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Consumer Preference Studies on Apple Sauce: Sugar-Acid Relations[a]

(Manuscript received June 20, 1957)

IN THE MANUFACTURE of canned apple sauce, two of the most important variables affecting the flavor of the product are sugar content and acidity. Of these two variables, the first—the sugar content—may be accurately controlled by the manufacturer by adjusting the amount of sugar added to the mix. The second variable, the acidity, is, in practice, largely not controlled, although it may be regulated to a certain extent by adjusting the distribution of varieties going into the blend. (For instance, if acid varieties are available only in the early part of the season, they may be stored, and utilized when most needed.) In any case, most manufacturers would find it difficult to maintain the acidity of their apple sauce within sharp limits, even if they could be sure what would be an optimum value.

Experience has shown that in the preparation of fruit juices and of naturally and artificially flavored beverages, maintenance of an optimum sugar-acid ratio is important *(3)*, not only for producing the proper sensation on the taste buds, but for bringing out the olfactory element in flavor. For instance, an increase or decrease in acidity may not be noticed as an increase or decrease in sourness, but as an off-flavor or a lack of flavor. It may be supposed that these observations would be equally true in the case of apple sauce. It is well known that good flavor in apple sauce is most often associated with relatively high acidity, and that sauces made from varieties of apples low in acid are insipid in flavor *(2)*, but no actual data have been available to show how consumer preferences are affected by altering the sugar-acid relations in a given product. The present paper is an attempt to throw some light on this subject.

EXPERIMENTAL PROCEDURES

Survey of commercial brands. A preliminary survey of 13 brands of commercially packed apple juice showed the following ranges of values: Brix (by refractometer), 16.6° to 23.4°, with a mean of 19.3°; pH, 3.40 to 3.70, with a mean of 3.56; total acidity (as malic acid), 0.308% to 0.515%, with a mean of 0.388%; and Brix-acid ratio, 37.8 to 62.1, with a mean of 50.6. Brix values and acidity were not significantly correlated, indicating either that the manufacturers of the sauces examined do not attempt to control the sugar-acid relationships of their products, or that they are not agreed as to what constitutes an optimum Brix-acid ratio.

Acidity and sugar adjustment of samples. A sample of a typical commercial apple sauce for use as a control was obtained from a plant in southern Pennsylvania. The blend was made up of equal proportions of Grimes Golden, Jonathan, Golden Delicious and Northern Spy apples. This sauce had a Brix reading of 17.9°, a pH of 3.42 and a total acidity of 0.393%. To prepare samples containing less sugar than the control, several cans of a dietetic-type pack containing no added sugar were obtained. This sauce was prepared on the same day as the control. It was made from a similar blend and was similar in pH and in acidity (taking into account the diluent effect of added sugar in the control), but gave a Brix reading of only 10.1°.

Since two variables were to be considered, *viz.*, sugar content and acidity, it was decided to present the samples in groups in which one of these factors would be held constant and the other varied by regular increments. The increments chosen were 2% for the sugar content and 0.05% for the acidity. Samples containing more sugar than the control were prepared by adding dry sucrose to the control and mixing thoroughly. Samples containing less sugar were prepared by mixing a calculated quantity of the dietetic pack with the control. Samples containing more acid than the control were prepared by adding the desired amount of acid in the form of a concentrated solution. Citric acid was used for this acidification, since it is inexpensive and readily available. However, the amount added was adjusted so as to be equivalent to the stated quantity of malic acid. Samples containing less acid than the control were prepared by adding a calculated amount of 1 *N*. sodium hydroxide and mixing thoroughly.

Flavor evaluation procedure. Each group of samples was presented to a panel of 100 tasters, consisting of employees of the Eastern Regional Research Laboratory. Makeup of the panel changed somewhat from test to test, but a majority of the members participated in most or all of the tests. Tasters were given no training, and no information about the samples. They were asked to rank the samples on the basis of preference. Four samples were offered in each test, and presented in random order. Code letters for the samples were chosen at random, but were reversed midway in each test in order to reduce the effect of code-letter bias. Each taster recorded the code letters of the 4 samples in order of preference. When a taster was unable to choose between two or more samples, which happened occasionally, he was asked to make a guess.

RESULTS

Results of the tests were recorded by adding the number of first choices, second choices, etc., for each sample in a group. In evaluating the results, 4 points were assigned to each first choice, 3 to a second choice, 2 to a third choice, and one to a fourth choice. This system has the advantage of giving a total value which is a positive function of the degree of preference, and which is also capable of being subjected to analysis of variance.

In the first test, the sugar content remained constant (17.9° Brix) and additions of 0.05%, 0.10% and 0.15% acid were made. Results of the test, shown in Table 1, seem to indicate that the addition of acid to the sauce resulted in a progressive decrease in the degree of acceptance. However, when the results were analyzed by Duncan's multiple range test *(1)*,

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pa., May 14, 1957.

[b] A laboratory of the Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

TABLE 1

Evaluation of apple sauce samples
No added sugar (17.9° Brix)

	Amount of added acid			
	None	+0.05%	+0.10%	+0.15%
Acidity	0.393%	0.443%	0.493%	0.543%
Brix-Acid Ratio	45.5	40.5	36.5	33.2
Number of:				
first choices	36	24	21	19
second choices	26	27	27	20
third choices	15	31	27	27
fourth choices	23	18	25	34
Total Score	275	257	244	224

Differences below 5% level of significance

the differences were shown to be below the 5% level of significance.

In the second test, 2% of additional sugar was added to all of the samples, and the acidity was varied as before. In this case (Table 2), the addition of 0.05% of acid gave the highest score, but the differences were again below the 5% level of significance.

TABLE 2

Evaluation of apple sauce samples
2 per cent added sugar (19.9° Brix)

	Amount of added acid			
	None	+0.05%	+0.10%	+0.15%
Acidity	0.393%	0.443%	0.493%	0.543%
Brix-Acid Ratio	50.6	45.0	40.6	36.9
Number of:				
first choices	25	21	25	29
second choices	24	41	19	16
third choices	25	26	29	20
fourth choices	26	12	27	35
Total Score	248	271	242	239

Differences below 5% level of significance

In the third test, a sauce containing 2% less sugar (15.9° Brix) than the standard was prepared by mixing the standard sauce with the low-sugar dietetic pack. The acidity was varied by adding acid or by neutralizing part of the acid. As shown in Table 3,

TABLE 3

Evaluation of apple sauce samples
Minus 2 per cent sugar (15.9° Brix)

	Amount of added acid			
	−0.05%	None	+0.05%	+0.10%
Acidity	0.343%	0.393%	0.443%	0.493%
Brix-Acid ratio	46.4	40.5	36.0	32.5
Number of:				
first choices	35	31	18	16
second choices	18	37	31	14
third choices	25	19	35	21
fourth choices	22	13	16	49
Total score	266	286	251	197

Differences below 5% level of significance

the control sample gave the highest score, but although the differences were greater than before, they were still below the 5% level of significance.

In the fourth test, no acid was added to the samples, but the sugar content was varied by 2% increments. As shown in Table 4, a significant preference was shown for a sauce containing 2% added sugar.

In the fifth test, 0.05% acid was added to all the samples, and the sugar content again varied in the same manner as above. As shown in Table 5, the

TABLE 4

Evaluation of apple sauce samples
No added acid, Brix variable

	Amount of added sugar			
	−2%	None	+2%	+4%
Brix value	15.9°	17.9°	19.9°	21.9°
Brix-Acid ratio	40.4	45.5	51.7	58.0
Number of:				
first choices	17	18	37	28
second choices	14	25	33	28
third choices	20	37	22	21
fourth choices	49	20	8	23
Total score	199	241	299	261

Differences above 5% level of significance

preferred sample was the one containing 4% added sugar, a majority of the tasters giving it as their first choice. The differences were significant at the 5% level.

SUMMARY AND CONCLUSIONS

In general, the higher the acid content of a sauce, the higher was the sugar content required for the

TABLE 5

Evaluation of apple sauce samples
0.05% added acid

	Amount of added sugar			
	−2%	None	+2%	+4%
Brix value	15.9°	17.9°	19.9°	21.9°
Brix-Acid ratio	35.9	40.4	45.9	51.4
Number of:				
first choices	6	18	22	54
second choices	19	17	40	24
third choices	23	40	26	11
fourth choices	52	25	12	11
Total score	179	228	272	321

Differences above 5% level of significance

optimum flavor effect. However, the optimum Brix-acid ratio was not the same in all tests. Changes in sugar content affect the degree of preference to a greater extent than proportionally equivalent changes in acidity.

The data indicate that the sauce preferred by most tasters was one containing about 0.45% acid, with a Brix value of about 22, that is, with 0.05% more acid

and 4% more sugar than the standard sauce chosen for the tests.

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