SHERBET STUDIES USING ORANGE AND CRANBERRY CONCENTRATE

by

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INTRODUCTION

Sherbet is a semi-frozen product made of water, sugar, fruit, and milk or milk products which may or may not contain added color, flavor, acid, and stabilizer (20, p.484). A product similar to this definition has been made for over 2,000 years yet probably no other product made by ice cream plants is more variable in quality.

This variability might be anticipated since there are no industry-wide standards for sherbet composition. Until such standards are established and are used by sherbet manufacturers, this product will continue to lack uniformity.

The manufacturer should, if he wishes to take advantage of the increasing sherbet consumption, produce a high quality, uniform product.

This study was undertaken for the following reasons:

1. Investigate the use of cranberries in the manufacture of sherbet.
2. Determine consumers' preferences in regard to different sherbet formulations.
3. Investigate the claims that there is a large profit in the manufacture and sale of sherbet.

It was believed that none of the objectives could be accomplished without an investigation to determine what a high quality sherbet contains. Cranberries were used as the source of flavoring to explore the possibility of establishing an additional outlet for the sale of this northwest fruit.

Since no established taste panel studies have been made, it seemed timely and necessary to determine the reaction of consumers to some sherbet formulations.

Because of these objectives, this report discusses some aspects of sherbet quality, consumers' preferences, and cost.

REVIEW OF LITERATURE

Before the best quality sherbet can be made, it must be decided as to what an ideal sherbet contains. It is quite natural to suppose that the taste of all people is not alike. These taste preferences, according to Leiendecker (11, p.63), not only vary in different localities, but there are great variations between people in the same locality. Based on this supposition, from a commercial standpoint, an ideal sherbet is the one that satisfies the greatest number of consumers in any given trade territory.

Fabricius (8, p.56) states: "The big problem of sherbet manufacturers is the lack of adequate standards. Studies as to consumers' preference both in flavor and body and texture are lacking. Undoubtedly our idea as to what is desirable in flavor and body and texture in sherbet is gained largely from our inadequate knowledge of consumers' preference in respect to ice cream."

To exemplify the variations in the composition of sherbet, it seemed advisable to tabulate the results of analysis of commercial products as analyzed by four organizations. These data appear in Table 1. From this table it can readily be observed that there is a wide variation in total solids, titratable acidity, and overrun. It is

Table 1

Variations in Sherbet Composition as Reported by Various Organizations

Date	Analyzing Organization	Number of Samples	Average and Range of Total Solids Per Cent	Average and Range of Overrun Per Cent	Average and Range of Titratable Acidity 1/ Per Cent
1934	Minnesota State College (6, p.38)	19	32.9 26.8-39.4	No statement of analysis	0.43 0.27-0.75
1955	Oregon State College (22, p.2)	15	34.5 29.9-38.0	No statement of analysis	0.50 0.28-0.75
1955	Private Co. interplant study (1, p.13)	18	33.6 28.9-39.9	44 18-75	0.37 0.26-0.58
1955	Private Co. interplant study (2, p.11)	22	33.6 28.2-37.2	45 16-66	0.42 0.24-0.86

1/ Calculated as Citric Acid

also apparent that little gain has been made in standardizing sherbet manufacturing in the last twenty years.

In the manufacturing of sherbet, two factors must be considered: quality and cost.

Quality

The major considerations in sherbet quality are body and texture, acidity, flavor, and color.

1. Body and Texture

Desirable body and texture is dependent upon a number of factors (5, p.1 and 11, p.62), principally: (a) the stabilizer used, (b) the milk solids, (c) the sweeteners, and (d) the overrun. Sommer (20, p.488) adds freezing method to this list of determinates.

(a) Stabilizers. Tracy et al. (8, p.56) state that stabilizers assist in the formation of a smooth texture and firm body, and to a certain extent aid in controlling overrun. It has also been reported that a good, well-balanced stabilizer protects the sherbet against body and texture changes (5, p.1). The use of inadequate amounts of stabilizer may result in a coarse, brittle or crumbly body; however, a soggy or sticky body and poor melting qualities are usually due to an excessive use of stabilizer.

Because of the greater amount of water in sherbet as compared with ice cream, and the lower content of fat

and serum solids, stabilizers are more important in sherbet than in ice cream (20, p.488). Sherbet stabilizers are usually manufactured by combining two or more of the basic stabilizers in order to utilize the merits of each (21, p.332).

(b) Milk Solids. The usual procedure in making a sherbet is to add ice cream mix to an ice base (6, p.39 and 21, p.325). Milk solids may also be added in the form of condensed whole or partially skimmed milk, fluid whole or skim milk, or in some form of whey.

According to Combs (6, p.39), it is a common practice among many ice cream manufacturers to use ice cream mix because of its availability in all ice cream plants. He also states that the use of mix alleviates the necessity of homogenizing the sherbet mix. Illes (10, p.58) believes that it is more desirable to homogenize the whole sherbet mix together as this gives a much better mixture than adding a finished ice cream mix to the sherbet base.

Potter and Williams (16, p.44) reported that good quality sherbet can be made by using whey solids in place of the milk solids normally used. They recommend using 5 per cent whey solids, which can be obtained from plain condensed, sweetened condensed, or dehydrated whey.

The whey sherbet can be successfully frozen in a continuous freezer, but when it is frozen in a batch freezer

excessive whipping occurs. Overrun in the batch freezer can be controlled by the addition of 0.6-1.5 per cent unhomogenized fat. These workers also reported that whey sherbet possesses a smoother body and texture and is more refreshing than sherbet made with solids from milk or ice cream mix.

Work conducted by Ross (18, pp.70-71) showed that as the milk solids-not-fat were increased from 2 to 6 per cent, the flavor and acid taste become less intense but the product had a smoother texture. He also reported that a sample containing 7.2 per cent total milk solids was considered by many to be an ideal product; however, it was stated that some judges criticized this product because of its resemblance to ice cream. Tracy et al. (21, p.325) suggested using 2 to 5 per cent total milk solids depending on the type of body and texture desired.

(c) Sweeteners. The body of the finished sherbet depends largely upon the proper use of sugar and sugar solids (10, p.57). These sugars make up the bulk of the total solids in a commercial sherbet.

According to Martin (13, p.39), the desirable range of sugar content in sherbet is 30 to 33 per cent and the sugar content depends on the following conditions:

1. Sweetness desired
2. Sugar content of the fruit and fruit juices used
3. Type of body and texture desired
4. Kind of sugar used
5. Freezing, hardening and storage conditions

Because of the high sugar content and low content of other solids, the sugar in the unfrozen product is in a high degree of supersaturation. The exclusive use of sucrose would result in a product with a low freezing point. This would probably result in dipping losses at the dealer's cabinet and possibly surface crustation caused by the crystallization of the sucrose. These problems can be prevented by replacing some of the sucrose with some other sugar. Several sweeteners can be used to replace a portion of the sucrose and reduce the undesirable conditions stated.

The use of dextrose and invert sugars will result in a lowering of the freezing point of the sherbet and consequently less water will be frozen at any given temperature. This, together with the reduced amount of sucrose when the combinations of sugars are used, creates conditions less favorable for sugar crystallization but may increase dipping losses at normal ice cream cabinet temperatures (14, p.61).

van der Zant and Caulfield (17, p.199) reported that the use of 8 per cent corn syrup solids in combination with

22 per cent sucrose resulted in sherbets which were superior to comparable samples containing only sucrose or a combination of sucrose and dextrose. They stated that those samples containing corn syrup solids had more body resistance than the products containing the other sugars.

The effects on sherbets when the total sugar solids and type and amount of sucrose replacement are varied was studied by Ross (18, pp.40-41, 69). The results of his work are summarized in Table 2. As a result of his work, he made the following conclusions (18, p.75).

1. As the percentage of sugar is increased, the body and texture are improved, the flavor is more distinct, and the acid flavor becomes less sharp.
2. The amount of sugar used has a definite effect upon the drawing and dipping temperature.
3. Approximately 26 per cent total sugar produced a sherbet of proper dipping qualities and of good flavor, body, and texture.
4. Corn syrup solids do not lower the freezing point to the same extent as dextrose when used to replace approximately 27 per cent of the cane sugar.
5. A smoother texture and a more resistant body will result from the replacement of 27 per cent of the cane sugar with corn syrup solids.

Table 2
Results of Variations in Types and
Amounts of Sugar in Sherbet Mixes

Total Sugar Solids %	Components of Total 1/				Remarks
	Sucrose %	Dextrose %	Corn Syrup Solids %	Enzyme Converted Corn Syrup %	
24.98	16.5	5.06	-	-	Lacked sweetness--coarse texture
26.94	18.00	5.52	-	-	Composition desirable
28.90	19.50	5.98	-	-	Total sugar slightly too high
30.86	21.00	6.44	-	-	Total sugar content too high
32.72	22.50	6.80	-	-	Sugar content too high
34.78	24.00	7.36	-	-	Sugar content too high
31.42	19.60	-	8.40	-	A satisfactory formula
31.42	19.60	-	-	8.40	A satisfactory formula
31.42	19.60	8.40	-	-	Less total sugar should be used.
31.42	28.00	-	-	-	A more satisfactory formula could be made by replacing cane sugar with corn syrup solids or dextrose.

1/ Total of components listed do not add up to per cent total sugar solids since ice cream mix and sweetened fruit juice were used in manufacturing the mix.

(d) Overrun. It is just as important to have overrun control on sherbets as it is in ice cream. Too much incorporated air will result in a coarse textured, snowy bodied product with poor keeping qualities, whereas too low an overrun is uneconomical. Combs (6, p.39) states that sherbet should not be whipped to contain more than 40 per cent overrun. Crest Foods Company (15, p.2) believes that the range should be between 35 to 40 per cent although higher overruns are satisfactory on high solids mixes. Caulfield (15, p.4) suggested that there should be a balance between the sugar solids and the overrun.

2. Acidity

Sherbets are most commonly made from acid fruits which will vary a great deal in the acidity conferred to the sherbet by the fruit itself (12, p.350). For example, fresh cranberries have an acidity of 2.40 per cent calculated as citric (9, p.4), whereas oranges contain approximately half that amount. It is therefore a common practice to standardize this acid through the addition of other acids. The acids available for sherbets are generally citric, tartaric, lactic, and phosphoric. These acids have various strengths; however, the following solutions have the same neutralizing power.

1. 50 per cent citric acid
2. 50 per cent tartaric acid
3. 28 per cent phosphoric acid
4. 75 per cent lactic acid

Citric acid is frequently used to reinforce the acidity of sherbets and is common to many of the fruit juices used for flavoring. Because of this, it is common practice to measure and calculate the acidity of sherbet using N/10 NaOH and expressing the results in terms of citric acid (6, p.39).

Coulter and Thomas, as referred to by Caulfield (4, p.25), suggest that the titratable acidity of sherbets is not the best guide to the intensity of the acid taste because the proteins and minerals of milk solids will buffer the acid taste. Thus, sherbets which contain low milk solids will have a lower pH at any given titratable acidity than sherbets with a higher milk solids content and will taste more acid.

Dahlberg and Henning (7, p.372) believe that more consistent results can be secured by using citric acid in the crystalline form instead of the conventional 50 per cent solution.

The obtaining of the desired tartness by the addition of acid depends to some extent on the total sugar content of the product. Caulfield and Martin (4, p.25) suggest

that for every 5 per cent increase in total sugar content, approximately 0.05 per cent acid should be added.

According to Potter and Williams (16, p.46), the acid should not be added while a mix is hot. If the mix or part of the mix is heated with the acid present, the stabilizer may undergo some hydrolysis and loss in effectiveness. These workers also reported that the addition of acid to the sherbet mix before freezing will cause curdling of the milk products. The presence of this denatured casein can retard overrun.

3. Flavor

Illes (10, p.66) divides flavors for sherbets into four basic groups: (1) fruit juices, which require 15 to 20 per cent by volume for flavoring; (2) alcoholic extracts or emulsion flavors; (3) combinations of pure juices and emulsion flavors; and (4) combinations of concentrated pure flavor and pureed whole fruit.

In tests run by the Home Economics Department of Iowa State College (15, p.4) on twenty-five samples of orange sherbet, samplers considered flavor as being of primary importance. Leiendecker (11, p.63) states: "We are selling flavor when we market sherbets." Fabricius (8, p.56) believes that the flavoring material used in sherbets is comparatively more important than the flavoring of ice cream. Ross (18, p.74) reported that orange sherbet

flavored with frozen fresh juice had much less of the peel flavor and was therefore of better quality than those products flavored with fresh juice.

4. Color

Few natural fruits or purees have sufficient pigmentation to impart the desired characterizing color to sherbets. Added color must be used. Sommer (20, p.492) states that in coloring, judgment and experience are necessary. Too faint a color is objectionable but too vivid or gaudy a color is even more so.

Cost

According to many authors and manufacturers, there is a large profit in the making of sherbets; however, the available literature contains little information about the relative cost of manufacturing sherbets as compared to the production of ice cream. Illes (10, p.56) reported that the cost of production for a top quality sherbet will average about 60 per cent of the cost of manufacturing ice cream. Crest Foods Company (5, p.1) believes that a good sherbet can be produced at a cost 50 per cent under that of ice cream. Caulfield (15, p.4) states that sherbets are the most profitable item produced in a dairy plant.

QUALITY

This phase of the experimental work was devoted to an investigation of some factors affecting the quality of sherbet. With the exception of one series of mixes, all products are flavored with a cranberry base.

Experimental

The cranberry sherbet base used in these studies contained the following constituents:

Constituents	Per Cent
Cranberries	54.58
Corn Syrup Solids	6.99
Sucrose	28.32
Stabilizer	.21
42 per cent Cranberry Concentrate	4.78
Water	5.12

In all sherbet formulations, the mix was prepared in five gallon milk cans and mixed by means of a stirring rod. The mix ingredients were weighed on a platform spring scales with the exception of the stabilizer which, because of the small amount needed, was weighed on a triple beam balance calibrated in grams. With the exception of stabilizer, the ingredients were weighed to the nearest one-half ounce.

The cranberry sherbet mixes were all frozen in a Sweden fountain freezer which had a capacity of one gallon.

The sherbet mixes in this study were all prepared using the following procedure:

1. About one-half of the water used was placed into the mixing container.
2. The stabilizer was pre-mixed with approximately one-third of the sucrose and stirred into the mixture.
3. The balance of the water was added to the remainder of the sugar, including the corn syrup solids.
4. The milk solids and flavoring material were added.
5. A sample was taken for determining the acidity of the mix. The amount of acid needed to bring the titratable acidity up to the desired concentration was then computed.
6. The color was added.
7. The acid was added to the mix at the freezer.

1. Acidity

The mix acidity was adjusted for varying amounts of flavoring by the following method:

1. The acidity of the mix was determined before the addition of any supplementary acid by titrating with N/10 NaOH using phenolphthalein indicator.
2. The titratable acidity of the mix was calculated in terms of citric acid.

3. The acidity of the mix was subtracted from the desired acidity. This gave the per cent acid to be added.

4. The amount of a 50 per cent solution of citric acid needed to increase the acidity of the mix to the desired concentration was computed. This was accomplished in the following manner:

    a. The results from step three were divided by the per cent acid[1] in the acid solution used.

    b. The results obtained from (a) were multiplied by the pounds of mix.

The cranberry mix exhibited a peculiar color change when phenolphthalein was used as an indicator for the titration; however, a slight pink color occurred at the normal pH for this indicator. With this mix, the color changed from cranberry red to a greyish brown and finally to pink. In all titrations, the nine gram samples were diluted with 100 milliliters of distilled water to reduce the intensity of the cranberry color and to facilitate end point determination.

2. Evaluation of Samples

All cranberry sherbets manufactured during the

1/ Since granular citric acid crystals contain 8.6 per cent water, a 50 per cent solution contains in reality 46 per cent acid.

experimental work were judged by experienced tasters from the Department of Dairying at Oregon State College.

Sweetness

A series of six sherbet mixes was formulated as the first step in the determination of the most desirable and economical cranberry sherbet. In these six mixes, the total sugar solids content varied from 24 to 34 per cent, and in all cases 25 per cent of the sugar solids was in the form of corn syrup solids. Ice cream mix was the source of the milk solids.

The sherbet formula that is currently recommended by the manufacturer of the cranberry sherbet base being used in this work was taken as the base formula. The suggested formula contains approximately 24 per cent total sugar solids, and 2.25 per cent milk solids. This formula is as follows:

Constituents	Per Cent
Cranberry Base	21.40
Sucrose	11.03
Corn Syrup Solids	6.89
Ice Cream Mix	9.65
Stabilizer	.40
Water	50.63

This basic formula was used as the low sugar mix of the series. In all mixes of this group, 22 cc. of a 50 per cent solution of citric acid were added. This gave all products a final titratable acidity of 0.44 per cent.

To facilitate comparison of the tasters' comments on this series, it seemed advantageous to present the results in a tabular form. These results appear in Table 3.

Table 3

Effects of Different Amounts of Sugar Solids on Sherbet Quality

Total Sugar Solids Per Cent	Comments			
	Body and Texture	Acidity	Flavor	Sweetness
24	Coarse	Too high	No distinct flavor	Lacks sweetness
26	Coarse	Too acid	No distinct flavor	Lacks sweetness
28	Coarse	Slightly acid	Lacked cranberry flavor	Lacks sweetness
30	Slightly coarse	Satis-factory	Satis-factory	Satis-factory
32	Slightly coarse	Satis-factory	Satis-factory	Satis-factory
34	Sticky	Satis-factory	No distinct flavor	Too sweet

The tasters concluded that the 30 and 32 per cent sugar products were the most desirable of the series; however, there was no significant difference between the samples. None of the samples in this series were considered to have a desirable body and texture. It was believed that the coarse texture was due to the low overrun, and the low milk solids content of the sherbets.

Using the Sweden freezer, the maximum overrun obtainable was 15 per cent. It was believed that a higher percentage of milk solids would be necessary to obtain a satisfactory overrun.

From the tasters' analysis, it appeared that there was a definite correlation between the sweetness of the product and the type and amount of flavor exhibited by the cranberry base. The comments of the judges seemed to indicate that low sugar products do not enhance the flavor. This could possibly be a result of the product being too sour. The samples containing in excess of 32 per cent sugar solids were also criticized as lacking flavor.

Since all samples containing less than 30 per cent sugar solids were considered too sour, there is an indication that a relationship exists between the sugar and acid content. It appears that low sugar products must contain a lesser concentration of acid than those sherbets containing more sugar.

Milk Solids

Series "A"

1. Ice Cream Mix. Samples in series "A" were prepared to determine the effect of variations in milk solids on the finished sherbet. Ice cream mix was utilized as the sole source of milk solids in this series.

Since the 30 per cent sugar solids product of the previous series was selected as the best sample of that group, it was used as the basic mix for series "A." This group consisted of a four, five, and six per cent milk solids mix with all other constituents remaining the same as in the basic mix.

All samples of this series were drawn from the freezer after a freezing time of nine minutes. The freezing time was kept constant to determine the effect of the milk solids on overrun.

The comments of the judges of this series are shown in Table 4.

Table 4

Effects of Different Amounts of Milk Solids on Sherbet Quality

Total Milk Solids Per Cent	Comments			
	Overrun Per Cent	Acidity	Body and Texture	Flavor
4	29	Slightly acid	Slightly coarse	Distinct cranberry
5	33	Satis-factory	Satis-factory	Good--less intense than 4 per cent
6	41	Very desirable	Very desirable	Good--less intense than other samples

The majority of the tasters selected the 6 per cent milk solids sample as the preferred product; however, some of the judges selected the 5 per cent product on the basis of a more distinct cranberry flavor.

It was demonstrated by this series that as the milk solids are increased, the texture becomes smoother, the acid sensation becomes less intense, and the flavor is somewhat masked. The results of this series tended to substantiate the work conducted by Ross (18, pp.70-71). However, it was not established that increasing the milk solids was directly responsible for the decreasing intensity of the flavor and tartness since this could possibly be attributed to the higher overrun obtained with the higher milk solids mixes.

It was also noted that the products containing more milk solids tended to exhibit a better melt down.

All samples in this series were considered to be much more desirable than any of the samples from the previous series.

Series "B"

Since series "A" did not conclusively show that the masking effect on flavor and tartness was due solely to milk solids, another series of sherbet mixes was prepared to determine the effect of overrun on these properties.

This group consisted of two mixes, one containing 4 per cent milk solids, and the other 6 per cent. The basic formula used in series "A" was also used in this series.

Each mix was divided into three individual samples and frozen in three separate batches. These batches were drawn from the freezer at varying overruns.

The three 4 per cent milk solids samples were drawn at an overrun of 15, 19, and 23 per cent; the three 6 per cent samples were drawn at an overrun of 23, 31, and 36 per cent.

It was again concluded by the tasters that a 6 per cent milk solids mix produced the better sherbet.

By comparing the sherbets with 23 per cent overrun made from the 4 and 6 per cent milk solids mixes, the judges believed that there was a definite masking effect exhibited by the milk solids since the 4 per cent product had a more definite cranberry flavor. When the varying overrun products from within one mix were compared, it was also shown that the sherbets containing the lower overrun had more flavor than did the products containing a higher overrun.

It was therefore concluded that both overrun and milk solids contribute to decreasing the intensity of flavor and tartness.

Series "C"

2. Whey. This series was designed to investigate the use of whey solids in cranberry sherbet. Since the results from previous series of sherbet mixes indicated that it was desirable to use at least 4 per cent milk solids, this series contained three mixes containing 4, 5, and 6 per cent whey solids. The basic formula used in series "A" was also used in this group. Dehydrated whey was used in all samples.

Each mix of this series was divided into two parts; one-half contained the basic mix, and 1.4 per cent milk fat was added to the other half. The fat was added in the form of 40 per cent pasteurized unhomogenized cream. The mixes containing the added cream then contained approximately 5.6, 6.6, and 7.6 per cent milk solids respectively.

In the mixes which did not contain any additional fat, the overrun was uncontrollable and whipped immediately to approximately 100 per cent. The overrun was controllable in the mixes containing the added cream. Although the overrun was controllable in the mixes containing cream, they required a greater freezing time in order to freeze out the excess air and did not freeze as satisfactorily as sherbet mixes containing ice cream mix.

In judging these products, no fair comparison could be made between the sherbets containing the extra fat and those without added fat because of the excessive overrun on the latter.

All samples containing cream were judged as saleable product, and it was agreed, as Potter and Williams reported (16, p.44), that sherbets made with whey do exhibit a sharper flavor and acid sensation than sherbets made with ice cream mix. When these samples containing whey were judged with comparable samples made with ice cream mix, the latter were selected as the better product from the standpoint of over-all eating quality. The tasters criticized the sherbet made with whey for its foamy melt down.

It may be worthy of mention that out of eighteen sherbet samples in a judging program conducted by a northwest dairy products company (1, p.14), the three highest scoring samples were manufactured using some or all whey solids as the source of milk solids.

Series "D"

3. Buttermilk. Because of the relatively high concentration of phospholipids in buttermilk, it was believed that buttermilk could be used in conjunction with sherbets containing whey to assist in the control of overrun. This series was also designed to investigate the use of

buttermilk as the sole source of milk solids. Sweet cream dried buttermilk was used in all samples.

The basic mix was again the same as was used in series "A," except 5 per cent milk solids was used in all cases. To determine the effects of the different compositions, the sherbet was drawn from the freezer after a freezing time of 9 minutes.

The mixes manufactured for this series contained the following blends of whey and buttermilk.

Mix		Blend
A	-	One-half whey; one-half buttermilk
B	-	Three-fourths whey; one-fourth buttermilk
C	-	Seven-eighths whey; one-eighth buttermilk
D	-	All buttermilk

None of the sherbets in this series were considered saleable, because they all developed an oxidized flavor within two days. The intensity of this flavor was somewhat proportional to the amount of buttermilk replacement. Since the buttermilk used was of good quality, the occurence of this flavor was not readily explainable.

These results indicated that buttermilk could not be used in cranberry sherbet.

Although the samples had an unsatisfactory flavor, it was of interest to note that buttermilk did tend to suppress the overrun in mixes containing over 50 per cent buttermilk replacement. The overrun of the four samples was as follows:

Mix	Per Cent Overrun
A	36
B	85
C	90
D	34

Series "E"

This series was prepared to determine if the development of an oxidized flavor was peculiar only to cranberry sherbets made with buttermilk or if this condition was characteristic of all sherbets containing buttermilk.

Mixes in this series were identical to those in the previous series except the cranberry base was replaced by an orange concentrate.

None of the sherbets in this group developed the objectionable flavor present in the cranberry flavored samples. It was therefore believed that some constituent inherent in the cranberries, or the addition of some constituent due to the method of processing the cranberry base was responsible for the development of the oxidized flavor.

When the all-buttermilk sample of this series was judged with a comparable sample containing ice cream mix, the tasters again selected the sherbet made with ice cream mix as the better product. However, the buttermilk sample was judged as having a heavier body and a much smoother texture.

The major criticism of the sample containing buttermilk was that the orange flavor was not as distinct as in those products containing other sources of milk solids. Some tasters believed that the product was somewhat undesirable because of its very smooth texture.

Acidity

This group consisted of four mixes of different combinations of citric, lactic, and tartaric acid. It was designed to determine the effect, if any, of the different blends of acids on the acceptability of the finished product.

Because of the objective of this series, the basic mix used in previous determinations was not utilized in this group. It was believed that a low solids sherbet with a common flavor would enhance any differences exhibited by the various blends of acids. For these reasons, the basic mix used in all samples contained orange flavoring, 4 per cent milk solids, and 24 per cent sugar in the form of sucrose. All samples contained 0.36 per cent acid, calculated as citric, and were drawn from the freezer at an overrun of 35 per cent.

Since the acids used do not all have the same neutralizing power, they were made up in solutions of comparable neutralizing strengths. These solutions were as follows:

50 per cent Tartaric Acid
50 per cent Citric Acid
75 per cent Lactic Acid

The four mixes of this series contained the following acids:

Mix		Blend
A	-	All citric acid
B	-	One-half citric acid; one-half lactic acid
C	-	One-half citric acid; one-half tartaric acid
D	-	One-half citric acid; one-fourth tartaric acid, one-fourth lactic acid

Although the tasters agreed that sample "C" was the most undesirable of the group, they did not agree as to which was the most desirable.

It was noted that none of the sherbets gave the same taste sensation. Sample "A" was the mildest of the group; sample "B" had the sharpest sensation; sample "D" possessed the most delicate flavor; and sample "C," although originally giving a sharp sensation, left an unpleasant after-taste.

From the tasters' selections and comments, it appears that the acid blends used do not improve the acceptability of the product. The judges' selection of one product over another was apparently made on the basis of individual taste preferences.

By using the procedure listed on page 16 of this report, sherbet acidity can be effectively controlled. By predetermining the acid requirement, the manufacturer can

determine the amount of acid required, no matter what type of flavoring is used or what flavor of sherbet is manufactured.

If a pH meter is used to determine the acid requirement, consideration must be given to the type of milk solids used in the sherbet mix. A pH reading was taken on all mixes manufactured during the experimental work and it was noted that buttermilk, whey, and ice cream mix all exhibit a different buffering capacity, and that the pH will vary with the type of milk solids used, even though the mix has the same titratable acidity and the same concentration of milk solids. Perhaps this can best be explained by an example.

A product containing 5 per cent milk solids and a titratable acidity of 0.44 per cent gave the following pH readings with the type of milk solids listed.

Product	pH
Ice Cream Mix	3.45
Whey Solids	3.80
Buttermilk Solids	3.90

These data appear to indicate that if pH is used as the method of determining the proper acidity, the operator will have to consider the type of milk solids used in the product.

Flavor

To determine the amount of cranberries needed to impart a cranberry flavor and still enable the manufacturer to produce a cranberry sherbet at a comparable cost to other flavored sherbets, a series of mixes were prepared with varied concentrations of cranberry base.

All samples contained 30 per cent total sugar solids, 4 per cent milk solids, and 0.44 per cent acid. They were drawn from the freezer at 40 per cent overrun.

Two types of cranberry base were employed. One had no fruit particles or seeds visible, and the other contained cranberry chunks. These two products were used interchangeably throughout the experimental work.

The four mixes used in this series contained the following amounts of cranberry base:

Mix	Per Cent
A	25
B	22
C	20
D	18

According to the judges, all samples possessed cranberry flavor, although in sample "D" the flavor was not distinct. It was believed that many consumers would not be able to identify this sherbet as cranberry.

Product "A" exhibited a distinct flavor and was preferred by those judges who had a definite liking for cranberries.

Those judges that did not particularly relish this fruit believed that the flavor was too intense but all judges believed that this sample possessed a better color and had more eye appeal than did any of the other products. This observation was understandable since product "A" contained a more natural color, due to the higher concentration of fruit, than did any of the other samples.

It was difficult to determine any difference in flavor intensity between samples "B" and "C;" therefore, the judges had no preference as to the desirability of these two samples. It was believed that both products had sufficient cranberry flavor to satisfy the majority of the consumers.

All tasters agreed that the sherbets containing cranberry chunks had more eye appeal than did those sherbets which had no cranberries visible. In some instances, tasters would select a sample containing visible cranberries as having a better flavor than an identical sherbet with no cranberries visible.

On the basis of this work, it appears that the most acceptable cranberry sherbet should contain 20 to 22 per cent cranberry base. This base should contain visible cranberry chunks.

Color

In preliminary work with cranberry sherbet, Strawberry Red was used as the source of added color. This proved to

be an unsatisfactory source of coloring as high concentrations of the dye would impart a purple color and smaller amounts would not be sufficient to impart a characteristic color.

Through personal correspondence with a commercial supplier of food colors, it was suggested that a combination of Ponceau 3-R, Sunset Yellow, and Fruit Red color be used. It was believed that a blend of these dyes would approach a typical cranberry color.

Since Ponceau 3-R and Sunset Yellow are normally not sold in solutions, or customarily used, it was necessary that the powdered dyes be made into solutions when received.

A gallon of each of the color solution was made up as follows:

1. Four ounces of the powdered dye was added to approximately one-third of the total water.
2. One ounce of 50 per cent citric acid solution was added to the mixture.
3. To the dye, acid solution was added one-half ounce of benzoate solution. (Two pounds of sodium benzoate to a gallon of solution.)
4. Water was added to make up to one gallon.

To determine what combinations of these dyes to use, it was necessary to utilize a trial and error method of determining the best possible mixture. These different

blends were used on all cranberry sherbets manufactured during the experimental work.

It was found to be extremely difficult to duplicate the dark red color of cranberries; however, it is believed that the following mixture will most nearly approach the desired color.

Two parts Ponceau 3-R
Two parts Sunset Yellow
One part Fruit Red

The amount of this blend to use will depend upon the amount of cranberry base incorporated in the mix, the per cent overrun obtained, and the intensity of the color desired. By adding a large volume of this coloring mixture a dark red color could be obtained. This large amount did not appear feasible from the standpoint of economy and from its undesirable effects on the consumer.

It was found that 0.2 per cent of the blend would impart a satisfactory color for a sherbet containing 20 to 22 per cent cranberry base, and 40 to 50 per cent overrun.

CONSUMERS' PREFERENCE

This phase of the experimental work was designed to test the reactions of consumers to some formulations of sherbets. According to Bliss *et al.* (2, p.5) most tests of palatability have been made by trained observers, and it is questionable as to how well professional judges' results will compare with preferences shown by untrained tasters. Yet, these untrained tasters represent the users of sherbet.

Experimental

The taste panels were comprised of Oregon State College students who were not screened as to tasting acuity.

Orange concentrate was used as the flavoring material for all samples, and all mixes were frozen on a Creamery Package batch freezer.

To determine consumers' preferences on some properties of sherbet, two taste panels were conducted.

For testing, the samples were served in small paper cups on a metal serving tray to the tasters. These tasters were seated separately at two tables and were not allowed to discuss the products.

Each taster received three sample cups which were coded with three-digit, random numbers. The tasters were then asked to rank the samples on a printed ballot in order of their preference as to texture, flavor, and over-all eating quality. This ballot is shown in Plate 1.

Plate 1

Taste Panel Ballot

Date:_____ Product: Orange Sherbet Name_____

DIRECTIONS: Please indicate the order of your preference for these samples - from the best to the least preferred. The number of the sample you like best should be placed first, 2nd best second, etc.

DO NOT RANK ANY OF THE SAMPLES THE SAME

	OVER-ALL EATING QUALITY	FLAVOR	TEXTURE
FIRST			
SECOND			
THIRD			

The results of the tasters' ratings were analyzed for variance using the method prescribed by Snedecor (1, pp.253-261).

The sherbet mixes were prepared in the manner indicated on pages 16 and 17 of this report.

Taste Panel "A"

All constituents of the three mixes used in this taste panel were constant except for the amount of sugar solids and the acid content.

The three mixes contained 24, 26, and 32 per cent sugar solids. In all cases 25 per cent of the sucrose was replaced with corn syrup solids. To determine as accurate results as possible on the three factors tested, the amount of acid used was varied in a direct proportion to the sugar. This was done to reduce the sweetening or lack of sweetening effect exhibited by the different amounts of sugar. The acidity of the three samples was 0.44, 0.46, and 0.50 per cent respectively. These acidities were selected on the basis of previous trials with the formulations used.

All the mixes were drawn from the freezer at 40 per cent overrun.

The panel of 112 tasters ranked each sample for texture, flavor, and over-all eating quality. The rank for each product tested is shown in Tables 5, 6, and 7. These tables show, in addition to the frequency distribution, the least significant differences for the means. The least significant difference is computed for a 5 per cent confidence interval. This gives the difference that is

required between any two means or average rank before it can be considered significant.

1. Texture. As shown in Table 5, the panel conclusively preferred the high sugar product. Since this sample possessed the smoothest texture of the three products, the results indicate that the majority of the consumers prefer a smooth textured sherbet.

2. Flavor. For flavor, the rated difference between samples was also highly significant. Table 6 shows that the tasters definitely preferred the high sugar product. In other work conducted for this report, experienced tasters believed that a high sugar content decreased the flavor intensity; there was no indication of this from the taste panel results. However, this could possibly be explained by the assumption that the variance in the sugar content used does not affect the flavor intensity enough to be detected by the average consumer.

It is believed that the high sugar sample was not selected purely on the basis of having a better orange flavor. It seems logical that the tasters selected this sample partially because of its greater sweetness.

3. Over-All Eating Quality. As would be expected and is exhibited in Table 7, the tasters selected the sherbet containing the most sugar as the most acceptable

Table 5
Frequency Distribution
Texture Rating by 112 Tasters

Total Sugar Solids Per Cent	Rank 1	2	3	Average Rank
26	15	37	60	2.40
28	21	53	38	2.15
32	76	22	14	1.45

Least Significant Difference - 0.23

Table 6
Frequency Distribution
Flavor Rating by 112 Tasters

Total Sugar Solids Per Cent	Rank 1	2	3	Average Rank
26	13	41	58	2.40
28	36	35	41	2.04
32	63	36	13	1.55

Least Significant Difference - 0.24

Table 7
Frequency Distribution
Over-All Eating Quality Rating by 111 Tasters

Total Sugar Solids Per Cent	Rank 1	2	3	Average Rank
26	13	24	74	2.39
28	24	47	40	2.14
32	74	22	15	1.47

Least Significant Difference - 0.23

product. From these results, it appears that consumers, as represented by the panel, prefer a smooth textured, relatively sweet sherbet.

Taste Panel "B"

All ingredients of the samples tested in panel "B" were constant except for the amount of milk solids. In this series of three mixes, the milk solids present were 4, 5, and 6 per cent.

Since the 32 per cent sugar solids product of panel "A" was selected as the best sherbet of that series, it was used as the 4 per cent milk solids sample of this series.

Although the 4 per cent product contained 40 per cent overrun, the 5 and 6 per cent samples were drawn from the freezer at 55 per cent overrun.

All samples in this series contained 0.50 per cent acid and 32 per cent sugar solids.

The 134 tasters judged the samples in this series on the same basis as the samples in panel "A" and the results are presented in the same manner. These data appear in Tables 8, 9, and 10.

Table 8
Frequency Distribution
Texture Rating by 134 Tasters

Total Milk Solids Per Cent	Rank 1	2	3	Average Rank
4	43	26	65	2.16
5	57	42	35	1.84
6	34	66	34	2.00

Least Significant Difference - 0.24

Table 9
Frequency Distribution
Flavor Rating by 134 Tasters

Total Milk Solids Per Cent	Rank 1	2	3	Average Rank
4	50	34	49	2.00
5	47	50	36	1.92
6	36	49	48	2.09

No Significant Difference

Table 10
Frequency Distribution
Over-All Eating Quality Rating by 134 Tasters

Total Milk Solids Per Cent	Rank 1	2	3	Average Rank
4	49	37	48	1.99
5	49	40	45	1.94
6	36	57	41	2.03

No Significant Difference

1. Texture. As Table 8 shows, there is a significant difference between the 4 and 5 per cent milk solids samples, although the difference between the other samples is not significant.

Although the difference between the 6 and 5 per cent milk solids samples was not significant, the tasters did indicate a slight preference for the latter. This was not expected and cannot be readily explained; however, this could possibly be explained if it was assumed that the 6 per cent milk solids product was approaching or had exceeded the point of a desirable texture and was too smooth.

2. Flavor. In the test for flavor, as is shown in Table 9, there was no significant difference between any of the three samples.

This reaction from the panel is somewhat contrary to findings of trained tasters and to results obtained from work for other sections of this report. It is believed that there is a certain amount of masking of flavor by milk solids, although this was not indicated by the taste panel.

These differences of reactions could be explained by assuming that the difference in flavor intensity, as affected by milk solids and overrun, is normally not great enough to be detected by the majority of the consumers.

Another possible explanation could be that some consumers like a sharp, intense flavor while others prefer a more bland product.

3. Over-All Eating Quality. As is shown in Table 10, there was no significant difference between the samples when they were judged for their over-all eating qualities.

These results appear to indicate that when using a high solids mix, as was done in this experiment, sherbets can be whipped to at least 55 per cent overrun with no apparent effect on consumer acceptance. These results also showed that the tasters preferred a relatively smooth textured product.

The concept that consumers do not prefer a 4 per cent milk solids, 40 per cent overrun sherbet over one containing 5 per cent milk solids and 55 per cent overrun is significant from the standpoint of cost of production. The higher overrun and milk solids product used in this experiment can be manufactured at a cost less than the product containing the lower overrun and lower milk solids.

COST

In the manufacture of sherbet, the cost of ingredients per unit of finished product will vary primarily with the mix formulation and the amount of overrun obtained.

This section of the report is presented to show the differences in cost of ingredients for sherbets of varying compositions. In addition, a comparison will be made of ingredient cost per unit of finished product between ice cream and sherbet. No attempt will be made to analyze or compare the cost of processing or merchandising.

The costs presented are not to be construed as being indicative of what the majority of the manufacturers' cost are or should be, but are presented to show the relative cost of ingredients for the different products. The costs stated are computed on the basis of prices quoted to Oregon State College in March 1956.

Formula "A": 30 per cent total sugar solids, 5 per cent milk solids.

Ingredients (pounds)	Cost Per Pound (dollars)	Total Cost (dollars)
21.74 - Ice Cream Mix (12%)	0.1500	3.2610
18.75 - Sucrose	0.0928	1.7400
6.25 - Corn Syrup Solids	0.0964	0.6025
0.50 - Stabilizer	0.7200	0.3600
2.00 - Orange Concentrate	0.8130	1.6260
50.67 - Water	-	-
100.0		

Formula "A" (Continued)

168 cc. 50 per cent Solution Citric Acid	0.4000	0.1500
164 cc. Orange Coloring	0.0350 per ounce	0.2050
Total cost of ingredients		7.9445

Formula "B": 26 per cent total sugar solids, 5 per cent milk solids.

Ingredients (pounds)	Cost Per Pound (dollars)	Total Cost (dollars)
21.74 - Ice Cream Mix (12%)	0.1500	3.2610
17.05 - Sucrose	0.0928	1.5822
5.69 - Corn Syrup Solids	0.0964	0.5485
0.50 - Stabilizer	0.7200	0.3600
2.00 - Orange Concentrate	0.8130	1.6260
56.72 - Water	-	-
100.00		
140 cc. 50 per cent Solution Citric Acid	0.4000	0.1250
164 cc. Orange Coloring	0.0350 per ounce	0.2050
Total cost of ingredients		7.7077

Formula "C": 30 per cent total sugar solids, 4 per cent milk solids.

Ingredients (pounds)	Cost Per Pound (dollars)	Total Cost (dollars)
17.39 - Ice Cream Mix (12%)	0.1500	2.6085
20.54 - Sucrose	0.0928	1.9061
6.85 - Corn Syrup Solids	0.0964	0.6603
0.50 - Stabilizer	0.7200	0.3600
2.00 - Orange Concentrate	0.8130	1.6260
52.72 - Water	-	-
100.00		

Formula "C" (Continued)

168 cc. 50 per cent Solution Citric Acid	0.4000	0.1500
164 cc. Orange Coloring	0.0350 per ounce	0.2050
Total cost of ingredients		7.5159

Formula "D": 30 per cent total sugar solids, 5 per cent whey solids, 6.14 per cent total milk solids.

Ingredients (pounds)	Cost Per Pound (dollars)	Total Cost (dollars)
5.26 - Dehydrated whey	0.1500	0.7890
22.50 - Sucrose	0.0928	2.0880
7.50 - Corn Syrup Solids	0.0964	0.7230
0.50 - Stabilizer	0.7200	0.3600
2.50 - 40 Per Cent Cream	0.7900 per lb.fat	0.7900
2.00 - Orange Concentrate	0.8130	1.6260
59.74 - Water	-	-
100.00		
168 cc. 50 per cent Solution Citric Acid	0.4000	0.1500
164 cc. Orange Coloring	0.0350 per ounce	0.2050
Total cost of ingredients		6.7310

Formula "E": 12 per cent Ice Cream Mix.

Ingredients (pounds)	Cost Per Pound (dollars)	Total Cost (dollars)
40.00 - 30 Per Cent Cream	0.7900 per lb. fat	9.4800
39.52 - Skim Milk	0.0120	0.4740
15.00 - Sucrose	0.9280	1.3920
5.08 - Dried Milk	0.1800	0.9140
0.40 - Stabilizer	0.6800	0.2720
100.00		
42 cc. Vanilla	17.0000 per gallon	0.1992
6 cc. Color	4.5000 per gallon	0.0007
Total cost of ingredients		12.7319

Table 11

Comparative Cost of Ice Cream and Different Formulations of Sherbets (In Dollars)

Formula	Cost per 100 Pounds of Mix	Cost per Gallon of Mix	Ingredient Cost per Gallon of Finished Product				
			Overrun 1/				
			30%	40%	50%	60%	90%
A	7.944	0.715	0.55	0.51	0.48	0.45	-
B	7.708	0.694	0.53	0.50	0.46	0.43	-
C	7.516	0.676	0.52	0.48	0.45	0.42	-
D	6.731	0.606	0.47	0.43	0.40	0.38	-
E	12.732	1.146	-	-	-	-	0.60

1/ Cost for the different overruns are rounded to the nearest one cent.

As shown in Table 11, there is a significant cost differential between samples and between different overruns within a sample.

It is believed that sherbet manufactured from any of the formulas shown would be acceptable to most consumers. However, a sherbet made from formula "B" would probably be less acceptable than a sherbet made by the other formulas which utilize ice cream mix.

On the basis of the taste panel results discussed earlier in this report and from other work conducted for the report, the sherbets made from formulas "A" and "C" would be preferred over sherbet manufactured from formula "B." A sherbet made from either formula "A" or "C" could be whipped to a greater overrun than could a sherbet made from formula "B" and still be considered a higher quality product.

Assuming that a sherbet manufactured from formula "A," the highest cost formula of the group, is whipped to a 10 per cent greater overrun than a sherbet manufactured from formula "B;" then a sherbet from formula "A" could be produced at a cost savings of approximately two cents per gallon under a sherbet formed from formula "B." This observation tends to indicate that it is more economical to use a relatively high sugar solids content in the manufacture of sherbets.

Formula "D" is the least expensive formulation presented. Since limited work was done with sherbets containing whey, it is not known how a sherbet manufactured from this formula would compare with the others if judged by a taste panel. For this reason, no evaluation can be made of this product from the standpoint of cost of quality and value of quality.

A comparison of ingredient cost between ice cream and sherbet as manufactured from the formulas listed shows that the ingredients for sherbets are less expensive than the ingredients for ice cream. This cost difference will depend upon the formulation used and the overrun obtained. The ingredient cost of a sherbet made from formula "A" and drawn from the freezer at an overrun of 50 per cent would be 80 per cent of the ingredient cost of ice cream manufactured from formula "E" and whipped to an overrun of 90 per cent. Even with the formula containing the least expensive ingredients (formula "D") and containing an overrun of 50 per cent, the cost of ingredients is 67 per cent of the cost of ingredients in the ice cream formula shown.

Crest Foods Company and Illes (10, p.66) state that high quality sherbets can be manufactured for 50 to 60 per cent of the cost of manufacturing ice cream. These cost figures were not substantiated by the findings of this report.

SUMMARY AND CONCLUSIONS

A study of the factors affecting sherbet quality revealed the following information:

1. As the percentage of sugar solids is increased the texture becomes smoother and the flavor and acid sensation become less intense.
2. When 25 per cent of the sucrose is replaced with corn syrup solid and the milk solids content is 4 per cent or greater, a total sugar solids content of 30 to 32 per cent produces a sherbet with a good flavor, body and texture.
3. Both milk solids and overrun contribute to the masking of the intensity of flavor and tartness.
4. A milk solids content of at least 4 per cent is desirable.
5. Buttermilk did not prove to be satisfactory as a source of milk solids although when used in conjunction with whey it did assist in overrun control.
6. A high quality cranberry sherbet can be manufactured by using the following percentage constituents:

Constituent	Per Cent
Cranberry Base	21
Total Sugar Solids	30
Milk Solids	5
Total Titratable Acidity	0.45
Color	0.2

Whip to an overrun of 45 per cent.

A study of consumers' preferences, as indicated by taste panels, showed the following:

1. Consumers prefer a smooth textured, relatively sweet sherbet.
2. A high solids sherbet can be whipped to an overrun of 50 to 60 per cent without decreasing consumer acceptance.

A comparitive analysis of ingredient cost for some sherbet formulations, and a comparison between ingredient cost for sherbet and ice cream revealed the following information:

1. The cost of ingredients for a high quality sherbet is less than that for ice cream.
2. A high quality sherbet can be produced at an ingredient cost of approximately 75 per cent of the ingredient cost for ice cream.
3. Because higher overruns may be obtained without sacrificing quality, high sugar solids sherbets can be produced at less cost than low sugar solids products.

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