applications, but the relatively high market prices of MC and HPC have precluded them from volume applications in the past. Somewhat more than 2 thousand metric tons of these cellulose ethers (primarily MC) are annually used as food thickeners and stabilizers and growth in their usage in the United States is expected to average 3-4% per year. They perform particularly well in products like reformed potatoes, veggie burgers, breaded onion rings, whipped products and bakery items, and have good growth potential in hand-held convenience foods, frozen foods and fast foods.

Microcrystalline cellulose (MCC) for which the best known trade name is Avicel (from FMC) is more widely used in food applications than MC, HPC or HPMC with some 5.1 thousand metric tons currently consumed. Growth over the 1998-2001 period was reasonably strong, about 4% per year, because of MCC's fit with dairy beverages/meal replacers like SlimFast. Growth in food industry consumption of MCC is expected to average 2-3% per year through 2006.

For the cellulosics, their status (i.e., GMO or non-GMO) does not appear to be an issue. Some food manufacturers, particularly the major European-based ones, require suppliers to certify the GMO or non-GMO status of the cotton linters used as raw material in the production of some cellulosics. For suppliers, this just means more paperwork rather than any real impact on sales.

Guar gum

Guar gum is one of the most economical and widely used gums in the United States, extensively used in a variety of industrial (e.g., oil field) and food applications. Along with natural starch and gelatin, guar gum is close to being a commodity product. Major uses for guar gum include ice cream and frozen desserts, dessert toppings (e.g., Cool Whip®), cheese spreads, barbecue sauces, salad dressings, frozen and refrigerated prepared meals, dry mix bakery formulations, citrus fruit drinks, instant hot cereals and canned pet foods.

Guar gum is derived from a soyalike legume native to the semiarid regions of the Asian subcontinent. In spite of several attempts by major domestic guar concerns to encourage domestic production of guar in arid agricultural areas of the American Southwest (only Rhodia historically has had its own U.S. guar crop, which it cultivates near its Vernon, Texas plant), most of the guar gum consumed in the United

States is derived from imported degermed guar beans (splits) sourced primarily from India and Pakistan.* Because of changing supplies due to weather and harvest conditions as well as the demand for guar gum for industrial applications, the price for guar gum has tended to shift dramatically every three to five years and therefore has been very difficult to forecast. Since 1999, however, with irrigation added to some of the foreign production acreage, supply has been ample and prices have tended to stabilize and even decline some. As a result, food companies seem less reluctant to use guar in new products than in the past.

A large portion of imported guar is bought by stabilizer houses that blend it with other additives for sale to ice cream manufacturers and other food processors. Guar, is also finding use as a source of soluble dietary fiber in functional foods and beverages. Benefiber®, a partially hydrolyzed guar gum from Novartis Consumer Health, has a high dietary fiber content (more than 80%) and blends well into many food formulations and processes. However, the fiber use is as yet a negligible portion of guar sales.

Growth in guar use over the next five years is forecast to average 2-2.5% annually.

Alginates

Alginates are extracted from different types of seaweeds, mainly from brown seaweed Macrocytis pyrifera and Laminaria sp. Consumption of alginates was estimated at almost *data removed* in 2001, with cheeses, restructured foods, and sauces and salad dressing the largest end-use categories.

The alginate category includes the various salts of alginic acid and propylene glycol alginate (PGA). Sodium alginate is the most commonly used and finds application primarily as a binder in frozen desserts, reconstituted onion rings, crab and shrimp analog applications, instant pudding mixes, fabricated puddings, sauces, gravies (particularly those containing milk or requiring the low “weep” property of alginates) and reformed meats.

PGA is used as a foam stabilizer in beers and ales manufactured in the United States. In addition, PGA is used by major food manufacturers in their salad dressing formulations. A major user of PGA reportedly removed PGA from a key product line over the 1997-1999 period, precipitating a significant drop in total PGA use from which it has not yet recovered. The nonsodium light metal salts of alginic acid are used as sodium alginate alternatives in low-sodium and dietary food specialties. Alginates are also used by the pet food industry.

The alginates market is becoming mature. However, there does not appear to be any decline in existing applications. Even with some new applications, however, the relatively high cost of alginates (prices have come down somewhat for sodium alginate because of exchange rate fluctuations) and the maturity of the major applications will limit the growth of alginate usage to 1.5-2.5% per year over the next five years. Consumption of PGA should grow significantly faster than sodium alginate.

* Interestingly, at the beginning of 2002, USDA announced a $0.5 million development grant for the construction and operation of a guar splitting facility in Brownfield, Texas. The facility will have annual capacity of 47.5 million pounds of guar beans and will be operational in time to process the 2002 crop. Processed guar from the facility will be commercially available in 2003.

Xanthan gum

Xanthan was approved for food use by the FDA in 1969. Since then, its scope of approved applications has greatly increased. A fermentation product, it is used in a wide range of salad dressings, relishes, syrups, sauces, bakery fillings, prepared puddings, glazes and toppings, processed cheese products, dry cake and beverage mixes, and fruit and carbonated beverages. A significant amount of food use is in dairy products, where it prevents the separation of the contained whey from the rest of the food product. Xanthan does not exhibit any reactivity with milk proteins and, therefore, is often used in combination with other hydrocolloids, particularly carrageenan. Moreover, the stability that xanthan gum adds to acid and high salt content makes it very useful for many types of foods, and xanthan is considered a very "forgiving" product.

Since its approval, xanthan gum has exhibited the fastest growth rate and market penetration of any of the hydrocolloids used as food thickeners or stabilizers. The introduction of a few differentiated product types has aided the adoption of this product for new applications. The xanthan market is highly competitive. While it has historically been one of the more profitable hydrocolloids on the market, the fall-off in oil drilling (a major end use), the consumer's retreat from nonfat and low-fat foods and from some home prepared foods (e.g., from baking mixes), capacity expansion via debottlenecking of plants and ADM's entry into the food-grade ranks have put xanthan prices into a two-year slump, with more capacity than demand at the moment. But lower prices have sparked new uses, particularly in baking. Some question whether xanthan has gone from a specialty to a commodity. However, xanthan remains the hydrocolloid of choice in the food industry and expectations are that the U.S. market for xanthan will grow at a solid rate of 5% or better annually through 2006.

The only downside to the xanthan business is China's entry into international markets. While Chinese product is reported to be of rather poor quality at present and only used in foods when blended with product from a different source, industry participants expect Chinese product to improve in quality over time and, thus, to become a price (and margin) spoiler. Reportedly, the availability of Chinese product, regardless of quality, has been used by some U.S. buyers to put price pressure on xanthan suppliers.

Pectin

Pectin is a fruit extract obtained mainly from the peel of citrus fruits and from apple pomace. The main commercial types used in foods are pectin itself and potassium pectinate, sodium pectinate and amidated pectin. Commercial products include high-ester (degree of esterification of 50) or low-ester (DE of less than 50) pectins. About 98% of all pectin is used in food applications, with about 2% used in minor industrial applications (surgical dressings, ostomy devices and hair spray). Traditional food uses are in jellies and jams. Newer applications include gummy candies and fruit-flavored juices and carbonated drinks. In gummy candies and jellies, it is continuing to replace starch for the fruit flavor aspect. It is also easier to work with, and the texture is better for cuttables and chewables. In fruit-flavored drinks, it stabilizes the constituents and makes the product more shelf-appealing.

Over 70% of total pectin consumption is high methoxyl; the remainder is low-methoxyl pectin. Low-methoxyl pectin has been showing higher growth than high methoxyl pectin; it is used in low-calorie products that do not contain enough sugar to gel regular pectin.

The supply of pectin is limited by the availability of raw material for processing. Currently, the major suppliers have tied up most of the available raw material in long-term contracts. Another constraint on the supply of pectin is the regulatory approvals required by the EPA to start up a new plant. Because of the high costs of compliance to dispose of the large volume of wastes generated during pectin production, the last U.S. pectin production facility was relocated to Mexico.*

Pectin is well-known and perceived by consumers as a natural product. It enjoys an ideal label image and broad functionality and is environmentally friendly as well. Pectin could also benefit from the growing demand for nutritionally enhanced foods and beverages, and from developments in low-calorie preparations because pectin allows gelling without sugar. It is being specified for many new “healthy” beverages including soy beverages. Pectin is expected to show good growth of 5% annually per year through 2006.

Locust bean gum

Locust bean gum is obtained from the carob tree, which grows primarily in Mediterranean countries. The size and quality of the crop are directly related to climatic conditions. Therefore, there are periodic shortages of supply and substantial cyclicality in prices.

Chemically, locust bean gum is similar to guar gum. Anionic, cationic and hydroxyalkyl derivatives are also produced commercially. Locust bean gum swells in cold water, but heating is necessary for maximum solubility. Locust bean gum is widely used in frozen dairy products, in conjunction with guar gum and carrageenan, and is used for preventing syneresis in cream cheese. In addition, locust bean gum is used in cultured dairy products, cheese spreads, sauces, dips, pet foods, and many nonemulsified sauces and dressings as a thickener, as well as in prepared meals and bakery products as a moisture retention aid.

Much locust bean gum is supplied in a blended form to the dairy industry. Thus an estimated 70% of locust bean gum sales in the United States has been made via blenders and distributors such as Germantown (now part of Danisco), Bunge Foods (whose Dari-Tech Division is now part of Degussa Texturant Systems) and Gumix International.

Supply shortages and high prices since the mid-1990s have caused locust bean gum to fall into disfavor among food and petfood producers. After peaking at about $26 per kilogram in 1996, prices somewhat stabilized in 1998 at about $15 per kilogram. Food and petfood processors have dealt with this price volatility by substituting other gums (xanthan and guar are generally good replacements) or by using locust bean gum in combination with guar or another gum, and by not formulating locust bean gum into new products. As a result, estimated U.S. consumption of locust bean gum fell over the 1995-1998 period. Then, a crop shortfall in Spain in 2001 promised a return to high prices. However, gum manufacturers had sufficient stocks on hand and stabilizer houses reverted to alternative formulations so the price spike did not materialize as expected. In fact, prices have been somewhat depressed. However, future consumption is expected to grow at best by 2% annually during the 2001-2006 period.

Gum arabic

Gum arabic is obtained from various trees of the genus Acacia, primarily from A. senegal. Gum arabic is highly soluble in water (up to 50%), and its solutions are of relatively low viscosity. Other advantages of gum arabic as a food additive are its nontoxicity and its lack of odor, color and taste. These properties are especially useful in systems requiring outstanding emulsifying properties, such as high-solids suspensions.

---

* Pectin could conceivably be made in the United States again if the USDA-ARS can find a business partner that would license new technology developed by ARS. ARS scientists have patented a microwave-based technique that economically extracts high-quality food-grade pectin from orange peels.

It is used as an emulsifier in beverages for citrus oil and flavors, as a foam stabilizer in beer, as a crystallization retarder and emulsifier in confectioneries, and as a stabilizer in dairy and bakery products. Gum arabic is also a good source of soluble dietary fiber and, thus, has applications in meal replacers, nutritional beverages and weight loss products.

Supply and prices also fluctuate with weather conditions. Shortages of product occurred in 1992 because of poor weather in the Sudan, which is the source of 70-90% of the world's gum arabic. Then, just as the gum arabic industry was beginning to recover from the high prices and product shortages of the early 1990s, politics entered the picture. In December 1997, President Clinton issued an executive order putting into effect trade sanctions against the Sudan amid suspicions that millionaire terrorist Osama bin Laden had a major interest in the Sudanese gum arabic industry and some association with Gum Arabic Company, the Khartoum-based firm that controls exports of gum arabic. But with no other reliable sources for gum arabic, exemptions in the form of special import licenses enabled continuing imports. Then in 2000, Congress passed legislation that made an exception in the trade sanctions for Sudanese gum arabic.

One U.S. company, Tic Gums, which imports approximately half of all the gum arabic used in the United states, grew tired of working with the Sudanese and in 1998 began looking for other sources that could guarantee the same quality at more stable prices. The result was that Chad has now become a major gum arabic supplier.

For the past several years, prices have been very low—down to a quarter of what they were a few years previously—and supplies have been ample, with substantial stocks on hand. Prices have been so low that the U.S. Federal Trade Commission in mid-2000 started an investigation into whether gum arabic (and acacia) imported from France and the United Kingdom were being dumped in the U.S. market. With low prices, improved quality in lower grades, and its natural image, arabic has been undergoing a bit of a renaissance, finding applications in diet shakes and other products where caloric content is an issue. While it is difficult to forecast gum arabic prices and volumes to 2006, consumption growth in the 4% per year range is expected over that time.

Researchers at the USDA's ARS are developing a gum arabic replacer from sugar that would allow domestic production of a gum arabic alternative. Scientists have made versions of a nonfattening carbohydrate, alternan, which mimics gum arabic's bulking feature. Now they are trying to develop versions that mimic gum arabic's emulsifying properties.

Carrageenan

Carrageenan is extracted from Irish moss Chondrus and Gigartina species, which are harvested off the Atlantic shores of New England, the Canadian Maritime Provinces, Chile and several European countries, and Eucheuma species, warm water weeds farmed primarily in the Philippines and Indonesia. Carrageenan is readily soluble in water to form an inelastic gel and is commonly used with other gums. Its most important property is a high degree of reactivity with certain proteins such as casein. The largest application of carrageenan food use is in dairy products (frozen desserts, flavored milk powder, nondairy creamers) and in processed chicken, ham and turkey products.

One of the most significant developments for carrageenan in the 1990s was its widespread use in poultry applications for moisture retention. The product serves to retain moisture before and during cooking and allows the poultry to be pumped with high levels of water.

While the trend toward healthier foods and a spurt of new applications for carrageenan would indicate strong growth for the future, one cloud has loomed over suppliers. In 1990, the FDA decided that the unrefined seaweed extract known as Philippine Natural Grade (PNG) was equivalent to carrageenan and could be used interchangeably with it, meaning that food processors could switch to the less expensive PNG without relabeling. Traditionally, refined carrageenan is made in a ten-step process in which carrageenan is extracted from the seaweed and then filtered to remove the cell walls, or cellulose, and other substances from the seaweed. PNG (or PES as it is now termed—Processed Eucheuma Seaweed—while some just call it semirefined carrageenan) is prepared in a reverse five-step process that extracts the unwanted substances from the seaweed, leaving a product that contains both carrageenan and about 10-14% cellulose, as opposed to less than 1% found in traditionally refined products. The major traditional carrageenan suppliers as well as the International Food Additive Council, filed petitions with the FDA and the General Accounting Office (GAO), but these government agencies decided to allow PNG to use the designation of “carrageenan” because PNG is produced from approved seaweed sources that have been considered as safe. The PNG/PES product, which is priced more than 10-15% below refined carrageenan (in line with its cellulose content), has already taken away an estimated 2-3 million pounds of the U.S. market, primarily in meat and chocolate milk. It is now well-accepted and often used in a blend with refined carrageenan (30-40% PNG/PES and 60-70% refined) with the blend being sold on a performance basis.

While carrageenan as an additive had a good image and excellent functionalities, rising prices because of higher raw material costs and occasional raw material shortages associated with ocean storms (as in the last six months of 1998) constrained growth in carrageenan use somewhat in the late 1990s. There is now overcapacity in the industry and prices have declined. Carrageenan suffered an additional blow when the FDA recalled the water jelly candies that were becoming popular, but which had proved dangerous to small children.

The market for carrageenan is expected to grow in volume at 2.0-3.0% annually between 2001 and 2006 with PNG/PES taking a steadily increasing share. Growth in the early part of the period will be almost nonexistent but will resume in the latter part of the period when the water jelly candy issue fades.

Gellan gum

Gellan gum is the latest hydrocolloid approved for food use. Kelco Biopolymers (now part of CP Kelco) received FDA approval to use gellan gum in icings, frostings, bakery fillings and low-solids jams, jellies and confections. It is claimed that gellan gum can be used at levels substantially below those required by conventional hydrocolloids. However, the very high unit price for pure gellan precludes its use for cost savings.

Gellan gum is produced with a fermentation process like that used for the fermentation of xanthan gum by the organism Auromonas elodea. There are two forms of gellan gum. The first is a high-acetyl gum, which is partly acetylated and provides thermoreversible gels. The second is a low-acetyl gum forming a firmer and more brittle gel. CP Kelco is the sole producer of gellan gum in the world.

Other

Agar (also called agar-agar) is obtained from various red-purple seaweeds of the class Rhodophyae. Agar is used primarily in baked foods (icings, toppings, meringues) and in confectionery products. Because agar is the most expensive of the seaweed extracts, there have been continual efforts to substitute other extracts such as carrageenan. An annual growth of 1% is expected between 2001 and 2006. Agar prices fell abruptly in 1998 when the Asian economic collapse hit, and much of the world's agar production was without a market. Since then prices have stabilized somewhat and are still relatively low.

A number of other thickening agents have been used by the U.S. food industry. They are currently used commercially at less than one thousand metric tons each, and these represent a very minor portion of the U.S. food additives market. Most are higher priced, in erratic supply and facing increasing competition from the principal thickeners. Other thickening and stabilizing agents and their principal uses include the following:

- **Ghatti Gum.** Obtained from India and Sri Lanka, ghatti gum has no functional properties other than thickening and emulsion stabilization.

- **Tragacanth Gum.** Obtained from the Middle East (however, imports from Iran are embargoed), tragacanth gum is used in a limited number of applications, including some jams and jellies.

- **Karaya Gum.** Obtained from India, it is used for extremely thick to pastelike gels.

- **Tara Gum.** Now permitted for use in the United States after GRAS self-affirmation in 1997, tara gum is structurally similar to guar and locust bean gum and has been used for many years in Europe. The gum originates from the tara bush, indigenous to South America.

- **Curdlan.** In 1996, the FDA approved curdlan for use as a formulation aid, processing aid, stabilizer, thickener or texturizer in foods. Curdlan is said to produce colorless, tasteless and odorless gels when heated. It has potential applications in processed meats, noodles, surimi-based foods and processed cooked foods.

- **Konjac Flour (also known as konjac gum).** Obtained by grinding the foot of the Amorphophallus konjac plant, konjac is GRAS and is widely used in Asia in noodles and similar products. Clinical studies have shown that konjac flour added to some foods can cut serum cholesterol by 10% and blood glucose levels by 75%.

In addition, the coprocessing of some thickeners allows the creation of new or improved functionalities in existing thickeners. For example, FMC is coprocessing MCC and guar gum to create Novagel™ BK 2130, an ingredient that can improve the texture and shelf life of snackbars while mimicking the mouthfeel properties of fat.

Technology and Manufacture

The production of the various thickeners is detailed in a number of SRI Consulting reports: the SCUP *Water-Soluble Polymers* report, the CEH *Water-Soluble Polymers* report, and the CEH *Cellulose Ethers* report. Therefore, Table 22 below simply indicates the raw material sources and general processes used in their production.

Table 22

Food Thickener Sources and Basic Production Steps

Thickener	Raw Material	Process Technology
Unmodified Corn Starch	Field corn	Wet milling, centrifuging
Modified Corn Starch	Field corn	Wet milling, centrifuging, followed by one or more of various treatments: acid, akali, enzymatic, bleaching, esterification, oxidation
Casein	Skim milk	Precipitation by acid or rennin
Gelatin	Beef and pork skin and bones	Hydrolysis, extraction, purification
Cellulose Ethers	Cellulose fibers	Reaction with appropriate halide, sulfate or epoxide
Guar Gum	Guar seed	Separation, milling, grading
Alginates	Kelp	Extraction, filtration, precipitation
Xanthan Gum	--	Fermentation, recovery, precipitation
Pectin	Citrus peel	Extraction, separation, concentration
Locust Bean Gum	Carob seed	Separation, milling, grading
Gum Arabic	Acacia exudate	Grading, dissolution, filtration, drying
Carrageenan	Seaweed	Extraction, recovery
Agar	Seaweed	Extraction, purification, drying

SOURCE: SRI Consulting.

Market Participants

The prominent U.S. producers of the major food-grade thickeners are listed in Table 23. Many thickening products are also supplied through importers.

There have been a number of major changes in the industry in recent years.

- Monsanto put its biopolymers businesses on the block at the beginning of 1999, selling the alginates unit to International Specialty Products Inc. (ISP) for an estimated $50-70 million, about equal to the alginates business sales. ISP’s alginates business purchase makes it the second-largest alginates maker in the world after FMC. The sale of the algin business included all of the assets of the Kelco Alginates Division, including manufacturing facilities in San Diego, California and Girvan, Scotland, and laboratory and sales facilities in England. After the acquisition, ISP reduced the production volume of the factories in San Diego and Scotland by 25%. ISP also has joint ventures in Iceland, Ireland and Tanzania for specific species of seaweed.

- Unable to afford Monsanto’s xanthan business on its own, Hercules formed a 29:71 joint venture with Lehman Bros. Merchant Banking Partners II L.P. in 2000 to acquire the biopolymers business and combine it with Hercules’ Copenhagen Pectin/Food Gums Division. The resulting company, CP Kelco, is first in xanthan, pectin and gellan sales in the world and second in carrageenan with revenues of some $470 million. (Monsanto had about a 60% share of the world xanthan business with estimated sales of some $250 million a year.) A year later, CP Kelco filed suit against Pharmacia, Monsanto’s parent, for fraud conduct in relation to the sale of the xanthan business it acquired. The suit claims $430 million in actual damages. More recently, CP Kelco has announced plans to expand its Okmulgee xanthan facility.

- In a major restructuring of the gelatin industry, Degussa reached agreement to sell its gelatin unit (SKW Gelatin & Specialties) to Sobel N.V. (Netherlands) for $230 million, making Sobel second in world gelatin sales. The SKW unit accounts for 18% of gelatin production volume worldwide.

Deutsche Gelatine-Fabriken (DGF) Stoess is acquiring 75% of Leiner Davis Gelatin, the global edible gelatin business of Goodman Fielder Ltd. The $112.5 million deal would make DGF first in the global gelatin market. DGF is already a major player in the U.S. market. It acquired Dynagel in 1998 and quadrupled the nameplate capacity of its Kind & Knox subsidiary in Iowa to 12,000 metric tons per year. Because of objections raised by the U.S. Federal Trade Commission, Goodman Fielder excluded from the sale a pork skin gelatin plant in Iowa and a beef skin gelatin plant in Argentina.

- In 1999, FMC Corporation expanded its food additives portfolio by acquiring Norsk Hydro's Norwegian alginates unit, Pronova Biopolymers. A few months later, FMC created FMC Biopolymers out of FMC's Food Ingredients and Pharmaceutical divisions and Pronova Biopolymer. With the Pronova acquisition, FMC added alginates to its existing lines of cellulose gel, carrageenan and konjac products.

- Cargill is acquiring Montedison's 56% share of Cerestar. After the U.S. Justice Department rules on that acquisition, Cargill intends to file a tender to acquire the remaining share of Cerestar. The acquisition would raise Cargill's share of global starch production from 13% to 21%. Indications are that after the acquisition is complete Cargill may close Cerestar's plants in Indiana and Alabama and convert the Texas facility to ethanol.

- ADM entered the food-grade xanthan business in 1999 and expanded its Decatur plant by 50% to 4,000-5,000 metric tons of capacity. ADM had originally planed to build a 10,000 metric ton xanthan gum unit at its Cedar Rapids, Iowa, corn processing complex but opted for the smaller unit at Decatur. Both European producers—Rhodia and Jungbunzlauer—are expanding xanthan capacity as well.

- Danisco A/S acquired Germantown, a supplier of texturants, from Goodman-Fielder for $100 million in 2001.

Table 23

Major U.S. Producers of Food-Grade Thickeners and Stabilizers—2002

Company and Plant Location	Guar Gum	Locust Bean Gum	Alginates	Carrageenan	Gelatin	Modified and Unmodified Starches	Xanthan Gum	MCC and Cellulose Derivatives	Gellan Gum	Casein and Caseinates	Gum Arabic
American Casein											
Burlington, NJ											
Archer Daniels Midland Company											
ADM Corn Processing Division											
Clinton, IA											
Decatur, IL											
Cargill Inc.											
Cargill Corn Milling											
Blair, NE											
Eddyville, IA											
Cerestar USA (now part of Cargill)											
Decatur, AL											
Hammond, IN											
Corn Products International Inc.											
Stockton, CA											
Summit-Argo, IL											
Winston-Salem, NC											
CP Kelco											
Danville, PA[a]											
Okmulgee, OK											
Dow Chemical U.S.A.											
Midland, MI											
Plaquemine, LA											
Erie Foods International Inc.											
Erie, IL											

Table 23 (continued)

Major U.S. Producers of Food-Grade Thickeners and Stabilizers—2002

Company and Plant Location	Guar Gum	Locust Bean Gum	Alginates	Carrageenan	Gelatin	Modified and Unmodified Starches	Xanthan Gum	MCC and Cellulose Derivatives	Gellan Gum	Casein and Caseinates	Gum Arabic
FMC Corporation											
FMC BioPolymer											
Newark, DE											
Rockland, ME											
Goodman Fielder Ltd.											
Davenport, IA											
Grain Processing Corporation											
Muscatine, IA											
Hercules Incorporated											
Aqualon Division											
Hopewell, VA											
Kenedy, TX											
Parlin, NJ											
Interchem, Inc.											
Hi-Tek Polymers, Inc. subsidiary											
Louisville, K											
International Specialty Products Inc.											
San Diego, CA											
Kind & Knox Gelatine, Inc.											
Sergeant Bluff, IA											
Midwest Grain Products, Inc.											
Atchison, KS											
National Starch and Chemical Company											
Indianapolis, IN											
Island Falls, ME											
North Kansas City, MO											

Table 23 (concluded)

Major U.S. Producers of Food-Grade Thickeners and Stabilizers—2002

Company and Plant Location	Guar Gum	Locust Bean Gum	Alginates	Carrageenan	Gelatin	Modified and Unmodified Starches	Xanthan Gum	MCC and Cellulose Derivatives	Gellan Gum	Casein and Caseinates	Gum Arabic
New Zealand Milk Products											
Allerton, IA											
Penwest											
Penford Products											
Bellevue, WA											
Rhodia Inc.											
Consumer Specialties Division											
Vernon, TX											
Roquette America, Inc.											
Keokuk, IA											
A. E. Staley Manufacturing Company											
Starch Business Group											
Decatur, IL											
Houlton, ME											
Lafayette, IN											
Loudon, TN											
Monte Vista, CO											
Stanfield, OR											
Van Buren, AR											
TIC Gums											
Belcamp, MD											

a. Owned and operated by Merck. Merck produces for CP Kelco under long-term contract.

SOURCE: SRI Consulting.

There is no production of agar or pectin in the United States.

Many gums and thickeners are supplied via blenders and resellers. Blends make up approximately 30% of the food hydrocolloids business in North America. Blends contain mostly hydrocolloids—namely guar, locust, CMC, carrageenan, pectin, xanthan gum and modified starches. A small portion of the blends, about 20%, also contain emulsifiers, but typically no other type of functional ingredient is included. Blends are sold largely to the dairy industries for frozen desserts, processed cheese, yogurt, sour cream and other applications. Also, blends are often used in products in which numerous hydrocolloids are required in small quantities. In other areas of the food industry (e.g., salad dressings), there is little use of blends. Leading U.S. blending firms are listed in Table 24. The large hydrocolloids manufacturers are increasingly selling blends for selected accounts, being careful not to disrupt their important blender accounts.

Table 24

Major U.S. Hydrocolloid Blenders and Resellers—2001

Company	Ownership	Estimated Sales (millions of dollars)
Continental Custom Ingredients, Inc.	Privately held	na
Danisco Cultor USA	Danisco A/S	na
Degussa Texturant Systems	Degussa Corporation	na
Frutarom Inc.	Frutarom Ltd.	50[a]
Germantown (USA) Co.	Danisco Cultor	70
Gumix International Inc.	na	na
TIC Gums Inc.	Family owned	30-55

a. Includes nonthickener products.

SOURCE: SRI Consulting.

Prices

As is the case with most products, prices vary depending on the grade specified and the amount purchased. Consequently, the data given in Table 25 are provided to illustrate order-of-magnitude rather than exact prices for these products in 1998.

Table 25

Representative U.S. Prices for Selected Thickeners—2001
(dollars per kilogram)

Unmodified Corn Starch
Modified Corn Starch
Casein
Caseinates
Gelatin
Carboxymethylcellulose
Guar Gum
Alginates, Sodium
Xanthan Gum
Pectin, High Methoxyl
Pectin, Low Methoxyl
Locust Bean Gum
Gum Arabic
Agar
Carrageenan
Carrageenan PNG (Philippine Natural Grade)

SOURCE: SRI Consulting.

Future Trends and Strategic Issues

Over the next five years, producers of food texturizers and stabilizers will need to respond to shifting consumer demand trends. Some of these trends favor thickeners as an additive category, while others will likely result in changes in patterns of thickener usage. Key consumer-driven demands that will affect the fortunes of thickener suppliers include:

- **Increased Emphasis on Nutrition.** Fortified foods and nutraceuticals, especially in beverage form, typically require the addition of food gums to compensate for the damage to texture done by nutritional additives. In fortified beverages, for example, where processors are trying to get more calcium and other minerals, proteins and/or vitamins into the products, they need a suspension aid like MCC or pectin. In addition, some thickeners slow absorption of glucose into the bloodstream—of interest in products for athletes and diabetics.

- **A Focus on Disease Prevention.** Many gums are also high in soluble fiber—a plus even where they are used at relatively low levels. Also, clinical studies have shown blood cholesterol reduction with guar, pectin, gum arabic and konjac flour (which is widely used in Asia).

- **A Shift Away from Fat Free Foods to "Controlled-Fat" Formulations with an Indulgent Quality.** Gums are getting renewed attention here for a number of reasons: they can deliver specific textural qualities, are cost-effective at low usage rates and can be synergistic with other ingredients. On the other hand, this has resulted in reduced demand for fat replacer hydrocolloids, such as Slendid.

- **A Continued Interest in Natural Ingredients and Clean Labels.** Many gums are natural and classified as GRAS substances.

- **A Greater Awareness of Food Safety and the Presence of Significant Minority Populations.** Europe's fears surrounding mad cow disease (BSE or bovine spongiform encephalopathy) have had a major impact on animal-based hydrocolloids like gelatin and even casein use in foods both in the United States as well as Europe. In addition, food companies also have to take into account the growing vegetarian population as well as religious dietary practices (e.g., Judaism, Buddhism and Islam).

- **Some Emerging Discomfort with Genetically Modified (GMO) Food Materials and an Interest in Organic.** Companies like National Starch, ADM, CP Kelco and Rhodia now offer products that are classified as non-GMO like ADM's Xanthan NCD (non-corn-derived) for customers where GMO content is of concern. And cellulosic gum producers are willing to certify that no GM cotton raw material has been used in their products. With organic foods increasing in popularity, new corn starches like National Starch's with Novation technology are being introduced to substitute for modified starches, which cannot be used in organic foods.

As these changes occur, thickener/stabilizer suppliers continue to reposition their additives and redirect their application efforts, and the debate over single ingredients versus blends continues. Some suppliers argue that big food processor customers are in a "deblending mode," preferring to do additive formulation themselves. Other suppliers feel that blends are the most advantageous way to go for many food processor customers and that buying blends is a problem-solving approach to new food product needs. Catering to a food customer's needs, whether via blends or individual additives, remains the cornerstone of this business area, particularly with many gums still subject to significant price/supply volatility and others moving in and out of favor because of politics, food safety issues, and perceptions about label- and environmental-friendliness.