NONCALORIC SWEETENERS:
THEIR POSITION IN THE SWEETENER INDUSTRY
PREFACE

This study of the economic position and prospects of noncaloric sweeteners and their relation to other parts of the sweetener industry was undertaken on the recommendation of the Oilseed, Peanut, and Sugar Crops Research Advisory Committee. It was made possible by the cooperation of both the producers and users of noncaloric sweeteners, and representatives of the sugar and corn sweetener industries.

The author was assisted by L. C. Larkin of the Economic Research Service in preparing plans for the study and in conducting field interviews.
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SUMMARY

The rapid increase in the consumption of noncaloric sweeteners, particularly cyclamate, in the early sixties has added a significant new dimension to the market for sweeteners in the United States. Prior to 1950, nearly all sales of noncaloric sweeteners and of foods sweetened with them apparently were made to persons who were unable to use sugar.

With the introduction of cyclamate, followed by mixtures of saccharin and cyclamate, consumption of noncaloric sweeteners began to increase. The most rapid increase occurred in the soft drink market in 1963 and 1964. Rather large gains were also made in these years in other uses, such as for dry beverage bases and in direct retail sales.

It is estimated that approximately one-third of the sales of soft drinks manufactured with noncaloric sweeteners in 1964 and 1965 were substitutes for sales of sugar-sweetened drinks and two-thirds represented additional sales. Similar estimates of the extent of substitution for other products were not available. However, the characteristics of many of these products and the quantities of noncaloric sweeteners used in them suggest that substitution for sugar was relatively less important, except perhaps for dry beverage bases, than it was for soft drinks. Decreased sugar sales probably amounted to less than 100,000 tons in 1965, although total usage of noncaloric sweeteners was equivalent in sweetness to about 343,000 tons of refined sugar.

Consumption of noncaloric sweeteners in the United States is likely to continue to increase. The most important factor supporting this conclusion is the expected growth in sales of soft drinks and the proportion of these products which is likely to be made with noncaloric sweeteners.

Based on trade estimates, the use of noncaloric sweeteners in soft drinks in 1970 will about double that of 1965. If the consumption of noncaloric sweeteners in uses other than soft drinks increases only at the same rate as the projected population increase, total consumption of these products in 1970 would be about 21 million pounds of cyclamate and 4 million pounds of saccharin. This is equivalent in sweetness to about 915,000 tons of refined sugar. Substitution for sugar will likely amount to between 250,000 and 350,000 tons. This is about 3 percent of probable sugar consumption in 1970.
NONCALORIC SWEETENERS: THEIR POSITION IN THE SWEETENER INDUSTRY

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INTRODUCTION

The rapid increase in the production and use of noncaloric sweeteners in the United States in recent years, especially during 1963 and 1964, has established these products as important competitors with other segments of the sweetener industry. The changing situation also is of great importance to users of sweeteners, particularly industrial food processors, many of whom are able to substitute one sweetener for another in some or all of their products.

This study seeks to appraise the current status of noncaloric sweeteners in relation to the caloric sweeteners—sugar, corn sirup, and dextrose—and attempts to evaluate the future prospects of noncaloric sweeteners in relation to sugar and corn sweeteners. Some attention is given to the international aspects of the sweetener industry, primarily because the growing use of noncaloric sweeteners in several foreign countries has become a concern of the International Sugar Council. Also, significant amounts of noncaloric sweeteners have at times been imported into the United States.

Much of the information on which this report is based was obtained from Government and trade sources. Interviews with both the producers and users of noncaloric sweeteners also provided a great deal of data not otherwise available. In addition, representatives of the sugar and corn sweetener industries supplied information regarding the competitive aspects of the sale and use of noncaloric and caloric sweeteners.

DESCRIPTION OF NONCALORIC SWEETENERS

Type of Products

Noncaloric sweeteners, sometimes called nonnutritive or synthetic sweeteners, are products of the chemical industry and are derived from nonagricultural materials. The appearance of such materials in competition with agricultural products is not unique. For example, synthetic fibers compete with agricultural products such as cotton, wool, silk, and linen; synthetic detergents compete with soap; and various materials compete with leather. What is unique about the situation is that nonnutritive substances are competing with nutritive ones. Some newly developed foods, of course, compete as substitutes for established ones, such as margarine for butter and mellorine for ice cream; however, these are substitutions between agricultural products where differences in nutritive value are slight.

The two most important noncaloric sweeteners are cyclamate and saccharin. Cyclamate was introduced commercially in the United States about 1950. Saccharin has been produced and used since the early years of the 20th century.
Cyclamate is produced and marketed both as calcium cyclamate and sodium cyclamate. Chemically, these substances are salts. Cyclohexylamine, the material from which the cyclamates are commonly prepared, possesses both a sweet and tart taste. Small quantities are sold commercially in cases where both tastes are desired. Cyclohexylamine has a number of uses in the field of chemistry in addition to its use as a raw material for the manufacture of cyclamates. Trade estimates indicate that slightly less than half the quantity produced in 1964 was used to produce cyclamates.

Calcium cyclamate is produced and sold in much larger amounts than sodium cyclamate, although a few users prefer the latter product. Calcium cyclamate is preferred for sweetening foods and beverages where freedom from compounds containing sodium is desired.

Saccharin, a sweetener that has been on the market far longer than cyclamate, is most often used as a sodium salt. It is also available as a calcium salt and in an acid form. The acid form is commonly known as insoluble saccharin. Until recently, the consumption of saccharin has been confined largely to uses that did not compete materially with other sweeteners. This included its use by persons who, for health reasons, could not eat products sweetened with sugar.

Within the past 4 or 5 years, mixtures of saccharin and cyclamate have been sold in increasing quantities. The most common mixture contains about 10 parts cyclamate to 1 part saccharin. However, other ratios, such as 12 to 1, 25 to 1, 3 to 1, and 1 to 1, are used in the United States. In a mixture of 10 parts cyclamate to 1 part saccharin, each ingredient contributes about half the sweetening power of the mixture. In addition, it is sometimes claimed that these mixtures have a synergistic effect, that is, the sweetness of the mixture is greater than the sum of the sweeteneses of the two ingredients. The extent of this effect, if it exists at all, apparently has not been measured.

Mixtures of noncaloric with caloric sweeteners have also been offered for sale on a commercial basis, although up to the present time sales appear to have been small.

An important advantage of cyclamate-saccharin mixtures is that certain undesirable tastes of each, which become recognizable by many persons when enough of either is used to impart the desired degree of sweetness to the product consumed, do not appear or are less noticeable in a mixture. That is, the amount of saccharin or cyclamate used is small enough that the bitter taste sometimes associated with their use is less conspicuous to most consumers.

In addition to cyclamate and saccharin, there are a number of other noncaloric and low-caloried sweet substances. Most of these products are not suitable for use in food and their use in the United States has not been approved by the Food and Drug Administration. Use of two products, maltol and ammoniated glycyrrhizin, is permissible in the United States.

Maltol, an organic product derived from a number of plant materials, is manufactured and sold in pure form. It is considered a flavor enhancer for carbohydrates generally. In this respect, its effect has been compared to that of monosodium glutamate on proteins. One of its effects is to intensify the sweet flavor of sugar when added to certain food products in amounts varying from 30 to 3,300 parts per million.
Ammoniated glycyrrhizin is derived from licorice root. It is considered to be about 50 times as sweet as sugar when used alone and 100 times as sweet when used with sugar. However, because of its licorice flavor its usefulness is limited.

Neither maltol nor ammoniated glycyrrhizin has yet been used in sufficient quantities to have had any material effect on the market for sugar or other sweeteners. They are of potential importance in food industries partly because they affect sweetness.

Commercial Characteristics

The principal commercial characteristics of cyclamate and saccharin are sweetness and complete lack of nutritive value. Persons who wish to limit their consumption of sugar find it convenient to use food and drink prepared with some noncaloric sweetener in order to maintain the palatability of their diet. While there is general agreement that the use of noncaloric sweeteners is beneficial to persons who for medical reasons should not eat sugar, there is much less agreement as to the effectiveness of these substances in assisting persons to control their weight.

It is sometimes argued that, since a product made with sugar contains more calories than an otherwise identical product sweetened with cyclamate or saccharin, the product containing sugar satisfies the appetite better than the nonsugar one. Consequently, sufficient quantities of other food are likely to be eaten during the day to offset or perhaps more than offset whatever reduction in caloric intake was achieved by eating nonsugar sweetened items. Also, the number of calories involved ordinarily is small enough that, in the absence of other changes in the diet, the effect is likely to be small.

Aside from sweetness and lack of calories, noncaloric sweeteners possess other characteristics of importance in some products. Only very small amounts of the noncaloric sweeteners, as compared with the caloric sweeteners, need to be used to attain comparable degrees of sweetness. Consequently, a product sweetened with cyclamate or saccharin requires the addition of other ingredients to obtain the same volume as the calorically sweetened one. For most soft drinks and some canned foods, water is used to attain the desired volume. This results in a product with somewhat less viscosity than one in which a caloric sweetener is used.

In soft drinks this difference may not be noticeable to most consumers; or if noticeable, it may be considered desirable. Other products, such as baked goods, require more elaborate shifts in ingredients—for example, the addition of other nutritive or nonnutritive products to provide the desired body and texture. These may be ingredients already present in the product, but used in larger amounts.

Noncaloric sweeteners have a higher melting point than sugar. For instance, bacon cooks differently when cured with a noncaloric sweetener than when sugar is used, since the noncaloric sweetener neither melts nor caramelizes. As a result, the bacon has a different taste and texture.

Producers claim that noncaloric sweeteners are of value in effecting (1) plumper canned fruit in certain cases—with noncaloric sweeteners the low brix of the liquid used in canning the fruit results in osmosis into the fruit rather than the reverse; (2) longer storage life of certain products where sugar, if used as the sweetening agent, inverts over time and produces a darkened product; (3) reduction in storage and handling costs because of less bulk.
In addition, noncaloric sweeteners will not ferment; that is, they are not food for yeast and similar organisms. Consequently, they are of no value in making bread and other products which are dependent on fermentation.

**Relative Sweetness**

The relative sweetness of sugar, cyclamate, and saccharin is of economic importance to both users and producers of these materials. The relative costs of sweetening many products are largely determined by the relative sweetness and prices of the various sweeteners.

However, measures of the relative sweetness of sugar and either of the noncaloric sweeteners are difficult to obtain and the results are inexact. Sweetness is measurable only by recording the reactions of individuals. The taste of most things varies somewhat among individuals, even when the tasting is done under controlled conditions by experienced taste testers. Moreover, taste may change over time for the same person, partly in relation to age and state of health. Also, measures at threshold value—the lowest degree of sweetness that can be detected—may produce different sweetness ratios than measurements made at higher levels of sweetness.

The most important factor associated with variations in relative sweetness seems to be the kind of product being sweetened. For instance, trade reports indicate that the sweetness of cyclamate varies from 30 to 140 times that of sugar at degrees of sweetness ordinarily used. Saccharin is 300 to 700 times as sweet as sugar.

Because of these variations, the use of a single factor to estimate the sweetness equivalent of either cyclamate or saccharin is subject to a considerable degree of error. Information on the quantities of cyclamate and saccharin used for different purposes is not sufficiently precise to permit the calculation of the meaningful weighted average value for either product. However, available information does indicate that the lower values, 30 for cyclamate and 300 for saccharin—or values closer to these figures than to the maximum values for sweetness—are the most common in actual practice. Consequently, estimates of the sugar-sweetness equivalents of cyclamate and saccharin used in this report are calculated on the basis of 30 to 1 and 300 to 1 ratios, respectively.

**INDUSTRY CHARACTERISTICS**

**Producers of Noncaloric Sweeteners**

The number of producers of noncaloric sweeteners and their volume of output have increased considerably in recent years. In most years prior to 1964, only two companies were producing saccharin and three were manufacturing cyclamate. None were making both products. Since 1964, new companies have entered the business and others have expanded their capacity substantially.

In 1965, nine companies in the United States were producing noncaloric sweeteners (20). Of these nine, three produced both cyclamate and saccharin, five produced

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1/ Underscored numbers in parentheses refer to items in the Bibliography, p. 19.
cyclamate only, and one produced saccharin exclusively. A part-owner of one company was also engaged in the production of sugar, while the owner of another produced corn sweeteners. At least four of the producers of noncaloric sweeteners used part of their output in products they produced and sold. This type of captive market appeared to be of major importance for two producing companies.

Trade estimates indicate that at the end of 1965 total industry capacity to produce cyclamate was about 30 million pounds per year, compared with 6 million at the end of 1963. Comparable figures for saccharin were 5 million and 2.5 million pounds per year, respectively. These estimates of plant capacity are not considered very accurate, at least by certain producers who indicate that substantial changes in output from present plants could be made quickly and at relatively low cost. Estimates of actual production in 1965 are substantially below these capacity figures, especially for cyclamate.

Most of the producers of both cyclamate and saccharin also produce a variety of other products, mainly chemicals. In addition to their role as producers, numerous firms act as dealers, purchasing cyclamate and saccharin from manufacturers which they then distribute to the trade.

Production and Imports

Precise data showing the production of either saccharin or cyclamate for most years are not available. The U.S. Tariff Commission (24, 25) has reported the production of saccharin for certain early years as:

<table>
<thead>
<tr>
<th>Years</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>1918</td>
<td>425,600</td>
</tr>
<tr>
<td>1919</td>
<td>547,988</td>
</tr>
<tr>
<td>1920</td>
<td>137,315</td>
</tr>
<tr>
<td>1921</td>
<td>188,759</td>
</tr>
<tr>
<td>1923</td>
<td>340,944</td>
</tr>
</tbody>
</table>

The sharp drop in production from 1919 to 1920 is apparently related to the shortage of sugar during World War I, which encouraged the use of saccharin. The end of the sugar shortage in 1920 resulted in a sharp decline in saccharin production.

Trade reports indicate that for a number of years prior to 1960 annual plant capacity for the production of saccharin was about 1.5 million pounds—an indication that production did not materially exceed this amount. Expansion of existing facilities and construction of new plants by companies entering the business for the first time about tripled capacity by 1965. However, some of the newer facilities merely convert insoluble saccharin into the calcium or sodium salt of saccharin and are not comparable in the extent of their operations to the older installations.

Commercial production of cyclamate appears to have been small until after 1960. Production capacity multiplied about 5 times from 1963 to 1965, reaching about 30 million pounds by 1965.

With one or two exceptions, all the companies producing cyclamate in the United States purchase cyclohexylamine and convert it into one of the cyclamates. The conversion is usually carried out in a separate plant even by companies producing cyclohexylamine.
The U.S. Tariff Commission reports that the combined production of saccharin and cyclamate in this country was 2,060,000 pounds in 1957; 2,350,000 pounds in 1958; 2,992,000 pounds in 1959; 5,715,000 pounds in 1963; 12,215,000 pounds in 1964; and 12,841,000 pounds in 1965. No data are available for 1960, 1961, and 1962. Separate data for saccharin and cyclamate are not available from the Commission's reports.

The combined production figures are not necessarily an accurate indication of increased output as measured in terms of sweetening power or sugar equivalent, since the proportions of saccharin and cyclamate in the total probably changed. In fact, information available from the trade indicated that from 1957 to 1964 the production of cyclamate increased much more rapidly than that of saccharin. Thus, the sweetening power of the combined output has not increased as rapidly as the physical volume.

In addition to production within the country, sizable quantities of both saccharin and cyclamate have been imported into the United States in certain years (table 1). The unusually large imports of saccharin in 1963 appear to have been largely a response to the temporary closing of one plant in the United States which was severely damaged by fire. The rapid increase in imports of cyclamate through 1964 parallels the development of the industry in this country. Exports of saccharin and cyclamate have been of negligible importance.

Table 1.--United States: Imports of saccharin and cyclamate, 1959-65

<table>
<thead>
<tr>
<th>Year</th>
<th>Saccharin</th>
<th>Cyclamate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thou. lb.</td>
<td></td>
</tr>
<tr>
<td>1959</td>
<td>302</td>
<td></td>
</tr>
<tr>
<td>1960</td>
<td>263</td>
<td></td>
</tr>
<tr>
<td>1961</td>
<td>231</td>
<td></td>
</tr>
<tr>
<td>1962</td>
<td>467</td>
<td></td>
</tr>
<tr>
<td>1963</td>
<td>1,121</td>
<td></td>
</tr>
<tr>
<td>1964</td>
<td>785</td>
<td></td>
</tr>
<tr>
<td>1965</td>
<td>755</td>
<td></td>
</tr>
</tbody>
</table>

Trade estimates of the production and imports of saccharin and cyclamate in 1963, 1964, and 1965 indicate that the supply of saccharin available for use in the United States increased nearly one-third between 1963 and 1965 and that of cyclamate more than doubled (table 2). The sugar-sweetness equivalent of saccharin and cyclamate was 453,000 tons in 1963, 646,000 tons in 1964, and 659,000 tons in 1965, or 5.0 percent, 7.4 percent, and 7.2 percent of the refined sugar distributed in the United States.

The sugar-sweetness equivalent figures in table 1 do not measure the extent to which sugar has been replaced by noncaloric sweeteners, since no allowance is made for the probable increase in inventories during this period, or for the quantities used for purposes which were partly or entirely noncompetitive with sugar.

Exact data concerning the size of inventories of saccharin and cyclamate at any time are not available. However, tentative estimates made by trade representatives indicate that in early 1966 inventories of cyclamate totaled about 2 million to 2.5 million pounds. This is known to have been substantially above inventories at earlier periods.
Table 2.--Production, imports, and total supply of saccharin and cyclamate available in the United States and their sugar-equivalent sweetness, 1963-65

<table>
<thead>
<tr>
<th>Year</th>
<th>Production</th>
<th>Imports 1/</th>
<th>Total supply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saccharin</td>
<td>Cyclamate</td>
<td>Saccharin</td>
</tr>
<tr>
<td>1963</td>
<td>1,000 lb.</td>
<td>1,000 lb.</td>
<td>1,000 lb.</td>
</tr>
<tr>
<td></td>
<td>1,429</td>
<td>4,286</td>
<td>1,121</td>
</tr>
<tr>
<td>1964</td>
<td>2,443</td>
<td>9,772</td>
<td>785</td>
</tr>
<tr>
<td>1965</td>
<td>2,568</td>
<td>10,273</td>
<td>755</td>
</tr>
<tr>
<td>Sugar-sweetness equivalent: 2/</td>
<td>1,000 tons</td>
<td>1,000 tons</td>
<td>1,000 tons</td>
</tr>
<tr>
<td>1963</td>
<td>214</td>
<td>64</td>
<td>168</td>
</tr>
<tr>
<td>1964</td>
<td>366</td>
<td>148</td>
<td>118</td>
</tr>
<tr>
<td>1965</td>
<td>385</td>
<td>154</td>
<td>113</td>
</tr>
</tbody>
</table>

1/ Tariff Commission records.
2/ Assumes saccharin 300 times and cyclamate 30 times as sweet as sugar.


Price Trends

Commercial price quotations for cyclamate first became available from trade sources in 1955. The published price quotation for cyclamate from January 1955 to October 1958 was $2.95 per pound in ton lots (table 3). If cyclamate is considered to be 30 times as sweet as sugar, this price is equivalent to approximately 8.85 cents per pound for sugar. During this period, the retail price of sugar in the United States averaged about 10.8 cents per pound and the wholesale price of refined sugar (New York) 8.94 cents.

The rapid decline in the price of cyclamate since 1958 coincides approximately with the rise in imports of cyclamate, the increase in domestic production, and the construction of a number of new plants. At 64 cents per pound, the level reached in December 1965, and a sweetness ratio of 30 to 1, cyclamate is equivalent in price to about 2.1 cents per pound for sugar (fig. 1).

The price of saccharin has been much more stable than that of cyclamate, despite a decline of about 12.5 percent since 1963. As with cyclamate, recent declines in the price of saccharin have more or less coincided with increased imports and the construction of additional production facilities.

Saccharin prices per unit of sweetness are much lower than those for cyclamate, even after the large declines in cyclamate prices. At $1.40 per pound and a sugar-sweetness ratio of 300 to 1, saccharin is equivalent to a price of about 0.5 cent per pound for sugar, less than one-fourth that for cyclamate.

At prices quoted at the end of 1965, a mixture of 10 parts cyclamate to 1 part saccharin (the approximate mixture most commonly used in manufacturing non-caloric soft drinks) would be equivalent to about 1.4 cents per pound for sugar.
Table 3.—Prices of noncaloric sweeteners, 1955-65

<table>
<thead>
<tr>
<th>Year</th>
<th>Calcium cyclamate</th>
<th>Saccharin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>------------------</td>
<td>-----------</td>
</tr>
<tr>
<td></td>
<td>Dollar per pound</td>
<td>Dollars</td>
</tr>
<tr>
<td></td>
<td></td>
<td>per pound</td>
</tr>
<tr>
<td>1955</td>
<td>2.95</td>
<td>1.60</td>
</tr>
<tr>
<td>1956</td>
<td>2.95</td>
<td>1.60</td>
</tr>
<tr>
<td>1957</td>
<td>2.95</td>
<td>1.60</td>
</tr>
<tr>
<td>1958</td>
<td>1/</td>
<td>2.82</td>
</tr>
<tr>
<td>1959</td>
<td>1.95</td>
<td>5/ 1.57</td>
</tr>
<tr>
<td>1960</td>
<td>1.95</td>
<td>1.40</td>
</tr>
<tr>
<td>1961</td>
<td>1.95</td>
<td>6/ 1.48</td>
</tr>
<tr>
<td>1962</td>
<td>1.95</td>
<td>7/ 1.56</td>
</tr>
<tr>
<td>1963</td>
<td>2/</td>
<td>1.86</td>
</tr>
<tr>
<td>1964</td>
<td>2/</td>
<td>1.12</td>
</tr>
<tr>
<td>1965</td>
<td>4/</td>
<td>.78</td>
</tr>
</tbody>
</table>

Quotations declined from $2.95 to $2.50 on October 20 and to $1.95 on December 8, 1958.

Declined from $1.95 to $1.85 on January 28, 1963.
Declined from $1.50 to $1.10 on March 16 and to $.85 on October 5, 1964.
Declined from $.85 to $.72 on July 19 and to $.65 on December 6, 1965.
Declined from $1.60 to $1.40 November 2, 1959.
Increased from $1.40 to $1.50 March 13, 1961.
Increased from $1.50 to $1.60 April 16, 1962.
Declined from $1.60 to $.60 August 10, 1964.

Source: Oil, Paint, and Drug Reporter: Calcium cyclamate, drums, ton lots: Saccharin: Granular, drums, 1,000 pound lots.

As a result of the rapid decline in the price of cyclamate and the growing use of saccharin-cyclamate mixtures, the cost relationship between sugar and the noncaloric sweeteners has altered materially since 1962. While further price declines for noncaloric sweeteners are possible, those for cyclamate obviously cannot continue to be as great as they have been in the last few years. Even in terms of a mixture, the decline in cost from the 1963 average to the level of January 1966 was about 61 percent. Any further declines in the prices of noncaloric sweeteners are not likely to have as great economic consequences to present or prospective users as those of the past few years.

When cyclamate prices were around $2.95 per pound in the midfifties, cost for use of cyclamate as a sweetener in soft drinks was about the same as for sugar. Since 1963, price declines for noncaloric sweeteners, the growing use of cyclamate-saccharin mixtures, and moderate increases in the price of sugar have made noncaloric sweeteners much cheaper. At the end of 1965, a 10-to-1 mixture of cyclamate and saccharin was selling at an average of about 71 cents per pound, equivalent to about 1.4 cents per pound for sugar. The wholesale price of sugar in New York in December 1965 was 10.35 cents per pound. At these prices, the difference in cost between the noncaloric mixture and the sugar needed to produce a standard case (192 ounces) of soft drinks containing 12 percent sugar is approximately 12.9 cents.

The difference, of course, increases as the degree of sweetness of the beverage increases. Differences in the cost of the sweeteners, however, are not the only
ones that arise because of the use of different sweeteners. For instance, shifting to noncaloric sweeteners frequently requires other changes in the formulation of the product. If the noncalorically sweetened line of products is added to the existing items, plant operations may be affected. No attempt is made in this report to analyze the direction or importance of these changes, or their effect upon cost; however, changes in formulation appear to be less of a problem in the soft drink and dry beverage industries than in most other cases.

Consumption Trends of Noncaloric and Other Sweeteners

Existing statistical information is inadequate to provide a precise basis for determining the trend in consumption of either cyclamate or saccharin. However, assuming (1) that consumption of cyclamate was still of little commercial importance in 1952, and (2) that consumption of saccharin in that year was around 1.5 million pounds, it is possible to make some rough comparisons with changes in the consumption of other sweeteners. The 1.5 million pounds for saccharin is the more uncertain, although it is not inconsistent with information on plant capacities at that time and on the small imports in 1951 and 1952 (only about 18,000 pounds for the 2 years).

Even in the most recent years, the estimates for cyclamate and saccharin are considerably less accurate than those for sugar and the corn sweeteners, although they do provide a general idea of the changes in the relative importance of the three main classes of sweeteners used in the United States (fig. 2). While the consumption of each type of sweetener has increased since 1952, the rate of increase has been
slower for sugar than for either the corn sweeteners or the noncaloric sweeteners. Most of this slower relative growth in sugar consumption has occurred since 1957. Between 1957 and 1965, sugar's share of total sweetener consumption declined by about 6 percentage points (from 87 to 81 percent), while the shares for corn sweeteners and for noncaloric sweeteners each increased by about 3 percentage points.

![Graph showing estimated consumption of sweeteners in the U.S.]

Total sweetener consumption in the United States increased by about 35 percent from 1952 to 1965, compared with a 26-percent increase in population. Per capita consumption during this period thus increased about 9 percent. Per capita consumption of sugar changed only slightly from 1952 to 1965, compared with an increase of about 39 percent for the corn sweeteners and 124 percent for noncaloric sweeteners.

COMPETITIVE POSITION OF NONCALORIC SWEETENERS

Consumption of Noncaloric Sweeteners by Type of User

With minor exceptions, all of the noncaloric sweeteners are used in foods or products such as pharmaceuticals which are consumed directly by individuals. The first important sales of cyclamate were made in the early fifties to the soft drink industry. However, the volume of sales of soft drinks manufactured with

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2/ Small amounts of saccharin are used in certain electroplating processes.
noncaloric sweeteners prior to 1962 appears to have been too small to have had any significant effect on the sales of sugar-sweetened soft drinks. Trade estimates indicate that in 1961 sales of noncalorically sweetened soft drinks amounted to only 1.5 percent of total soft drink sales, or about 23 million cases out of the total 1.524 billion cases sold.

Starting in the midfifties, the use of cyclamate and saccharin mixtures enabled producers generally to manufacture products with more consumer appeal than was possible with either cyclamate or saccharin. This development and the lower cost of such mixtures appear to have been the major factors responsible for the rapid increase in the use of noncaloric sweeteners since 1961.

Few estimates of the quantities of cyclamate and saccharin consumed in the United States are available. However, the carbonated beverage industry has reported that 1,948,590,000 standard cases (containing 24 8-ounce bottles or their equivalent) of soft drinks were consumed in the United States in 1964 and 2,104,282,000 standard cases in 1965. Representatives of the soft drink industry estimate that about 12 percent of the 1964 and 1965 consumption was prepared with noncaloric sweeteners, mostly a mixture of cyclamate and saccharin. These figures indicate a consumption of 233,831,000 cases of noncalorically sweetened soft drinks in 1964 and 252,514,000 cases in 1965.

A mixture of 10 parts cyclamate and 1 part saccharin is about 54.5 times as sweet as sugar. A standard case of carbonated beverage as sweet as one containing 12 percent sugar therefore requires about 0.264 pound of a 10-to-1 mixture of cyclamate and saccharin. The mixture would contain about 0.024 pound of cyclamate and 0.0024 pound of saccharin. At these rates, it would require 6,173,000 pounds of cyclamate-saccharin mixture to sweeten 233,831,000 cases of soft drinks. The sweetener needed in 1964 would consist of 5,612,000 pounds of cyclamate and 561,000 pounds of saccharin. The estimated consumption of soft drinks sweetened with noncaloric substances in 1965 was 252,514,000 cases. This volume would require 6,060,000 pounds of cyclamate and 606,000 pounds of saccharin.

Trade estimates of the distribution of cyclamate-saccharin mixtures in 1964 by principal uses indicate that 53 percent was used in carbonated beverages and the remainder distributed among other uses (table 4). The estimated percentage distribution in 1965 was approximately the same as in 1964. Based on these percentages and the estimates developed for the quantities used in carbonated beverages, the total usage of cyclamate and saccharin in 1964 would be 11,648,000 pounds, of which 10,589,000 pounds would be cyclamate and 1,059,000 pounds saccharin. In 1965, it would be 12,577,000 pounds, of which 11,434,000 pounds would be cyclamate and 1,143,000 saccharin.

The estimates presented in table 4 should be considered rough approximations only. Another estimate of total usage of cyclamate and saccharin in 1964 appearing in trade publications places the total at 9.5 million pounds, of which 7 million pounds were cyclamate and 2.5 million pounds saccharin. The estimate of 9.5 million pounds for the two sweeteners is about 18 percent below the estimate in table 4 and the figure for cyclamate is 34 percent lower. However, the 2.5 million pound figure for saccharin is 136 percent higher.

The estimate for saccharin in table 4 is almost certainly much too low, since sizable quantities are used without being mixed with cyclamate. These include retail sales and use in nonfood products such as toothpaste and pharmaceuticals. Trade sources have estimated that the total poundage of saccharin sold at retail may be about the same as retail sales of cyclamate, and that as much as one-third
Table 4.--Estimated utilization of cyclamate and saccharin mixtures by major uses, 1964 and 1965

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonated beverages</td>
<td>53</td>
<td>5,612 : 6,060</td>
<td>561 : 606</td>
<td>6,173 : 6,666</td>
</tr>
<tr>
<td>Dry-beverage bases</td>
<td>17</td>
<td>1,800 : 1,944</td>
<td>180 : 194</td>
<td>1,980 : 2,138</td>
</tr>
<tr>
<td>Dietetic foods</td>
<td>13</td>
<td>1,477 : 1,486</td>
<td>138 : 149</td>
<td>1,515 : 1,635</td>
</tr>
<tr>
<td>Retail</td>
<td>12</td>
<td>1,271 : 1,372</td>
<td>127 : 137</td>
<td>1,398 : 1,509</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>5</td>
<td>529 : 572</td>
<td>53 : 57</td>
<td>582 : 629</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>10,589 : 11,434</td>
<td>1,059 : 1,143</td>
<td>11,648 : 12,577</td>
</tr>
</tbody>
</table>

1/ Oil, Paint, and Drug Reporter (21).

Of the saccharin consumed in the United States is used in nonfood products. These estimates, added to the figure in table 4, suggest an overall consumption of saccharin of around 2.9 million pounds in 1964 and 3 million in 1965.

Substitution of Saccharin and Cyclamate for Other Sweeteners

The two major effects of the increasing consumption of noncaloric sweeteners on the sweetener market have been to add to the total consumption of sweeteners and to replace part of the sugar which would otherwise have been used. However, it is extremely difficult to determine how much of the recent increase in the consumption of noncaloric sweeteners has been an addition to total sweetener consumption and how much has represented substitution for other sweeteners.

The extent to which substitution has occurred is of great interest to producers and users of all sweeteners because it affects the size of their markets. Nearly all of the substitution that has occurred appears to have involved the use of noncaloric sweeteners in place of sugar. For example, noncaloric sweeteners are frequently used in soft drinks, dry beverage bases, and homemade products. Apparently, the substitution effect on corn sweeteners has been slight, since little use is made of noncaloric sweeteners in products using large amounts of corn sweeteners.

Soft drink industry sales have increased very rapidly in recent years (1). The use of sugar in the industry has increased simultaneously with the growth in the use of noncaloric sweeteners.

From 1950 to 1960, when noncaloric sweeteners accounted for only an insignificant part of the total sweeteners used, consumption of soft drinks increased at the rate of about 45.5 million cases (24 8-ounce bottles) per year. From 1960 to 1965, the increase was much more rapid, averaging about 121.5 million cases per year. During this period the consumption of sugar-sweetened soft drinks increased by about 71 million cases per year and the noncalorically sweetened ones by 50.5 million cases.

The rapid rise in the consumption of soft drinks since 1960 is related to the unusually rapid increase in consumer incomes. Disposable personal income increased
at an average rate of about $14.2 billion per year from 1950 to 1960 and $23.2 billion from 1960 to 1965. During 1950-60, the consumption of soft drinks in the United States increased by approximately 3,547,000 standard cases for each $1 billion increase in disposable personal income (fig. 3). The relationship is unusually close, the correlation being .99.

The 1950-60 relationship held fairly well through 1961 and 1962. However, total soft drink consumption in 1963, 1964, and 1965 was considerably larger than the size of the disposable national income would indicate. Consumption of sugar sweetened soft drinks in 1963 was about what would have been expected from the 1950-60 income-consumption relationship, but in 1964 and 1965 it was considerably smaller. This suggests that the use of noncaloric sweeteners in soft drinks in 1963 and earlier years replaced little sugar and served primarily to increase the size of the market for soft drinks.

Part of the much larger consumption of soft drinks manufactured with noncaloric sweeteners in 1964 and 1965 appears, however, to have represented the substitution of noncaloric for sugar-sweetened soft drinks. The projection of the trend line in figure 3 suggests that in 1964 and 1965 about one-third of the noncaloric soft drinks represented substitution for sugar-sweetened drinks and the other two-thirds an additional market which would not have existed if sugar-sweetened drinks had been the only type available. One-third of the noncalorically sweetened soft drinks consumed amounted to about 78 million standard cases in 1964 and 84 million cases in 1965. If sugar-sweetened, this output would have required about 56,000 tons of refined sugar in 1964 and 60,000 tons in 1965.
It is more difficult to arrive at an objective estimate of the extent to which noncaloric sweeteners have been substituted for sugar in other major uses.

The second most important use for noncaloric sweeteners in recent years has been in the manufacture of dry beverage bases which, when mixed with water, form a noncarbonated or "still" beverage. Unsweetened dry beverage bases, which require the addition of sugar and water to make an acceptable beverage, were marketed for several years before those manufactured with noncaloric sweeteners were introduced. However, data on volume of sales are not available and the type of analysis used for soft drinks cannot be made.

Producers of dry beverage bases containing noncaloric sweeteners regard convenience as the principal advantage of their products. Such products are popular with mothers of small children, because of the difficulty children have in adding sugar without spilling some. Use of a presweetened base greatly reduces this difficulty. Moreover, bases presweetened with noncaloric substances are less bulky and are more easily stored and transported than bases presweetened with sugar. Despite the factor of convenience, both unsweetened dry beverage bases and those containing sugar in the package continue to be marketed. Data showing changes in the volume sold are not available.

Retail sales of mixtures of cyclamate and saccharin amounted to 12 percent of the total consumed in the United States in 1964. According to trade reports (table 4), this would amount to about 1,398,000 pounds of a 10-to-1 cyclamate-saccharin mixture and in sweetness would be equivalent to about 38,000 tons of sugar.

Deliveries of sugar in consumer packages in 1964 amounted to 2,715,000 tons (23). On this basis retail sales of cyclamate-saccharin mixtures amounted, in terms of sweetness, to only a little over 1.4 percent of the total. These figures for noncaloric sales do not include sales of unmixed saccharin since data are not available. However, if the poundage of saccharin sold at retail is considered equal to that estimated for cyclamate, the sweetness equivalent of saccharin sold at retail in unmixed form would amount to about 172,000 tons of sugar. This amount added to the estimate for cyclamate-saccharin mixtures totals 210,000 tons of sugar, about 7 percent of the quantity of sugar reported as sold at retail. There is no feasible way of measuring the share of this 7 percent which can be considered as having been used as a substitute for sugar.

Other uses of noncaloric sweeteners in the United States are largely confined to the preparation of dietetic foods. In terms of sweetness these uses were equivalent to about 41,000 tons of sugar. However, presumably very little, if any, sugar would have been used in these products even if noncaloric sweeteners had not been available.

While no precise quantitative estimate of the amount of substitution of noncaloric sweeteners for sugar in products other than soft drinks is possible, it seems likely that the ratio is under one-third. The likelihood of substitution seems as great in soft drinks as in any other major use, although perhaps no greater than for dry beverage bases. If the figure of one-third estimated for soft drinks is also applied to dry beverage bases, the substitution of noncalorics for sugar in these two categories of uses would amount to about 74,000 tons of sugar in 1964 and 80,000 tons in 1965. Assuming no substitution in other uses, the substitution of noncaloric sweeteners shown in table 4 would amount to about 23.3 percent.

However, an assumption of no substitution except in beverages and beverage bases is hardly realistic, particularly for retail sales. If only 6 percent of the
noncaloric sweeteners used for purposes other than the preparation of soft drinks and dry beverage bases represented substitution for sugar, the average rate of substitution for all the noncaloric sweeteners listed in table 4 would be approximately 25 percent. This would represent about 80,000 tons of sugar in 1964 and 86,000 tons in 1965.

Substitution Effects of Mixtures of Noncaloric and Caloric Sweeteners

Products made with mixtures of noncaloric sweeteners and sugar or corn sweeteners are not sold in the United States at the present time. In some countries the sale of products sweetened with mixtures of noncaloric and caloric substances is fairly common. For instance, soft drinks sweetened with such mixtures have been marketed in England for many years and are reported to be popular with consumers in that country.

The Food and Drug Administration (FDA) originally regarded use of saccharin-sugar mixtures as a sweetener for foods intended for sale as a form of adulteration because saccharin possessed no nutritive value. However, FDA regulations issued in June 1966 3/ provide for the sale of products made with mixtures of noncaloric and caloric sweeteners if certain labeling requirements are met (11). These requirements are part of the labeling regulations which apply to foods containing noncaloric sweeteners and certain other substances, such as vitamins and minerals.

Under these regulations, foods represented by the seller to be for "special dietary use by reason of the presence of an artificial sweetener for the purpose of reducing or maintaining body weight" must be labeled with the name of the artificial sweetener used, and if the artificial sweetener is mixed with one or more nutritive sweeteners such as sugar this must also be stated on the label. An artificial sweetener is defined as one not used in normal metabolism as a source of calories.

For such foods the label must bear a statement comparing the caloric content of the artificially sweetened article with that of the same amount of the same food made with sugar so that the foods compared are equivalent in sweetness. The regulations provide that in calculating equivalent sweetness, cyclamate is to be considered 30 times and saccharin 300 times as sweet as sugar. If the comparison of calories shows that the reduction in the caloric content of the food is insignificant, the artificial sweetener shall not be used in foods represented to be useful in maintaining or reducing body weight. For foods of caloric importance in the ordinary diet, a reduction of less than 50 percent in calories resulting from the use of an artificial sweetener is considered insignificant.

Proposed regulations of the Food and Drug Administration permit exemptions from certain labeling requirements for foods which are not represented as being for "special dietary use" and which contain artificial sweeteners. In order to be marketed these foods must:

1. Require the addition of an artificial sweetener as a substitute for sugar or other natural sweetener to achieve their intended characteristics.

3/ The effective date (once set at 180 days unless delayed by the filing of objections) has been postponed by the FDA. Public hearings have been announced which may result in modification or withdrawal of the original proposals.
2. Contain not less than 90 percent as many calories as are present in the same food, or class of food, sweetened with caloric substances only.

3. Display on the label the name of the nonnutritive artificial sweetener used as an ingredient, but make no other representation for the food based on the nonnutritive value of the added artificial sweetener.

4. Have an application submitted by an interested person desiring an exemption for a food, or class of food, to the Commissioner of Food and Drugs supplying certain required information.

5. Have received an exemption from the Commissioner.

Exemptions approved by the Commissioner will be listed in the regulations. However, the regulations provide that no exemptions will be granted for poultry or meat products subject to the provisions of the Meat Inspection Act, if authorization to produce and market such food has been granted by the U.S. Department of Agriculture.

The effect of these regulations, if they are adopted, on the consumption of noncaloric sweeteners—called artificial sweeteners in the Food and Drug Regulations—and their competitive position relative to sugar and corn sweeteners is, of course, unknown. However, some uncertainties which have hampered industrial users of noncaloric sweeteners would be clarified. For instance, specific provisions are made for the labeling and therefore the sale of products sweetened with a mixture of noncaloric and caloric sweeteners.

The probable effect of the new regulations on the consumption of noncaloric sweeteners and the extent of their substitution for sugar and corn sweeteners appears to be considerably restricted by the requirement that foods for "special dietary use by reason of the presence of an artificial sweetener for the purpose of reducing or maintaining body weight" must contain a minimum reduction in calories of 50 percent as compared with the same food made with additional sugar, equivalent in sweetness to the artificial sweetener. Except in items such as certain soft drinks which contain few or no calories other than those in the sweetener, obtaining a reduction of 50 percent or more in calories in the food by substituting noncaloric for caloric sweeteners is not likely to be commercially feasible.

However, the requirement for foods not for "special dietary use" that a food containing noncaloric sweeteners must contain at least 90 percent as many calories as the same food without the noncaloric sweeteners would be much more restrictive for soft drinks than for most other classes of foods. Under this requirement, producers of beverages which contain few calories other than those in the sweetener could substitute little more than 10 percent of the caloric sweetener for a noncaloric one. This might not be worthwhile commercially.

The situation is very different for foods such as many baked and canned goods in which the sweetener, even if entirely caloric, contributes only a small proportion of the calories in the food. In such cases, most or all of the caloric sweetener could be replaced with a noncaloric one and the food would still meet the 90 percent caloric requirement.

For products such as soft drinks, where both calorically and noncalorically sweetened items are marketed extensively, the manufacture and sale of drinks containing a mixture of these sweeteners would amount to the introduction of an interfering...
mediate product which might be expected to possess in some degree the characteristics and consumer appeal of each of the types now being sold.

However, there would remain questions as to the extent to which sales of soft drinks sweetened with a caloric-noncaloric mixture would add to the total size of the market for soft drinks or reduce the sales of either sugar-sweetened or non-calorically sweetened drinks below the level that would otherwise be expected. Without much more knowledge of these factors than is now available, the effect of the sale of soft drinks containing mixed sweeteners on the industry's consumption of either sugar or noncaloric sweeteners is quite uncertain.

The range of possible market effects from the introduction of items sweetened with mixtures of noncaloric substances and sugar or a corn sweetener is much greater for most other products than it is for soft drinks. Corn sweeteners are of such slight importance in soft drinks that this factor can be largely ignored. This is not true of most other products where the use of corn sirup or dextrose is much greater and has been increasing more rapidly than sugar in recent years.

In some bakery products a mixture of sugar and a noncaloric sweetener offers advantages in quality, because the degree of sweetness that can be obtained with sugar alone is limited by the amount of sugar that can be used in the formulation without causing other quality problems in the product. The addition of a noncaloric sweetener makes possible the preparation of a sweeter product which should have greater consumer acceptance without reducing quality in other ways. The development and sale of such products would increase the consumption of noncaloric sweeteners, but probably would have little effect on the consumption of sugar.

**Prospects**

The slackening in the rate of growth in the use of noncaloric sweeteners beginning in 1965 has raised many questions concerning the market prospects for these substances in coming years. The market history of cyclamates and of cyclamate-saccharin mixtures is so short that the interpretation of past trends is more difficult than for most commodities.

The advantages of marketing soft drinks containing noncaloric sweeteners in addition to those sweetened with sugar seem likely to continue. The most important of these advantages are the lower cost of ingredients and the emergence of a market which was untapped by the sugar-sweetened drinks. Not only has the market for soft drinks in the United States been expanding rapidly, but the general expectation in the industry is that the expansion will continue. One industry report estimates that "by 1970 total consumption will climb to more than 2.6 billion cases, an increase of 34 percent over the 1964 figure, and roughly equivalent to an annual growth rate of 5 percent" (10, p. 12).

This forecast, if correct, would require an increase in soft drink sales of approximately 500 million standard cases between 1965 and 1970. If 12 percent of this increase consists of products manufactured with noncaloric sweeteners—the estimated proportion for all soft drinks for 1964 and 1965--about 1,440,000 pounds of cyclamate and 144,000 pounds of saccharin will be required above that used in 1965 in these products. These are increases of about 19 percent.

However, the assumption that the percentage of soft drinks sweetened with noncaloric substances will not increase between 1965 and 1970 appears unrealistic.
On this point the Corplan report says, "consumption will eventually level off at 20-30 percent of total soft drink consumption" (10, p. 29).

If 20 percent of the estimated 2.6 billion cases of soft drinks to be consumed in 1970 are sweetened with noncaloric substances in the manner estimated for 1964 and 1965 consumption, the industry will require about 12,480,000 pounds of cyclamate and 1,248,000 pounds of saccharin that year. If the proportion of noncalorically sweetened soft drinks should rise to 30 percent in 1970, the requirements would be about 18,720,000 pounds for cyclamate and 1,872,000 pounds for saccharin. These figures are 65 percent and 210 percent, respectively, above the estimated 1965 usage of cyclamate and saccharin.

In spite of this rapid rise in the prospective use of noncaloric sweeteners in soft drinks, the use of sugar in these products probably will remain near or slightly above the 1965 level. The 1970 projections for the total consumption of soft drinks, and for those sweetened noncalorically, taken at 25 percent of the total, indicate that the consumption of sugar-sweetened soft drinks would increase about 1.85 percent from 1965 to 1970. This would mean an increased use of about 74,000 tons of refined sugar by the soft drink industry during this 5-year period.

Prospects for increased use of cyclamate and saccharin are not confined to the soft drink industry, although they are perhaps greater there than in other industries. Consumption of few, if any, important commodities using sweeteners has been rising as rapidly as consumption of soft drinks. However, even if the use of noncaloric sweeteners, except in soft drinks, increases no faster than the population, the growth in use from 1965 to 1970 would amount to 5.6 percent, according to the median estimate of the 1970 population by the Bureau of the Census. In addition, there are distinct possibilities that new and expanded uses will be found for noncaloric sweeteners. Many of their present uses have been developed quite recently and it is likely that the economic possibilities have not been fully exploited as yet.

If, for purposes of illustration, the 1970 utilization of noncaloric sweeteners in soft drinks is projected at 15.6 million pounds of cyclamate and 1.56 million pounds of saccharin—the midpoint between the estimated 20 percent and 30 percent of the projected soft drink consumption—and that for all other uses at 5.6 percent above the estimated usage in 1965, total 1970 usage would amount to about 21 million pounds of cyclamate and 4 million pounds of saccharin.

The refined sugar equivalent, in terms of sweetness, of these quantities of cyclamate and saccharin is approximately 915,000 tons.

If the 1964-65 estimates of substitution, 25 percent, are carried forward to 1970, the reduction in sugar sales in 1970 would amount to about 229,000 tons. However, there are reasons for believing that the substitution factor increases in importance as the total consumption of noncaloric sweeteners rises, particularly when per capita use increases. At low levels of use, the consumption of products manufactured with noncaloric sweeteners logically would be confined to those who could not eat sugar-sweetened products. If the usage of noncaloric sweeteners becomes larger than the quantities needed by such persons, the likelihood of substitution by other persons will increase the possibility of substitution.

If that part of the consumption of noncaloric sweeteners which represents an additional market for sweeteners is estimated to increase in 1965-70 at the same rate as the population—5.6 percent—the share of projected consumption of noncaloric sweeteners which would represent an addition to the market would
amount to only about 60 percent in 1970, 15 percentage points below the 1965 estimate. On this basis the remaining 40 percent of projected 1970 utilization of noncaloric sweeteners would represent substitution of noncalorics for sugar. This would be equivalent to 366,000 tons of refined sugar.

However, it is probably more correct to assume that the use of noncaloric sweeteners, other than as a substitute for sugar, will increase at a greater rate than the population, as more people become concerned about problems of health or weight. If so, the 60 percent projected above may be on the low side.

These considerations suggest that the figure of 366,000 tons of sugar displaced in 1970 by noncaloric sweeteners probably is too large, just as for other reasons the previous figure of 229,000 tons seemed too small. The best guess would seem to be somewhere in the range of 250,000 to 350,000 tons.

Annual per capita consumption of sugar in the United States has been quite stable for several years at about 96.5 pounds of refined sugar. In 1965, this was equivalent to a total of 9,336,000 tons of refined sugar. Based on an increase of population of 5.6 percent from 1965 to 1970, sugar consumption in 1970 would be 9,859,000 tons of refined sugar. The projected substitution of noncaloric sweeteners for sugar at this level is approximately 3 percent.

Among the factors which may affect future trends not considered in these projections is the introduction of products sweetened with a mixture of noncaloric substances and sugar, corn sirup, or dextrose. Also, several representatives of companies manufacturing noncaloric sweeteners, or using them to sweeten products which they sold, reported that evidence was becoming available to them indicating that a significant number of consumers now prefer products manufactured with noncaloric sweeteners over those sweetened with sugar or mixtures of sugar and corn sweeteners. Noncalorically sweetened products seldom taste exactly like those sweetened with sugar or other products. However, as people become accustomed to such sweeteners some may come to prefer products made with noncaloric sweeteners.

BIBLIOGRAPHY

(8) Consumer Reports  

(9) Cordell, Richard, and Short, Douglas  

(10) Corplan Associates  

(11) Federal Register  

(12) Food and Agriculture Organization of the United Nations  

(13) Food Engineering  

(14) Food Field Reporter  

(15) Hickson, John L.  

(16) Journal of Commerce  

(17) National Bottlers Gazette  

(18)  

(19)  

(20) Oil, Paint, and Drug Reporter  

(21)  

(22)  

(23) U.S. Department of Agriculture  

(24) U.S. Tariff Commission  

(25)  