AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Have High-Intensity Sweeteners Reached Their Peak?

Peter Buzzanell and Fred Gray
(202) 219-0888

High-intensity—also called low-calorie or artificial—sweeteners are increasingly being used in a wide range of "diet" foods and beverages. In fact, their growth has firmly established them as a third major sweetener option, along with sugar and corn sweeteners.

The high-intensity sweeteners approved for use in the U.S. food supply are aspartame, saccharin, and acesulfame-K (see box on these leading products). Other high-intensity sweeteners—sucralose and alitame—have approval petitions pending before the Food and Drug Administration (FDA).

Prospects are strong that these sweeteners—and possibly some additional ones—will continue to expand both in their total level of use and in the variety of foods and beverages they sweeten. Soft drinks and fountain syrups combined are by far the leading use of high-intensity sweeteners. Tabletop use is second in importance. Other products containing high-intensity sweeteners include powdered gelatin desserts, canned fruit, ice cream and similar dairy products, confectionery, and chewing gum.

Food and Beverage Use Widespread and Growing, But Recent Rapid Growth May Be Slowing

Since the mid-1980's, overall use of high-intensity sweeteners has grown significantly, driven largely by broad consumer acceptance of products containing aspartame, saccharin, and, to a lesser extent, the relatively recent Ace-K (see box).

Some of the fastest growing products for these sweeteners include diet soft drinks, direct sugar substitutes (called tabletop sweeteners), chewing gum, yogurt, and frozen dairy products. Fledgling categories of potential growth are confectionery and baked goods.

Some industry sources estimate that beverages—mostly soft

High-intensity sweeteners are increasingly being used in a broad range of foods and beverages—notably soft drinks, tabletop sweeteners, confectionery products, and baked goods.

Buzzanell is a Section Leader, and Gray is an agricultural economist, with the Commodity Economics Division, Economic Research Service, USDA.

drinks—represent 60-75 percent of total U.S. consumption of high-intensity sweeteners, tabletop sweeteners use 20-35 percent, and commercially prepared foods 5-15 percent. Industry sources indicate the market for tabletop sweeteners has limited growth. There seems to be more potential for growth in commercially prepared foods, but it is not yet fully clear if this potential can be realized.

One hindrance to growth may be the physical properties of high-intensity sweeteners themselves. Unlike sugar and corn sweeteners, sweetness is the only property high-intensity sweeteners can impart to food and beverages. The major problem in replacing sugar in commercially prepared foods—particularly confections and bakery products—is replacing the bulk. Since soft drink bottlers use liquid sweeteners, it is the liquid that provides the needed bulk. Intense sweeteners are judged solely on their ability to impart sweetness. Moreover, removing the caloric sweetener from baked goods—particularly yeast-leavened bread, rolls, buns, and doughnuts—removes food for yeasts to produce carbon dioxide and alcohol, which improves the palatability of the products. Similarly, without caloric sweeteners, ice cream would get a very limited reduction in the caloric content since most of the calories are in the butterfat and not the sweetener.

Soft Drinks

The U.S. carbonated soft drink industry is the largest single commercial user of high-intensity sweeteners. In 1992, total U.S. soft drink consumption reached an estimated 12.4 billion gallons. Diet soft drinks accounted for 3.6 billion gallons, or about 29 percent of the total. Aspartame was the leading sweetener for diet soft drinks in bottles and cans, sometimes mixed with saccharin for diet fountain syrups in a 1 to 4 blend (sugar sweetness equivalent). More saccharin is used in fountain syrups because aspartame tends to lose its sweetness when kept in a liquid solution for a long period (see box).

What To Call the New Sweeteners

Various terms have been used for high-intensity sweeteners over the years. Artificial sweetener was an early favorite and used virtually interchangeably with synthetic sweetener. Because there is some difference of opinion as to what is natural, what constitutes artificial, and what is synthetic, there has been a tendency to shy away from calling saccharin, and more recently aspartame, an artificial or synthetic sweetener.

After World War II, noncaloric or non-nutritive sweeteners became a more widely acceptable term to describe saccharin and cyclamate. When aspartame became popular in the mid-1980's, noncaloric was changed to low-calorie, since aspartame has the same number of calories as a caloric sweetener, except on the average, only around 180th as much aspartame as sugar is needed to sweeten foods and beverages. Today, high-intensity sweeteners is the more acceptable generic term to describe saccharin, aspartame, and Ace-K, though low-calorie is also considered acceptable.

Figure 1
U.S. Soft Drink Consumption on the Rise

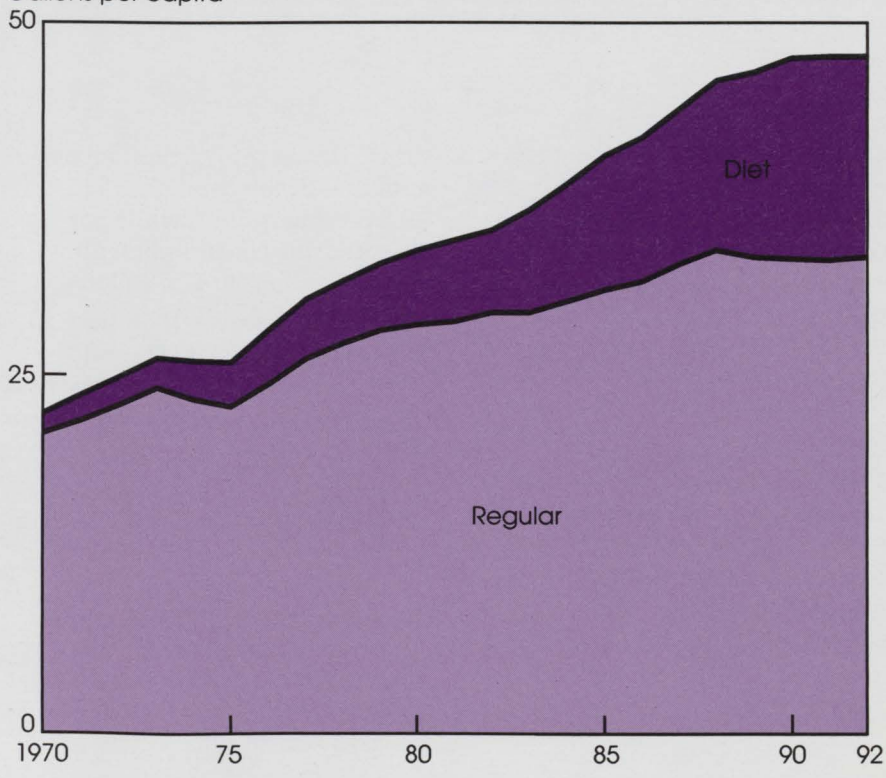


Table 1

High-Intensity Sweeteners' Share of U.S. Soft Drinks Fell Slightly for the First Time in 1992 Since the Uptrend Began in 1983

Year	Regular soft drinks		Diet soft drinks		Total consumption	Change from previous year	Diet's share of total	Total per capita consumption
	Consumption	Change from previous year	Consumption	Change from previous year				
	*Billion cases**	*Percent*	*Billion cases**	*Percent*	*Billion cases**	*Percent*	*Percent*	*Gallons*
1970	2.79	8.6	0.18	-14.3	2.97	6.9	6.1	22.7
1971	2.94	5.4	.24	33.3	3.18	7.1	7.5	24.0
1972	3.13	6.5	.27	12.5	3.40	6.9	7.9	25.3
1973	3.32	6.1	.29	7.4	3.61	6.2	8.0	26.6
1974	3.24	-2.4	.37	27.6	3.61	0	10.2	26.4
1975	3.20	-1.2	.43	16.2	3.63	.6	11.8	26.3
1976	3.47	8.4	.53	23.3	4.00	10.2	13.3	28.6
1977	3.75	8.1	.59	11.3	4.34	8.5	13.6	30.8
1978	3.93	4.8	.63	6.8	4.56	5.1	13.8	32.1
1979	4.09	4.1	.67	6.3	4.76	4.4	14.1	33.3
1980	4.18	2.2	.75	11.9	4.93	3.6	15.2	34.2
1981	4.24	1.4	.83	10.7	5.07	2.8	16.4	34.9
1982	4.36	2.8	.84	1.2	5.20	2.6	16.2	35.6
1983	4.65	6.7	1.13	34.5	5.78	11.2	19.6	37.0
1984	4.83	3.9	1.30	15.0	6.13	6.1	21.2	38.8
1985	5.00	3.5	1.50	15.4	6.50	6.0	23.1	40.8
1986	5.15	3.0	1.62	8.0	6.77	4.2	23.9	42.1
1987	5.39	4.7	1.77	9.3	7.16	5.8	24.7	44.1
1988	5.58	3.5	1.95	10.2	7.53	5.2	25.9	46.1
1989	5.54	-.7	2.14	9.7	7.68	2.0	27.9	46.7
1990	5.57	.5	2.34	9.3	7.91	3.0	29.6	47.7
1991	5.64	1.3	2.40	2.6	8.04	1.6	29.9	47.8
1992	5.76	2.1	2.40	0	8.16	1.5	29.4	48.0

Notes: These consumption estimates are 10-30 percent higher than Census of Manufactures figures published by the U.S. Department of Commerce. *A case is equal to 24 8-ounce containers totaling 192 ounces, fountain drinks included. Source: Wheat First Securities.

U.S. soft drink consumption has jumped over two-fold from 22.7 gallons per person in 1970 to 48.0 gallons in 1992 (table 1). But there was not much growth in high-intensity sweetener use in soft drinks in the 1970's, and into the early 1980's, with saccharin the only high-intensity sweetener approved for such use.

Following FDA's approval for aspartame use in soft drinks in 1983, which coincided with increasing consumer demand for diet foods, high-intensity sweetener use in soft drinks grew rapidly. These "diet" drinks grew from 19.5 percent of U.S. soft drinks in 1983 to 29.8 percent in 1991, while per capita soft drink consumption grew from 37 gallons to 47.5 gallons.

In 1992, however, high-intensity sweetener's share of U.S. soft drinks declined slightly for the first time since the uptrend began in 1983.

Analysts attribute the 1992 decline to the coolest summer in over a decade, the lingering recession, and expansion in consumption of so-called "new-age" beverages. These are nonalcoholic drinks containing natural ingredients without preservatives that consumers perceive as healthy alternatives to traditional soft drinks. The most popular are sparkling or still waters—not flavored or flavored with fruit essence or juice. Others include tea and herbal tea. Industry sources indicate the new-age segment grew 10 percent in 1992.

The softening in demand for diet soft drinks in 1992 followed a 4.9-percent average annual growth. Some analysts believe that diet soft drinks are at a saturation point and could lose incremental market share to new-age beverages in the years to come. The summer of 1993 may well prove a turning point.

Table 2
Ten Brands Hold Over 80 Percent of the U.S. Diet Soft Drink Market

Rank and brand	Consumption	Market share	Diet share	1992 growth	5-year growth
	Million gallons	*Percent*	*Percent*	*Percent*	*Percent*
1 Diet Coke	1,211.4	9.8	33.4	-0.8	+40.3
2 Diet Pepsi	764.2	6.2	21.1	+1.9	+51.8
3 Caffeine-Free Diet Coke	272.6	2.2	7.5	-2.8	+65.3
4 Caffeine-Free Diet Pepsi	166.2	1.3	4.6	-1.5	+57.1
5 Diet Dr Pepper	123.3	1.0	3.4	+16.8	+184.1
6 Diet Sprite	105.3	.9	2.9	-1.5	+36.9
7 Diet 7-Up	102.0	.8	2.8	+1.0	-2.6
8 Diet Mountain Dew	78.2	.6	2.2	+18.5	+77.3*
9 Diet Rite	69.0	.6	1.9	-7.5	-40.4
10 Diet Minute Maid	43.7	.4	1.2	-2.2	+16.5
Top 10 diet soft drinks	2,935.9	23.8	81.0	+.6	+40.3
All other diet soft drinks	690.9	5.6	19.0	-5.1	-13.5
Total diet soft drinks	3,626.8	29.3	100.0	-.5	+25.4

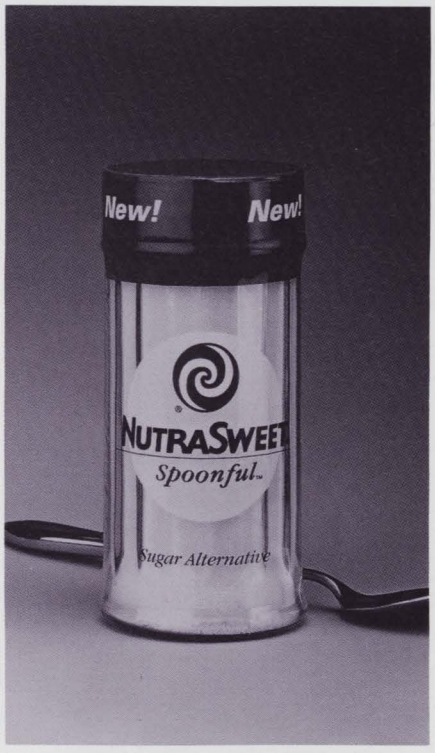
*Notes: Diet Mountain Dew commenced production in 1988. Growth reflects last 4 years. Source: Beverage Marketing Corporation.

Given their high level of total use in diet soft drinks, high-intensity sweeteners—particularly aspartame—will be affected by what drives the soft drink market.

Tabletop Sweeteners

U.S. consumers have a full range of sweeteners to choose from at the restaurant or dinner table at home—sugar, crystalline fructose, and all three high-intensity sweeteners. The leader in market share among high-intensity sweeteners is the saccharin-based Sweet-N-Low, maintaining over 40 percent of the diet tabletop market. NutraSweet's aspartame-based Equal comes in second, with about 30 percent of the market. The remaining share is taken by the Ace-K-based Sunette product.

The newest tabletop product is NutraSweet's Spoonful, an aspartame product which was granted approval in early 1992. Unlike other high-intensity tabletop sweeteners, Spoonful replaces sugar gram for gram, with the mass provided by maltodextrin, a cornstarch-based bulking agent. The product reportedly contains 2 calories per teaspoon, compared with 16 calories in a teaspoon of sugar.



Tabletop use appears likely to trend upward in the years ahead—with a wide array of sweetener choices. This new tabletop product replaces sugar gram for gram.

Confectionery and Baked Goods

Aside from chewing gum, high-intensity sweeteners have made little headway in gaining market share in confectionery and baked goods. However, this may be changing due to recent FDA approvals and introduction of new bulking agents. For example, American Hoechst Corporation received approval for Ace-K's use in confections in late 1992, and NutraSweet received approval for encapsulated aspartame's use in baked goods.

The potential for development of low-calorie confections hinges on introduction of suitable bulking agents to replace sugar's density. Caloric sweeteners, including sugar, supply other desirable functions along with sweetness, including bulk. When confectionery is made without sugar, over half the bulk supplied by sugar must be replaced. Bulk replacers, such as sorbitol, mannitol, polydextrose, and others, are more expensive than sugar. And, the resulting confectionery—particularly the taste—is frequently less acceptable than a similar product containing sugar.

The Leading High-Intensity Sweeteners: How Sweet They Are

Aspartame

Aspartame, now the leading high-intensity sweetener, is 180 to 200 times as sweet as sugar. It was discovered by G.D. Searle and Company in 1965 and is composed of two amino acids: phenylalanine and aspartic acid. Like all other proteins, it provides 4 calories per gram. But since its sweetness is so potent, only small amounts are needed to achieve a sweetening effect equivalent to much larger amounts of sugar. Aspartame has been approved by the Food and Drug Administration (FDA) for use as a tabletop sweetener (direct sugar substitute) and in soft drinks, dry beverage mixes, chewing gum, puddings, yogurt, fruit juice beverages, and many others. Its largest current use in the United States is in diet soft drinks.

Aspartame gradually loses its sweetness in liquids as a function of time, temperature, and pH. It also loses its sweetness when exposed to high heat, as in baking. A new encapsulated form of aspartame was recently approved by FDA for baking. Encapsulation protects aspartame under high heat and releases the sweetener only during the final stage of baking.

While aspartame is priced much higher than saccharin ($35-$40 a pound versus $3-$4 a pound), aspartame's price by itself has not restricted its use. Similarly, the U.S. aspartame-using industry has learned to cope with limitations on aspartame losing sweetness when kept in liquids for considerable time, and in baking. Also, reports from a significant number of people consuming aspartame who have experienced dizziness, headaches, and others with allergic reactions have not been sufficiently verified by the FDA to consider limiting its use.

Saccharin

Saccharin has a sugar sweetness equivalent of 300. First discovered over 100 years ago, it is currently approved by FDA in a variety of uses, most notably as a tabletop sweetener, and in fountain diet syrups. Saccharin is not metabolized, so it has no calories. Its major drawback is a bitter aftertaste, but that can be removed by blending with other sweeteners. Saccharin has a synergistic reaction with aspartame, and the combination is used in fountain drinks. In this synergistic example, the sweetness of both sweeteners are additive, but the aftertastes cancel out each other.

Saccharin is manufactured by PMC Specialty Products. In 1977, FDA proposed to ban saccharin because research indicated that it was an animal carcinogen (caused cancer in certain laboratory animals), but Congress imposed a moratorium on the ban. Although saccharin still is somewhat stigmatized by the moratorium, it is the second most widely used high-intensity sweetener in the United States.

Acesulfame-K

Called Ace-K, Acesulfame-K is a synthetic sweetener developed by Hoechst AG. It has a sugar sweetness equivalent of 200. Ace-K also is not metabolized and so has no calories. It is stable even at cooking temperatures. It has some bitter and astringent aftertastes, but these can be masked when combined with other sweeteners.

FDA has approved Ace-K for tabletop use, chewing gum, dry bases for beverages, instant coffee and tea, gelatins, puddings, and dairy product analogs (imitation dairy products). Soft drink use has been requested, but has not yet been approved by FDA. Its main uses are in a large number of relatively small markets, such as certain flavors of chewing gum.

Several other high-intensity sweeteners are pending approval. Among these are sucralose, 600 times the sweetness of sugar and noncaloric, and alitame, 2,000 times the sweetness of sugar. Like aspartame, alitame is composed of two naturally occurring amino acids: aspartic acid and alanine. As such it is caloric, but contributes few calories because only small amounts are used due to its very intense sweetness. The sucralose and alitame petitions are for use in baked goods, beverages, chewing gum, various dessert products, sauces and syrups, and as a direct sugar substitute.

Another sweetener, cyclamate—sugar sweetness equivalent of 30—has been petitioned for reapproval. Widely used in the United States in the late 1960's in the first wave of diet beverages, cyclamate was banned in 1970 due to studies claiming it was carcinogenic. In June 1985, however, the National Academy of Sciences said cyclamate was not a carcinogen. Cyclamate is considered a high-quality sweetener with limited discernible aftertaste. And since it is water soluble, it is useful in blending and formulating sweetened foods and beverages. (Before the ban, cyclamate was frequently blended with saccharin in a 50-50 mix in soft drinks.)

Table 3
On a Sugar-Sweetness-Equivalent Basis, High-Intensity Sweeteners Are Less Expensive Than Sugar

High-intensity sweetener	Sugar sweetness equivalent	U.S. average wholesale price	Equivalent price to sugar	Estimated domestic food use
	(Sugar = 1)	Dollars per pound		Million pounds
Saccharin	300	2.50-2.85	0.01	4.0
Aspartame	180	20.00-35.00	.17	17.0
Acesulfame-K	200	20.00-35.00	.17	NA
Cyclamate	30	NA	NA	NA
Sucralose	600	NA	NA	NA
Alitame	2,000	NA	NA	NA

Note: NA = Not available. Source: Estimates from Wheat First Securities.

However, both M&M Mars and Hershey, which together command 55 percent of the U.S. confectionery market, are currently test-marketing reduced-calorie and reduced-fat candy bars. Both candies rely upon two major ingredient changes: they replace much of their fat with caprenin, a cocoa-butter substitute, and use the polydextrose product Lituse II as a bulking agent, but they do not use high-intensity sweeteners. Hershey's new 1.37-ounce candy bar contains only 150 calories and 9 grams of fat, a 25-percent reduction compared with 1.37 ounces of Hershey's milk chocolate, which has 200 calories and 12 grams of fat.

Interestingly, the sugar content of these products is actually higher than that of the traditional chocolate bar, because sugar has only 4 calories per gram versus 9 calories per gram of fat. As such, sugar acts as a relatively cheap bulking agent in the replacement of some of the fat in cocoa butter. With refined sugar costing around 25 to 30 cents per pound, and cocoa butter normally selling for over $1 per pound, sugar costs about one-fourth the price of cocoa butter.

Regarding baked goods, FDA's approval in April 1993 of an encapsulated form of aspartame in commercial baking applications opens the way for the development and commercialization of new types of no-sugar and reduced-calorie baked goods. However, to compensate, a baker will need to add "low-calorie" bulking agents to compensate for the smaller amount of high-intensity sweetener used.

Future Growth of High-Intensity Sweeteners May Not Be as Sweet as in Recent Years

Prospects for high-intensity sweetener use in the United States may be at a turning point. The slight decline in high-intensity sweetener use in soft drinks in 1992 shows such use does not have unlimited growth. Also, with the more rapid growth of alternative new age beverages expected in the future, prospects for greatly increasing high-intensity sweetener use in beverages are uncertain.

The outlook for high-intensity use in beverages differs greatly from that not too long ago, when forecasts of diet soft drinks rising 3-5 percent annually were not uncommon. At that time, several analysts believed diet soft drinks would eventually account for at least half of total U.S. soft drink consumption. In light of the 1992 decline, limited growth at worst, perhaps 3-percent annual growth at best, seems to be more on target than earlier projections. Recent trends suggest per capita soft drink consumption, particularly for diet soft drinks, is reaching maturation.

Tabletop use appears likely to trend upward in the years ahead. This trend reflects population growth and the increasing trend toward eating away from home. At these eating places, consumers will have a wide array of tabletop sweetener choices—high-intensity ones as well as sugar and crystalline corn sweeteners.

High-intensity sweeteners in commercially prepared foods could be a significant growth category. Industry sources indicate that both aspartame manufacturers and high-intensity sweetener users are developing/adapting successful recipes and/or formulas for high-intensity sweetener use.

Success of these endeavors will depend on a few factors:

- How retail prices of low-calorie sweetened foods compare with similar caloric sweetened products.
- How the taste and acceptability of low-calorie sweetened foods compares with similar caloric sweetened products.
- How consumers weigh the tradeoff in consuming products containing high-intensity sweeteners compared with perceived health and safety risks.
- How much effort is put forth by the manufacturers to develop better tasting low-calorie sweetened foods, and
- How large and successful promotion and advertising budgets will be in introducing potential new consumers to newly developed and reformulated high-intensity sweetened foods.

Consumers—especially older people, an increasingly larger share

of the U.S. population—are more diet conscious and are more likely to try to consume fewer calories in the future. Over the long run, this trend of a growing population of older Americans is likely to be the basis for continued opportunities for growth in high-intensity sweeteners.

The number of new food and beverage applications is expected to continue expanding, as is the development of new and improved high-intensity sweeteners. For example, the NutraSweet Company is developing a new high-intensity sweetener called Sweetener 2000, which it hopes FDA will approve by the end of the decade. Sweetener 2000 is 10,000 times sweeter than sugar, tastes like sugar, and promises excellent stability in a variety of applications.

There is also an opportunity to make more use of blending of different high-intensity sweeteners to achieve synergies of use. For example, aspartame and Ace-K are being successfully mixed (in a 1 to 10 ratio) in beverages in Europe. Moreover, there is commercial interest in blending high-intensity, low-calorie sweeteners with the higher calorie sucrose and fructose. These blends could translate into fewer calories than sucrose and/or fructose alone, sweeter taste, and economic advantages for both food and beverage processors and consumers. These potential high-intensity caloric sweetener blends may have more applications. ■

Need the Situation and Outlook for Sugar and Sweeteners?

USDA's Economic Research Service is your source for the latest data and market analysis.

Sugar and Sweetener Situation and Outlook provides current intelligence and historical data on the sweetener industry and forecasts the effects of changing conditions, policies, and programs on the supply and demand for sugar and other sweeteners.

It's Timely...

Four times a year, you'll receive critical information on production, consumption, trade, stocks, and prices for U.S. and world sugar and U.S. corn sweeteners.

Fast...

Mailed first-class to ensure timely delivery.

And easy to obtain...

Get your subscription for $22 per year ($27.50 foreign)—multiyear discounts available—by calling toll-free 1-800-999-6779. Callers outside the U.S. and Canada, please dial 703-834-0125.

News from the last issue...

- World sugar production and consumption for 1993/94 is forecast at 112.4 and 114.2 million metric tons, respectively—with consumption expected to outpace production for the second straight year. Global stocks are forecast to fall, putting upward pressure on prices.
- U.S. sugar production for fiscal 1994 is forecast at 7.40 million short tons, down over 400,00 tons from last season's record. The downturn is largely due to a sharp contraction in sugarbeet production in the upper Midwest.
- U.S. consumption is forecast at 9.23 million tons, and the gap between domestically produced supplies and use will be made up from a drawdown in stocks and imports under USDA's tariff rate quota system.

Don't miss another issue!