Apples, Processed

Apple-Grapefruit Juice Products

CONSUMER PREFERENCE

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TABLE OF CONTENTS

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INTRODUCTION

Technological developments and modern means of transportation present opportunities for the manufacture and marketing of products that heretofore have not been possible under commercial practice. To the authors' knowledge, blends of apple and grapefruit juices have not been marketed.

Several characteristics of apple and grapefruit juices make them interesting to study and to combine into a blend. Grapefruit juice is described as being tart and zestful, while apple juice is commonly characterized as relatively sweet and bland. The combination of the apple and grapefruit juices in a blend may moderate the extreme character of the pure juices and produce a new product with a high level of consumer preference. Both juices are characterized by relatively low costs of preparation from the raw product. Costs of manufacturing and marketing apple-grapefruit juice blends could be comparable to those of other fruit juice blends. Therefore, apple-grapefruit juice blends have an inherent cost advantage over other common fruit juices and fruit juice blends.

Today it is economically possible to transport grapefruit juice from Florida to Virginia, or apple juice from Virginia to Florida in less than 24 hours. This has become possible somewhat recently because insulated stainless steel tank truck fleets that specialize in transporting perishable liquid foods have become available and because of improved highways.

The objectives of this work were: (a) to determine the proportions of apple and grapefruit juices in blends that might have the best consumer acceptability; (b) to find out the consumer acceptability of these blends, as compared with the acceptability of other fruit juice blends on the market; (c) to establish adequate processing and packaging characteristics for the blends; (d) to observe quality changes in these blends during storage at 36°, 75°, and 100°F; and (e) to determine the shelf-life characteristics of the product.

The research reported here consisted of seven taste panel tests and a consumer preference test. Four of the taste panel test studies were concerned with different blends of apple and grapefruit juices. The fifth study, which involved orange-grapefruit juice blends, was made to compare preferences for these blends with the preferences for the apple-grapefruit juice blends. The sixth study was similar to the fifth, except that it involved pineapple and grapefruit in the blends. The seventh study compared the preferences for orange-pineapple, pineapple-grapefruit, apple-grapefruit, and orange-grapefruit juice blends. All of those blends, except the apple-grapefruit juice blends, were commercial products being successfully merchandised at the time of the study. The data on the juice proportions in the commercial blends were unavailable.

The consumer preference test consisted of a comparison of preferences by 308 families living in Hartford, Connecticut. The products included in this preference test consisted of two canned apple-grapefruit juice blend products which were prepared under essentially commercial conditions especially for this research. In this phase of the work, preferences were also obtained for those blends compared with other juice products then currently being consumed by the 308 families.

EXPERIMENTAL PROCEDURES

Preparation of Products for Laboratory Blends and for Preference Tests

Apple Juice. — The apple juice was pressed in a commercial plant from a blend of 1/4 Golden Delicious, 1/4 York Imperial, 1/4 Stayman, and 1/4 Winesap apple varieties. The apples and the resulting juice were of a quality considered average for the product generally found in the retail market. The juice was enzymatically clarified, held for 13 hours at approximately 70°F, filtered, pasteurized for 2 minutes at 210°F, cooled to approximately 70°F, and manually filled into 5-gallon polyethylene containers. Within 4 hours the packaged juice was placed in a freezer at 0°F where it was held until used in blends with grapefruit juice.

Grapefruit Juice. — The grapefruit juice used was a 42 degree Brix commercially prepared concentrate. The concentrate was diluted with distilled and deionized water to prepare a reconstituted single strength juice with 11.3% soluble solids content.

Other Juices and Blends. — The blended juices in Studies I through IV consisted of combinations of the following juices:

1. A frozen single strength apple juice prepared as indicated above.
2. A frozen, 3 to 1, commercially prepared Florida grapefruit concentrate with no sugar added, identified hereafter as "commercial grapefruit juice."
3. A single strength debittered experimental grapefruit juice made available by the USDA Food Crops Utilization Research Laboratory, Weslaco, Texas. This juice had been debittered by using naringinase, and was included in Study IV only. It will be referred to as "debittered grapefruit juice."

The proportions in which these juices were blended in the various studies are shown in the second and third columns of Table 1.

Grapefruit Juice Blends With Other Fruit Juices. — In Study V, preference for a commercial orange-grapefruit blend was compared with that for four orange-grapefruit blends prepared in the laboratory. The juices prepared in the laboratory according to the proportions shown in Table 2 were made of the following products: (a) the 3 to 1 frozen commercial grapefruit concentrate juice used in the aforementioned studies; (b) a national premium brand, 3 to 1 frozen orange juice concentrate with no sugar added; (c) a commercial blend, non-premium brand, 3 to 1 frozen product without the addition of sugar, identified in the instructions given to the judges as "blended orange-grapefruit juice."

Study VI was similar to Study V except that pineapple juice rather than orange juice was used for combination with the grapefruit juice. Preferences were determined for a premium brand, commercial 3-to-1 frozen pineapple-grapefruit juice blend, and for four blends prepared in the laboratory from the following juices in proportions given in Table 2: (a) the 3-to-1 commercial frozen grapefruit juice concentrate used in the forementioned studies, and (b) a premium brand, 3 to 1 frozen pineapple juice with vitamin C added.

In Study VII the preference for a blend of 78 parts apple juice to 22 parts commercial grapefruit juice was compared with that for three other blended fruit juices sold in retail stores. The following four juices were used for the study: (a) commercial orange-pineapple blend, the same premium name brand as used in "b"

Table I. *Mean preference scores for different proportions of apple to grapefruit juice.*

Study	Blend Proportions: Apple	Blend Proportions: Grapefruit (Commercial)	Mean Preference	Duncan Test[1]	Correlation Coefficient[2]
I	90	10	6.52		.236**
	82	18	5.97		
	78	22	5.77		
	73	27	5.57		
	65	35	5.30		
II	90	10	7.10		.359**
	70	30	6.57		
	50	50	6.37		
	30	70	5.85		
	10	90	5.30		
III	100	0	6.35		.202**
	95	05	6.25		
	90	10	6.25		
	85	15	5.77		
	80	20	5.45		
IV		Grapefruit (Debittered)			
	90	10	6.85		
	80	20	6.68		
	70	30	6.08		
		Grapefruit (Commercial)			
	90	10	6.05		
	70	30	5.72		

[1]Figures enclosed by brackets are not significantly different from each other at the .05 level.

[2]Significance indicated by ** for .01 level.

Table 2. *Mean preferences for a variety of blended fruit juices.*

Study	Product	Preparation	Proportions		Mean preference	Duncan[1] Test	Correlation[2] coefficient
V			Orange-grapefruit				
	Orange-grapefruit	Laboratory	90	10	6.75		.345**
		Laboratory	75	25	6.75		
		Laboratory	50	50	6.15		
		Commercial			5.22		
		Laboratory	25	75	4.98		
VI			Pineapple-grapefruit				
	Pineapple-grapefruit	Laboratory	100	0	6.05		.117 (n.s.)
		Laboratory	92	08	6.00		
		Laboratory	76	24	5.75		
		Laboratory	52	48	5.45		
		Commercial			5.38		
VII							
	Orange-Pineapple	Commercial[3]			7.33		
	Pineapple-grapefruit	Commercial[3]			6.33		
	Apple-grapefruit	Laboratory	Apple Grapefruit (Commercial)	78 22	5.83		
	Orange-grapefruit	Commercial[3]			4.80		

[1]Figures enclosed by brackets are not significantly different from each other at the .05 level.

[2]Significance indicated by ** for .01 level and by n.s. for non-significant.

[3]Blend proportion unknown.

above, 3 to 1 frozen concentrate; (b) commercial pineapple-grapefruit blend, premium name brand, 3 to 1 frozen concentrate; (c) apple-grapefruit blend, made in the laboratory from 78 parts of apple juice and 22 parts of reconstituted commercial 3 to 1 frozen grapefruit concentrate; and (d) commercial orange-grapefruit blend, not a premium name brand, 3 to 1 frozen concentrate. Thirty-six subjects evaluated each of the four juice blends, identified in the instructions only as "blends of different fruit juices."

Preparation of Products for Consumer Use Test

Apple Juice. — The apple juice was pressed in a commercial juice plant from a blend of equal parts of York Imperial, Stayman, and Golden Delicious apple varieties. It was clarified and filtered as explained above, then held at approximately 60°F until mixed with grapefruit juice.

Grapefruit Juice. — The grapefruit juice was prepared from a 3 to 1 concentrate by diluting to single strength with tap water originating from the plant well, and having a neutral flavor. The concentrate had been prepared from Florida grapefruit and commercially concentrated to 42° Brix. The reconstituted juice was turbid. Its visual characteristics were at a level considered normal for processed grapefruit juice.

Blends. — Two blends with different proportions of apple and grapefruit juices were prepared by mixing apple juice with the grapefruit juice, which had previously been reconstituted to single strength, in a stainless steel tank at approximately 60°F. One blend had the juices in proportion of 78 parts of apple juice to 22 parts of grapefruit juice. The other blend had 67 parts of apple juice to 33 parts of grapefruit juice. Nothing else was added. Each blend was then pasteurized at 200°F, and filled at 186°F by means of a rotary filler in plain 46-oz. cans. The capped cans were held for 2 1/4 minutes before cooling by cold water sprays. The characteristics of the blends and component juices are given in Table 3.

Table 3. *Characteristics of blends and of component juices at time of packing.*

Juices		Soluble Solids (%)	pH	Total Acidity (% malic)	Ascorbic Acid (mg/100 ml)
Blend Juices					
Apple (%)	Grapefruit (%)				
78	22	13.3	3.62	.65	9.7
67	33	13.0	3.57	.72	12.8
Single Juices					
Apple		13.9	3.70	.56	2.1
Grapefruit		11.4	3.50	1.09	29.6

Labels of simple design were used to avoid test-subject bias that might be created either by attractive labels, or by ideas suggested by designs. The 78 to 22 and the 67 to 33 blends were differentiated only by the color of the especially printed labels. The 78 to 22 blend labels had blue lettering on white background, while the 67 to 33 blend had green lettering on white background. The information and terms used in the two labels were exactly the same. The labels read as follows:

APPLE AND GRAPEFRUIT JUICE BLEND

Refrigerate Before Serving

Any product leftover after serving should be transferred to a plastic or glass container and stored in covered container in the refrigerator.

The visual appearance of the blend was that of a brown, turbid liquid. When placed in a cylindrical, colorless, transparent glass container of 4.4 cm diameter and 33 cm height, the color of the juice blends approximated the Munsell system notation of 2.5 Y 7/10.

Preference Tests

Methodology. — Procedures designed to provide controlled conditions during evaluation of products by a panel of judges were employed in these studies. For example, panelists were isolated in private booths to minimize social influences during judgment of products. Products were identified by code numbers to prevent stimulus knowledge from biasing response. Physiological sensitivity was maintained during the session by providing pure water for mouth rinsing as desired and by instituting a minimum delay of 30 seconds between the tasting of samples. Illumination of samples and sample temperature were controlled, as they otherwise could have influenced evaluation. In addition to these general laboratory conditions, the following procedures were specified for these studies:

1. Panelists were selected by a systematic sampling procedure from a master list of 500 U.S. Department of Agriculture employees who had volunteered to participate in the sensory evaluation program. With one exception (N = 36 in Study VII) each of the seven studies had 40 panelists. In selecting judges for the studies, panelists were not replaced in the master list during Studies I through III. Panelists were replaced before Studies IV through VII, with no replacement over the course of these later studies.

2. Samples of five juices (four juices in Study VII) in 2-oz. portions held at $55^{\circ} \pm 2^{\circ}F$, were served to each subject. The order of presentation was balanced so that within a given session of 40 subjects, each sample appeared equally often in each of the five serving positions. Details about specific sample formulations, etc., are described in the section concerned with the separate studies.

3. The instrument of measurement was the nine category hedonic scale. Subjects indicated their preference attitudes towards juices by circling one of the rating categories.

4. The data, ratings made on verbal categories, were converted to numerical scores for statistical analyses by assigning them successive integers from "1" (dislike extremely) to "9" (like extremely).

5. Information provided subjects on the samples in most cases merely identified the components of the blend, such as "blended apple and grapefruit juices." In two studies, I and VII, the samples were described only as "blended fruit juices."

Formulation Studies of Grapefruit Juice With Apple Juice. — Four exploratory studies investigated different proportions of apple to grapefruit juice to determine the most preferred blend. These are identified as Studies I, II, III, and IV.

Initially it was suggested that some blend of apple and grapefruit juices might be preferred to either juice alone. The optimum blend was believed to be between 70 to 80 parts apple juice and 30 to 20 parts grapefruit juice.

The first study was conducted to determine the most preferred blend employing apple to grapefruit juice proportions within the range of 65 to 90 parts apple juice. The results of the first study did not demonstrate a most-preferred blend of the two juices. Instead, the study indicated that pure apple juice might be expected to be preferred over any combination with grapefruit juice. Declines in average preference of blends were directly related to lower proportions of apple juice in the blend. This finding was substantiated by further research in Studies II and III.

Consumer Use Test

Methodology. — Further evaluation of apple-grapefruit juice blends was carried out in cooperation with the Florida Citrus Commission of Lakeland, Florida. The work was done in three stages. The first stage was an informal in-depth interview with a panel of 8 to 10 homemakers in each of three different cities to determine their reaction to the idea, the product form, its taste, and its appearance. The second stage was an interview with 500 consumers randomly selected in Hartford, Connecticut, to obtain their reaction to the concept of the blend, to obtain demographic data for use in selecting a final panel of respondents to be given an in-home test of the product, and to solicit their cooperation. The third stage consisted of in-home use of two blends of the product for a week and a reinterview

of the consumers. By placing these products in consumer's homes where they could be served as a regular part of the family menus, the relative merits of the two formulations, uses that would be made of them, and the attitudes and basic response to an apple-grapefruit juice blend were assessed.

Initial contact with consumers was made in person, following a random block sample design. In this first phase of the study, 471 households were contacted. The products were placed in 308 households where the housewife was sufficiently interested in an apple-grapefruit juice blend to consider serving it to her family at some time and was willing to participate in this study. Each panelist was given two 46-oz cans of apple-grapefruit juice blend – one containing the 78 to 22 blend, and the other the 67 to 33 blend. The panelists were also given a diary with a questionnaire to record their family's reactions and comments. Two weeks after placement, the same women were reinterviewed by telephone.

Rate of Fermentation of Apple Juice

Methodology. – Considering the possibility of shipping single strength apple juice over distances of several hundred miles to blend it with grapefruit or other juices, it was thought desirable to evaluate the rate of fermentation of apple juice at different controlled initial levels of contamination with yeast, and at 78°F; i.e., under non-refrigerated conditions. Previous experience that the authors had in transporting 1,200 gallons of apple juice from Virginia to Florida indicates that apple juice can be shipped at temperatures in the range of 40° to 50°F for 36 hours without significant increase in microbiological flora, and that the juice maintains a characteristic fresh flavor and aroma.

Commercially clarified, pasteurized, and bottled apple juice with a soluble solids content of 12.5% and a pH of 3.70 was used. The juice, in 750 ml quantities, was placed in 1-liter Erlenmeyer flasks, stoppered with cotton, and sterilized at 250°F for 5 minutes. A yeast suspension from a 48-hr old culture was prepared which contained approximately 30 million yeast cells per milliliter as determined by optical density measurements. Pairs of samples of the sterile apple juice were inoculated with the yeast culture under sterile conditions, following the schedule shown in Table 4. Viable yeast plate counts were made using potato dextrose extract agar, following the method given in Standard Methods for the Examination of Dairy Products (1953).

Blend Prepared With Clarified Grapefruit Juice

Clarification. – Since the apple juice was clear, the turbidity of the apple-grapefruit juice blend was caused either by the unclarified grapefruit juice used, or by precipitates formed by blending the two juices.

Table 4. *Rate of fermentation of apple juice inoculated with different numbers of* Saccharomyces cerevisiae *and incubated at 25°C (78°F).*

Sample Pair	Inoculating Schedule (cells/ ml)	Viable Yeast Count (cells/ml)[a] Initial Counts (Zero time)	After 24-hr Incubation	After 72-hr Incubation
A	1,000,000	955,000	9,700,000	49,000,000
B	20,000	20,000	1,300,000	50,000,000
C	2,000	2,120	260,000	51,000,000
D	200	163	18,900	41,000,000
E	0	0	0	0

[a]Each figure is the mean of plate counts on two samples.

Tests were made to find out whether or not grapefruit juice could be clarified and to determine the conditions necessary to obtain its clarification. Pectinol 10-M, a commercial food-grade pectic enzyme product, was used. The clarifying effect of Pectinol 10-M on the 3 to 1 reconstituted grapefruit juice concentrate was tested at temperatures ranging from 75° to 125°F, and at Pectinol 10-M concentrations from 30 to 3,000 mg/liter. Incubation time was from 12 to 48 hours.

The effectiveness of the different sets of conditions was judged on the basis of obtaining clarification of the blend product in the shortest possible time, at the lowest incubation temperature, and by using the lowest concentration of pectic enzyme product. After 12 hours incubation at 75°F using a concentration of 150 mg of Pectinol 10-M per liter, the grapefruit juice could be filtered clear with the aid of the filtering agent Hyflo Super-Cel* in suspension in the juice and as a mat on the filter surface. The clear, filtered juice had a characteristic grapefruit flavor. No off-flavor was detected.

Blend Preparation. — A blend of 67 to 33 apple-grapefruit juices was prepared with clarified grapefruit juice, and another blend of the same proportion of juices was made up with unclarified grapefruit juice. The same high quality, clarified and pasteurized commercial apple juice was used for both blends.

Taste Panel Tests. — Taste panel tests were conducted to determine sensory differences and preference for the clear and non-clarified blends. First, a triangular difference taste panel test was conducted in a darkened room with 14 adult male and female panelists. The method given in Amerine *et al.* (1965) was followed. The objective of this test was to determine if there was any flavor difference between the two blends, without turbidity being a factor. Samples were kept in thermos jugs at 55°–60°F, and 1.5 oz. presented at the temperature in 2-oz. cups to the judges. Samples were coded with 3-digit, randomly selected numbers. Panelists were instructed to rinse their mouth with water after tasting each sample. The panelists could not see each other while judging. The panelists were told only that they were testing different apple-grapefruit juice blends and asked to give the number of one sample among the three that in their judgment was different. Two of the samples presented to the judges were alike, and one was different. The odd sample for each judge had been randomly selected in advance. If they could distinguish no difference, panelists were instructed to guess which sample was different. The triangular difference test was replicated three times with each panelist.

On the following day, duo-preference tests were conducted on the same blends in a lighted room to determine whether or not blend turbidity was a factor in the preference shown by the judges. The procedure given in Amerine *et al.* (1965) was followed. Eleven panelists participated, eight of whom had taken part in

*Trade name of Johns-Manville Corp.

the triangular difference tests. In the duo-preference tests one sample of each of the two blends was presented, and each panelist was asked to give the number of the preferred sample. Each panelist was asked to judge three duo-preference tests. In the first test the cups were covered with aluminum foil and a straw inserted for tasting. In the second and third tests the two cups were left open so that appearance, as well as flavor, could influence preference. The panelists were asked to judge which one of the two samples they preferred, or whether they found no difference between the two samples.

Color and Flavor Stability of Canned Apple-Grapefruit Juice Blends

Samples of the 78 to 22 and 67 to 33 blends of apple-grapefruit juice canned in plain 46-oz. cans were held in storage at -10°, 75°, and 100°F. At monthly intervals they were removed from storage and brought to room temperature. Color and flavor were compared organoleptically by a trained panel of three persons. The light transmittance spectrum in the region between 445 and 1020 mμ was also determined.

Analytical Methods and Apparatus

Transmittance Spectra. — A Beckman Du-2 spectrophotometer was used. Readings were made monthly for a period of 15 months, beginning when the product was packed. The product was a blend of 67 parts of apple juice and 33 parts grapefruit juice prepared as indicated elsewhere under Preparation of Products for Consumer Use Test. Transmittance determinations were made on products stored at 75° and at 100°F. Samples were centrifuged for 10 minutes at 3,000 G's to clarify them prior to transmittance determinations.

Soluble Solids. — A Bausch & Lomb, Abbe-type refractometer was used to determine soluble solids content. The refractive index was corrected for temperature and converted to percent sucrose from tables.

pH. — A Beckman Zeromatic pH meter was used.

Total Acidity. — The titration method given in Official Methods of Analysis of the AOAC (1965) was used. Results were expressed as percent malic acid.

Ascorbic Acid. — The indophenol method given in Official Methods of Analysis of the AOAC (1965) was used.

Can Vacuum. — A Bourdon-type gauge was used.

RESULTS AND DISCUSSION

Preference Tests for Formulations of Grapefruit Juice With Apple Juice

Study I. — Table 1 presents the mean preference scores found in Study I for blends ranging from 65 to 90 parts apple juice per 100 parts blend. The five samples were identified to the judges only as "blended fruit juices." Results of a Duncan Multiple Range Test are indicated by the brackets to the right of the means in Table 1. Mean preference scores within any bracket do not differ significantly from one another, but do differ significantly at the .05 level from any mean scores with which they do not share a bracket. Thus, the mean preference scores for blends composed of 90 and 82 parts apple juice, 6.52 and 5.97 hedonic scale points, share a bracket and do not differ significantly from one another, and the 90 juice which does not share a bracket with any of the remaining juices differs significantly from the remaining juices at the .05 level. The 82 juice blend is bracketed with juices through 73 parts apple juice and does not differ significantly from them, etc. The correlation of preference with blend proportion r = .236, while low, was significant at the .01 level as shown in Table 1.

An analysis of variance for Studies I to IV is shown in Table 5, in which the juice's main effect was significant at beyond the .01 level.

Inspection of mean preference scores obtained from Study I suggests that preference rises as the proportion of apple juice in the blend is increased. This relationship is presented graphically in Figure 1. The least squares method was used for fitting the regression line to the data for Study I. The regression equation relating changes in the dependent variable, preference ($\hat{Y}$), to the independent variable, (x) blend proportion, was:

$$\hat{Y} = 1.973 + .497x$$

Thus for a 10 parts per 100 change in blend, there was approximately a half (.497) scale point change in mean preference. The standard error of estimate was ± 1.78, indicating considerable dispersion of ratings about the line. Study I results imply that there was no blend of the apple and grapefruit juices that was preferred to the apple juice *per se*. However, only a narrow band of the possible blend proportions, from 65 to 90 parts apple juice was investigated.

Study II. — Study II was conducted to explore preference for a wider range of proportions, that is, from 10 to 90 parts apple juice, as shown in Table 1. In the second and later studies, unless otherwise noted, the juice components were identified and instructions to subjects read "blended apple and grapefruit juices." The slight change in instructions should not affect the results, although there is

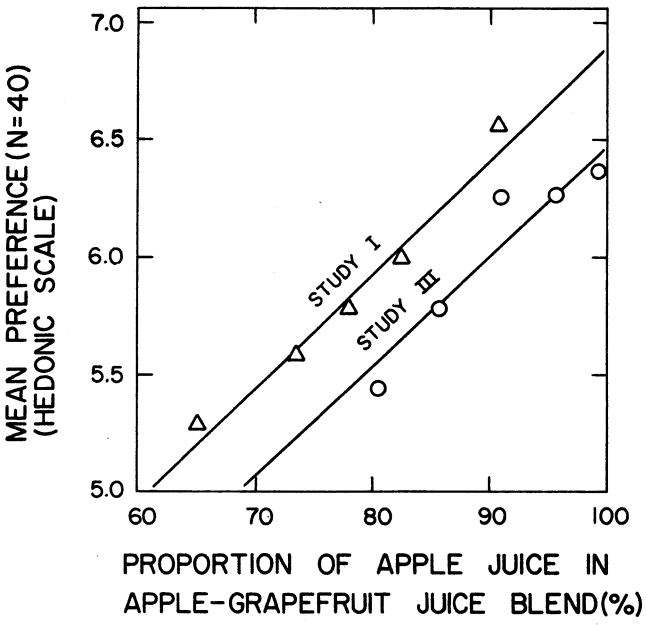

FIG. I. PREFERENCE FUNCTION OF PROPORTION OF APPLE JUICE IN APPLE-GRAPEFRUIT JUICE BLEND.

always a danger that providing more information will raise preference and/or reduce discrimination between samples (1,3). Study II mean preference scores are also shown in Table 1. An analysis of variance made on the data indicates that the juice's main effect was significant at the .01 level (Table 1). Results of the Duncan Multiple Range Test (.05 level) are shown by the brackets to the right of the mean scores. The correlation coefficient, r = .359, likewise presented in Table 1, was low but significant at the .01 level.

The regression equation for preference ($\hat{Y}$) on blend proportion (x) was:

$$\hat{Y} = 5.16 + .216x$$

The regression line fitted by the equation is shown in Figure 2. The regression line is not plotted in Figure 1 because the ranges of proportion in Studies I and II were not commensurate. The standard error of estimate was ± 1.70.

Study III. — Having established in the first two studies the direct relationship between preference and proportion of apple juice in an apple-grapefruit blend, a third study was designed to determine preference for blends prepared with small, equal increments of grapefruit juice. Five samples were evaluated; they consisted of a standard (pure apple juice) and four blends differing from pure apple juice in having relatively small, 5 parts per 100, successive increments of grapefruit juice. Table 1 shows the mean preference scores for these samples. Table 5 shows an analysis of variance made on the data indicating that the main effect of the juice was significant at the .05 level. A Duncan Multiple Range Test made on the data is shown by the brackets to the right of the mean preference in Table 1. Results of the Duncan Test showed that the mean preference score for the pure apple juice differed from that for the 80 part apple at the .05 level. The differences in mean preference scores between pure and 85 parts apple juice did not attain statistical significance. The regression equation for preference ($\hat{Y}$) on blend proportion (x) was:

$$\hat{Y} = 1.749 + .474x$$

The regression line for this equation is shown in Figure 1. The standard error of estimate was ± 1.58. The correlation coefficient, r = 202, was low but significant at the .01 level.

The data for Studies I and III are quite consistent. The regression equation for Studies I and III, where the ranges of juice proportions investigated were similar, showed a decline in preference of slightly less than half a scale point (.497 and .474) for a 10 parts per 100 decrease in apple juice. Therefore, decreasing the proportions of apple juice in a blend by more than 10 and less than 20 parts per 100 may be expected to decrease average preference by half a scale point or more. An empirical rule, based on hundreds of similar studies made under laboratory conditions and using 36 to 40 panelists, had indicated that differences in mean

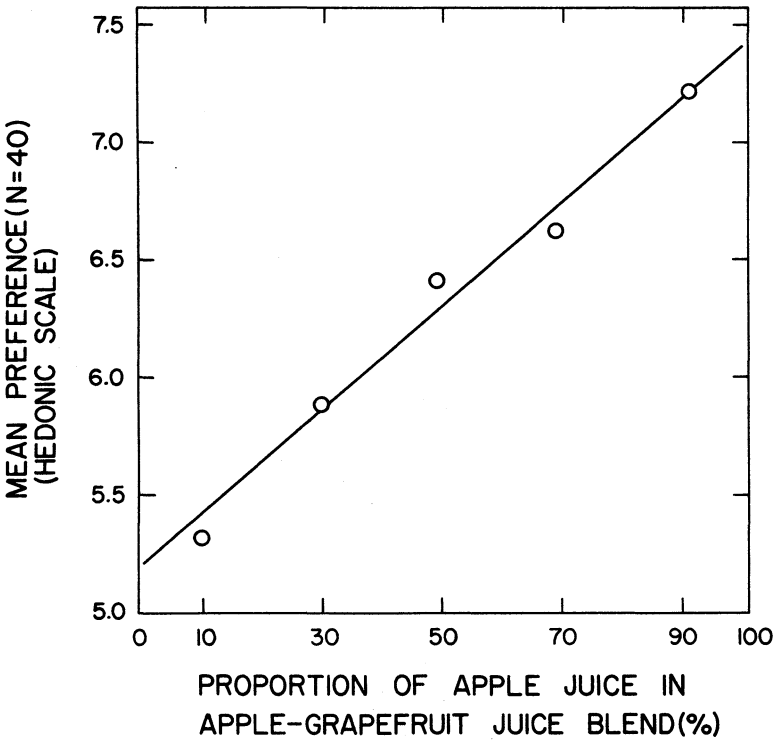

FIG. 2. RELATIONSHIP BETWEEN PREFERENCE AND APPLE–GRAPEFRUIT JUICE PROPORTIONS IN A BLEND.

Table 5. *Analysis of variance for Studies I to IV.*

Study	Source	Sums of Squares	Degrees of Freedom	Mean Squares	F Test[1]
I	Juice	34.12	4	8.53	4.33**
	People	267.42	39	6.86	3.48**
	J x P	386.68	156	1.97	
		608.22	199		
II	Juice	76.23	4	19.06	8.85**
	People	168.08	39	4.31	2.00
	J x P	336.17	156	2.15	
		580.48	199		
III	Juice	23.95	4	5.99	3.29*
	People	216.95	39	5.56	3.05*
	J x P	284.05	156	1.82	
		524.95	199		
IV	Juice	35.4	4	8.85	4.49**
	People	254.7	39	6.53	3.31*
	J x P	307.8	156	1.97	
		597.9	199		

[1]Level of significance indicated by * for .05 and ** for .01 levels and beyond.

preference of half a hedonic scale point, or more, are of practical statistical significance. The Duncan Multiple Range Test results for the mean preferences of Studies I and II indicate statistical significance at the .05 level for juices where the proportion of apple juice had decreased between approximately 11 in Study I, and 20 in Study III. Changes introduced in later studies consisting of a different range of proportion in Study II and the addition of a second debittered grapefruit juice in Study IV furnished, as might be expected, gave slightly different results. Differences in proportion of 20 parts or more in Study II and differences greater than 10 and less than 20 parts in Study IV for debittered juice were statistically significant at the .05 level.

While the discussion presented above pertains mainly to the specific juices combined, i.e., grapefruit juice A and a single apple juice, there is some evidence from Study IV to indicate that the direct relationship found between preference and proportion of apple juice may be generalized to other juice blends. Similar results were found for a blend made with a second, debittered grapefruit juice.

Study IV. — In Study IV, blends made with grapefruit juice A were compared with those made from debittered grapefruit juice. Five samples were prepared: three from the debittered product and two from grapefruit juice A. The mean preferences for these juices are shown in Table 1. The results of a Duncan Multiple Range Test are indicated by the brackets to the right of the mean preferences in Table 1. An analysis of variance made on the data indicates that the juice's main effect was significant at the .01 level, as shown in Table 5.

It should be noted that the preference previously noted for commercial grapefruit juice also occurs for the debittered product. Preference was directly related to the proportion of apple juice. Blends of apple juice and debittered grapefruit juice having greater proportions of apple juice exhibited greater mean preference. The results indicate that the debittered product makes a slightly more preferred blend than Brand A. The blend made with 10 parts per 100 of debittered grapefruit juice, mean preference 6.85, is significantly preferred to that made up with 10 parts of commercial grapefruit juice, mean preference 6.05. Although these data are not sufficient for forming a reliable opinion, apparently the point of origin and the regression line for the debittered product are raised over that for the commercial grapefruit juice on the preference axis.

Grapefruit Blended With Other Fruit Juices

Studies V, VI, and VII. — Studies I through IV show a depression of mean preference scores for apple-grapefruit juice blends with greater proportions of grapefruit juice. Those findings are relevant only when grapefruit is combined with apple juice, or with novel fruit juice products not currently on the market.

Studies V through VII were conducted to answer two questions:

1. Does the addition of various proportions of grapefruit to pineapple or orange juice, which thereby produces the familiar blends currently marketed, demonstrate a preference-proportion relationship similar to that found for apple-grapefruit?

2. How does preference for an apple-grapefruit juice blend compare with that of competitive blends already on the market?

Study V explored preference for orange juice blended with different proportions of grapefruit juice, and Study VI did the same for pineapple juice. Study VII compared preference for four blends of different juices. The commercial grapefruit juice was used in Study VII.

The mean preference scores of the juices are shown in Table 2. An analysis of variance made on the data showed that differences in mean preference between the samples was significant at the .01 level. Results of Duncan Multiple Range Test are indicated by the brackets to the right of the means shown in Table 2. The orange-pineapple juice, with a mean score of 7.33, was significantly preferred at the .05 level to the remaining three juices. The pineapple-grapefruit and apple-grapefruit blends, with mean preference 6.33 and 5.83 hedonic scale points respectively, while not differing significantly from one another, differed significantly from the non-premium orange-grapefruit blend — mean preference of 4.80 scale points. Preference scores within a bracket, while not differing significantly from one another, do differ significantly from all scores not within common brackets. Thus, mean preference scores for blended juices made from 10 to 50 parts grapefruit differed significantly at the .05 level from the commercial and the 75 parts grapefruit juice blends.

Inspection of the mean preferences for the four laboratory blends indicates that the preference declined with greater proportions of grapefruit juice. This relationship between preference and the proportion of grapefruit to orange juice is similar to that found in the apple-grapefruit blends. The regression evaluation expressing relationship between preference ($\hat{Y}$) and blend proportion (x) was:

$$\hat{Y} = 4.480 + .279x$$

Table 2 shows the mean preference scores for the juices. Analysis of variance made on the data did not demonstrate a main effect of the juice significant at the .05 level. Despite the small preference difference between the four laboratory juices, there is a trend toward decreased preference with greater proportions of the grapefruit juice, as had been found consistently in the preceding studies. The regression equation expressing the relationship of preference ($\hat{Y}$) to blend proportions (x) was:

$$\hat{Y} = 4.772 + .130x$$

The regression line fitted to the data by this equation is shown in Figure 3. The standard error of estimate was ± 1.91. The coefficient of correlations, $r_{yx} = .117$, was not significant. The standard error of estimate was ± 1.9 scale points. The regression line fitted by this equation to the data is shown in Figure 3. The correlation coefficient, r = .345, was low and significant at the .01 level.

Figures 2 and 3 show consistently that, when two fruit juices having distinctly different flavor characteristics are blended, as the proportion of one of the juices increases, the preference for the blend either increases or decreases in a linear manner, depending upon which juice is preferred by the evaluators. There were no proportions of the two juices that had a higher preference than that shown for the pure preferred juice.

Consumer Use Test

Of the 308 respondents to the question as to their preference between the two different blends, 139 (45.1%) expressed a preference for the 78 to 22 blend; 128 (41.6%) preferred the 67 to 33 blend, and the remainder had no preference.

Of the 308 respondents, 206 served one or more fruit juices or fruit drinks other than the apple-grapefruit blend during the week they tested the apple-grapefruit blend. Of these 206 respondents, 47.1% liked the 78 to 22 blend as well or better than the other juices consumed, 46.6% like the 67 to 33 blend as well or better than the other juices, and 42.7% liked the other juices as well as or better than either of the apple-grapefruit blends.

There were 85 respondents who were known to have compared the apple-grapefruit blend with either orange juice alone or with orange juice and some other juice. Of these, 47% liked the 78 to 22 blend as well as, or better, than orange juice; 43.5% liked the 67 to 33 blends as well as, or better than, orange juice; and 47% liked the orange juice better than either of the two blends of apple-grapefruit juice.

There were 289 respondents to the question as to which of the two blends was preferred by husbands. Of these, 30.8% expressed a preference for the 78 to 22 blend, 30.8% preferred the 67 to 33 blend, and 38.4% had no preference. There were 307 respondents to the question as to which blend was preferred by children. Of these, 54.4% preferred the 78 to 22 blend, 25.4% preferred the 67 to 33 blend, and 20.2% expressed no preference. When all data obtained were considered, it was found that the two blends showed approximately equal preference. The 78 to 22 product was preferred by 45.2% and the 67 to 33 blend

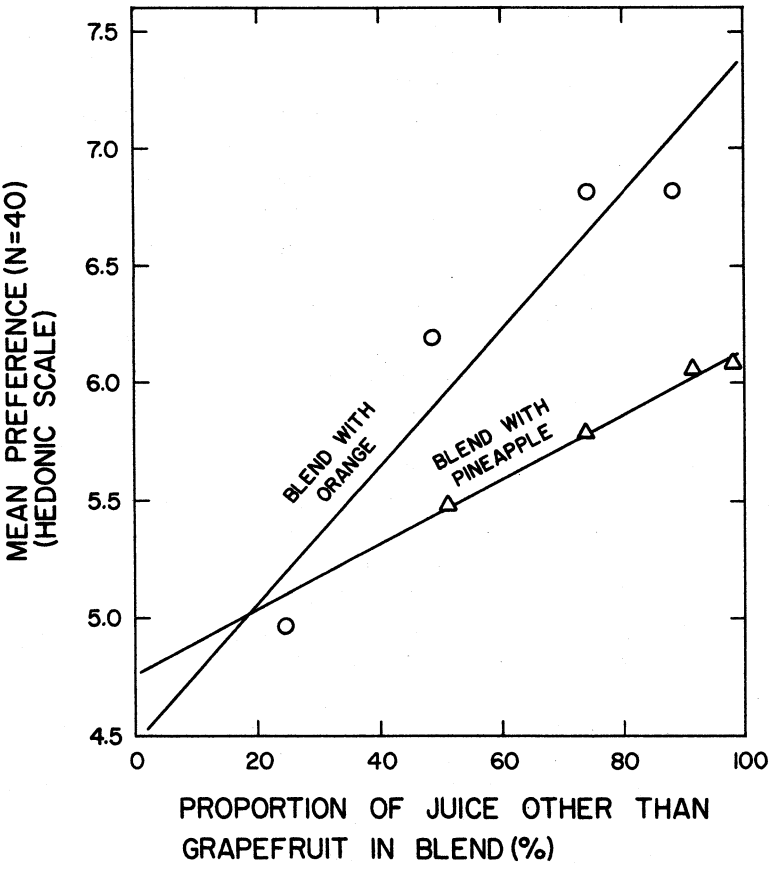

FIG. 3. RELATIONSHIP BETWEEN PREFERENCE AND PROPORTION OF GRAPEFRUIT JUICE IN TWO BLENDS WITH ORANGE AND WITH PINEAPPLE JUICE.

by 41.5% of the respondents, with 13.3% stating no preference. The difference between the 78 to 22 preference was not statistically significant at the .05 level.

While consumers did not express any clear-cut preference for one blend, they did distinguish between them on specific attributes. The difference in proportion of apple and grapefruit juice was recognized and led to different perception of the two products. The 67 to 33 product was found to be somewhat better for breakfast, having a taste more tart and tangy. It was perceived to be more like grapefruit and received more mentions for being bitter or strong. The 78 to 22 blend was readily perceived as having more apple taste and as being sweeter. It was thought that children would like it better and that it might be better for non-breakfast consumption. With regard to most other attributes, the two blends were found to be much alike. Although the 67 to 33 product was found to be slightly more refreshing or thirst-quenching, the answer to the question of which product had the fresher, cleaner taste was a standoff. The two products were found to be substantially equal also in flavor, body, texture, and color.

Inquiries into the perceived differences between the ideas of a chilled, single strength product and a pasteurized, canned product, disclosed that the canned product was thought more desirable. This was evident from the fact that 32.9% of the respondents named the canned products as more convenient, and 18.4% cited it as easily stored. The superior flavor ascribed to a chilled product was mentioned by 27.3% of those favoring the chilled product. About one person in five thought that the chilled form would better retain its flavor characteristics.

Within the industry there has been interest in the idea of developing a frozen concentrate form of an apple-grapefruit blend. This form does have appeal to the consumer as seen in the fact that 33.5% thought this would be the best way for the product to be sold. By comparison, only 11.9% thought that a chilled single strength form would be best, and 54.4% nominated the canned single strength form as the best way for the product to be sold.

Blend Prepared With Clarified Grapefruit Juice

In each of the three triangular difference tests each panelist made a judgment on the same samples. Therefore, in analyzing the results, the tests were all considered together so that there were a total of 42 tastings and judgments. In 24 of these tastings correct judgments were made. From a table giving the minimum correct judgments to establish significant differentiation (Amerine *et al.* p. 526), it was determined that the panelists could distinguish a difference in blends made from clarified and unclarified grapefruit juice, and that this ability to differentiate was significant at the 1% level.

In the duo-preference tests, the first test (in which the samples were covered) was designed to give further evidence on the ability of the panelists to distinguish a difference between the two blends. All panelists but one showed a preference for the blend containing unclarified grapefruit juice. This shows an ability to differentiate between the samples significant at the 1% level. The second and third duo-preference tests were statistically analyzed together, since they involved the same judgment. There were 22 tastings in total. In 15 instances, preference was shown for the blend containing unclarified grapefruit juice, and in 6 instances, for the blend containing clarified juice. In one test a panelist indicated no preference. The results were analyzed using the Chi square distribution, as given in Amerine *et al.* (1965). By that test, the panelists showed no significant preference for one blend over the other.

Those tests showed that, by tasting, the panelists could distinguish a difference between blends made from clarified and unclarified grapefruit juice. They preferred the flavor and related characteristics of the blend containing unclarified juice, thus indicating that the clarification process changes these qualities. However, when appearance became a factor, no significant preference was shown.

Rate of Fermentation of Apple Juice

Visual observation indicated that fermentation started in samples A after 16 hours, after 32 hours in samples B, and in samples C and D after 44 hours incubation at 78°F (see Table 4). Samples E showed no signs of microbiological activity. Samples A and B were set up with yeast counts representing high levels of apple juice contamination. Samples C and D had low levels of contamination. The results indicate that, to avoid flavor and appearance changes in apple juice, the pasteurized product, even when handled so that its yeast counts are low, should not be exposed to conditions favorable for fermentation for more than 24 to 36 hours. This precludes shipping of juice at temperatures above approximately 4° to 10°C (40° to 50°F) when consideration is given to time spent in filling tank trucks, time in route, time spent in loading and unloading, and time spent in holding tanks at both the shipping and the receiving plant. To obtain a high quality product under practical processing plant conditions, the juice should be handled so that significant microbiological changes are prevented for a period of at least 72 hours.

Color and Flavor Stability Tests of Canned Apple-Grapefruit Juice Blends

After 15-months storage, no perceptible difference was observed between the samples stored at 75° or 100°F and those held at -10°F. Transmittance spectra of

the canned apple-grapefruit juice blends showed virtually no changes throughout the same observation period. A slight "tinny" flavor was detected after 9 months at 100°F and after 24 months at 75°F. The "tinny" flavor became more pronounced after longer periods of storage.

SUMMARY AND CONCLUSIONS

Seven separate but related studies were conducted to determine how well people would like apple and grapefruit juices combined in a blend. Four studies explored formulations to determine the proportion of apple to grapefruit juice that would make the most desirable blend. Three more studies were conducted to determine how other fruit juices blended with grapefruit juice compared with an apple juice-grapefruit juice combination.

Formulation study results indicate that:

(1) Contrary to initial expectations, no blend of apple and grapefruit juices was preferred to apple juice alone.

(2) Preference among apple-grapefruit juice blends was directly related to the proportion of apple juice in the blend. Greater preference was shown for blends with greater proportions of apple juice. From another standpoint, preference for grapefruit juice was found to be increased by blends with apple juice.

(3) A decline in preference of slightly less than half a hedonic scale point for a 10 parts per 100 decrease in the apple juice proportion in apple-grapefruit juice blends took place.

(4) Blends made with debittered grapefruit juice showed a higher level of preference than those made with similar proportions of non-debittered, commercial grapefruit juice.

Studies which compared blends of other juices and grapefruit juice with the apple-grapefruit juice combination showed that:

(1) The effect of greater proportions of grapefruit juice on decreasing preference for the blend was not unique to the apple-grapefruit juice combination. Studies in which different proportions of orange and of pineapple juice, respectively were blended with grapefruit juice disclosed results similar to those discussed above for the apple-grapefruit juice combination. This finding was most conspicuous in the case of the orange-grapefruit blend.

(2) Preference for a blend prepared in the laboratory consisting of 78% apple juice and 22% grapefruit juice was similar to that for a premium brand of 3 to 1 frozen, blended pineapple-grapefruit juice then currently on the market.

(3) Comparison with other commercial 3 to 1 frozen fruit juice blends indicate that the apple-grapefruit juice blend was preferred over a non-premium orange-grapefruit blend, but not over a premium orange-pineapple blend.

Data obtained from the consumer use test indicate a rather high degree of preference for the apple-grapefruit juice blends tested, relative to the level of preference shown for leading fruit juices and fruit juice blends then on the market and used by the responding families. The two apple-grapefruit juice blends tested had approximately the same level of preference.

There is an apparent inconsistency between the results obtained in the panel tests and those obtained in the consumer preference test, with reference to preference for the two blends of apple and grapefruit juices. The slight difference in preference shown by the panelists for the higher proportion of apple juice in the blend may have been the result of the controlled conditions under which the panelists made their evaluations. Furthermore, it must be considered that the panelists were expressing their individual preferences, while the respondents in the consumer use study were expressing the preferences of their families.

The turbidity of the apple-grapefruit juice blends was considered by some of the subjects participating in the consumer use test as detracting from the appearance of the product. Tests run in the course of the work reported here indicate that grapefruit juice can be enzymatically clarified. When the clarified grapefruit juice is blended with likewise clarified apple juice, a clear product having an attractive amber color results.

Results of the stability tests indicate that the product canned under commercial conditions has flavor and color stability comparable to other fruit juice products now on the market.

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