METHODS OF ANALYSES

for

TOMATO PRODUCTS

Solids Content Determinations

FOR USE OF USDA PROCESSED FOODS INSPECTORS

UNITED STATES DEPARTMENT OF AGRICULTURE
CONSUMER AND MARKETING SERVICE
FRUIT AND VEGETABLE DIVISION
PROCESSED PRODUCTS STANDARDIZATION AND INSPECTION BRANCH

PREFACE

These instructions are designed primarily for Processed Fruit and Vegetable Inspectors of the U. S. Department of Agriculture. They are not intended to be a comprehensive treatise on the subject but give background information and guide-lines to assist in the uniform application and interpretation of USDA grade standards and other similar specifications.

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SOLIDS CONTENT DETERMINATIONS

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September 1970

Supersedure: All portions of instructions "Solids Content Determinations" dated January 1967 and previous to February 1970, are superseded and may be discarded. Content of the revised instruction -- February 1970 -- is as follows:

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SOLIDS CONTENT DETERMINATIONS

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NATURAL TOMATO SOLUBLE SOLIDS

Introduction

In the application of the United States Standards and Federal Specifications for comminuted tomato products it is necessary to determine the solids content of the samples to properly certify the product. In products such as tomato paste and tomato puree, sales and purchases are made on the basis of the tomato solids present or some equivalent measure of concentration. Furthermore, the Food and Drug standards of identity for tomato puree and tomato paste require a minimum natural tomato soluble solids. In view of the economics and regulatory aspects of the situation, it is of utmost importance that the degree of concentration or solids content be properly determined and accurately reported.

The FDA standards of identity were revised in January 1970 to change the method of expressing concentration in tomato paste and puree from -

"salt-free tomato solids"
to
"natural tomato soluble solids"

In addition the methodology was changed from the former vacuum oven method (correlated by NCA to refractometer) to the refractometric method using the International Sucrose Scale (20° C) as the referenced conversion table. In effect the newly revised procedure results in a slightly lower value since only soluble solids are measured (insoluble tomato solids are disregarded). Naturally occurring salt is now considered a part of soluble solids; however, such salts are not naturally present in sufficient amounts to compensate for the difference incurred in disregarding insoluble tomato material - hence the reason for slightly lower values.

The revised FDA standards of identity have brought about necessary changes in determining limits of concentration for the following USDA standards in the manner specified.

PRODUCT	MINIMUM	MAXIMUM
Tomato Puree	8%	< 24%
Tomato Paste	24%	--
Concentrated Tomato Juice	20%	<24%

The degree of concentration may be expressed in several ways depending upon the requirements of the specification or, in some instances, upon the wishes of the applicant.

Tomato paste and tomato puree are expressed in terms of natural tomato soluble solids when applying USDA and Food and Drug Standards or Federal and other Specifications, whereas industry frequently purchases tomato puree on the basis of specific gravity. Tomato catsup is expressed in terms of total solids and tomato sauce and chili sauce on the basis of refractive indices.

Brix of the filtrate is often used in international trade.

Regardless of the method of expressing results, certain fundamentals must be observed to attain accuracy and achieve uniformity.

REFRACTOMETRIC METHOD

When to Use the Refractometric Method

Use the refractometric method for determining solids content for all tomato products when applying the United States standards or Federal or other specification unless:

1) another method is specified in the specification;

2) another recognized method is requested by the applicant.

Accuracy of the Refractometric Method.

The accuracy of refractometric readings depends, in part, upon the technique used. It is imperative that a clear, sharp line be obtained. This generally necessitates filtering the samples to remove insoluble materials. Nevertheless, readings may be taken on unfiltered samples of tomato products (usually juice) by placing a direct smear on the refractometer prism, providing a sharp line can be obtained and providing the sample is not borderline in solids or of a controversial nature.

Temperature Corrections of Sucrose Value

It is often necessary to convert a Refractive Index, taken or quoted at one temperature, to another equivalent. The accompanying table of conversion to the sucrose scale is standardized at a temperature of 20° C. Therefore, if the refractometer is read at a temperature other than 20° C a correction must be applied in accordance with Table II of this instruction -

-- a plus correction for temperatures above 20° C.

-- a minus correction for temperatures below 20° C.

Before making the necessary temperature corrections the refractive index is converted to the corresponding sucrose value in accordance with the following three steps -

1) Record the Refractive Index and temperature.

2) Convert the RI from Step 1) to sucrose value by referring to Table I.

3) Correct the sucrose value in Step 2) for temperature according to Table II.

These steps are illustrated by the following examples:

Example 1 (RI at 25° = 1.3480)

1) RI at 25° = 1.3480
2) Sucrose Value (Table I) = 10.1%
3) Adjusted sucrose value (20°) =
   10.1 + 0.36 or 10.46% - Round up to 10.5%

Example 2 (RI at 17° C = 1.3612)

1) RI at 17° C = 1.3612
2) Sucrose value (Table I) = 18.4%
3) Adjusted sucrose value (20°) =
   18.4 - 0.2 or 18.2%

GENERAL METHODOLOGY

GENERAL

In determining "natural tomato soluble solids" there are a number of things to keep in mind. They are listed numerically for ease of reference and must be followed exactly as specified in this instruction.

A general outline of the step by step procedure is as follows:

1) Always use 100 grams of well mixed product as the test sample.

2) Alternative 1 - (Direct filtration)

   Obtain the refractive index of the clear serum from the test sample in Step 1.

3) Convert the RI (from Step 2) to sucrose value in accordance with Table II.

4) Correct the sucrose value (from Step 3) to 20° C, if read at temperatures other than 20°, in accordance with Table II. Do not correct the Refractive Index for temperature before converting to percent sucrose -- correct the sucrose value. If the refractometer has a "sugar scale" on it, read the scale directly as the "sucrose value" and then correct for temperature per Table II.

5) Deduct any added salt and the result is "natural tomato soluble solids".

6) If unable to readily obtain a clear serum under Step 2) take one of the following alternatives:

   Alternative 2 (Direct Filtration With Enzyme)

   Add 1 gram of dry enzyme to the 100 gram sample. Mix well and filter.

   Alternative 3 (1 to 1 Dilution With Enzyme Solution)

   Mix 100 gram of test sample with 100 grams of 1% pectic enzyme solution. Mix well and filter.

Alternative 4 (1 to 1 Dilution - No Enzyme)

Mix 100 gram of water with the 100 gram test sample. Mix well and filter.

7) Obtain the RI of the clear serum resulting from Step 6.

8) Refer to Table I and convert the RI to sucrose value. Apply temperature correction, if any.

9) If Alternative 2 is used, apply a minus correction for the 1% enzyme solution and deduct any added salt. The result is then "natural tomato soluble solids".

10) If Alternative 3 is used, apply a minus correction for the 1% enzyme solution and a plus correction for the effect of insoluble solids in the product. Deduct any added salt and the result is "natural tomato soluble solids".

11) If Alternative 4 is followed, apply a plus correction for the effect of insoluble solids in the product, deduct any added salt and the result is "natural tomato soluble solids".

The foregoing 11 steps prescribe the general outline of the method. Detailed procedures in applying these principles are given in the following section of this instruction. The inspector will soon know which of the general procedures will best fit the type of tomato concentrates in his area. Normally it will always be necessary to use the 1 to 1 dilution method on the higher concentrations - e.g. over 32% solids. Likewise, it is advantageous to use a pectic enzyme to digest the natural pectins in the product so it is recommended that Alternative 3 be used in preference to Alternative 4.

DETAILED METHODOLOGY

Equipment

Abbe Refractometer, such as B&L, Zeiss Opton or Zeiss Sugar and Oil.

Glass Funnels 75 mm diameter with stems cut off 1 inch or shorter at a 90° angle, fire polished (stemless funnels may be used). Fluted funnels must be used with nylon bolting cloth.

Erlenmeyer Flasks 200 ml or 250 ml (wide mouth preferred).

Filter Media, Fast Filtering Whatman No. 2V, 12.5 cm or the equivalent folded paper. Nylon bolting cloth can used -- No. HC-3-132 Nitex monofilament nylon - known supplier:

* H. R. Williams Mill Supply Co., 208 West 19th Street, Kansas City, Missouri 64108, Phone: (816) 474-1511. (40 inch width, 6 inch length makes approximately 10 to 12 filters; 56 inch width is also available.)

Balance capable of weighing to an accuracy of ± 0.1 gram. Capacity 500 grams or more.

Half pint Mason jars for blending apparatus.

Osterizer (or the equivalent) capable of blending samples in one-half pint Mason jars. Blender should have a slow speed or be used in conjunction with a powerstat. The lid and blending attachment must be sealed properly to prevent loss of liquid during mixing operation.

Glass or Plastic Petri Dishes to cover funnels and prevent evaporation.

Kleenex or similar tissue for cleaning refractometer.

Reagents

Distilled Water

* Pectic enzyme: Klerzyme Analytical or pectinol 10-R, or the equivalent (enzyme must be in a diatomaceous earth base).

Revised - June 1975

Pectic Enzyme Suppliers:

1) Klerzyme 200 (Analytical); (Wallenstein Co., Kingstree, South Carolina 29556)

2) Pectinol 10-R (Rohm & Haas Co., Independence Mall, West, Philadelphia, Pennsylvania 19105)

Pectic Enzyme Solution

Prepare a 1 percent solution of pectic enzyme by dissolving in water 1 gram of dry pectic enzyme for each 100 grams of solution. Obtain the Refractive Index of this solution, convert it to the appropriate sucrose value at 20° C. Use this value in subsequent calculations of the "Enzyme Correction Factor" in accordance with the following:

1) Dry Enzyme Added to Test Sample (No dilution)

Subtract 1.15 AC from the sucrose value of the tomato product where A = 1 (1% solution) and C = sucrose value of a 1% solution of pectic enzyme.

2) 1 to 1 Dilution with 1% Pectic Enzyme

Subtract 0.55 BC from the sucrose value of the tomato product, in which B = amount of enzyme added to pectic solution (1 gram) and C equals sucrose value of a 1% solution of pectic enzyme.

SUCROSE VALUES OF 1% ENZYME SOLUTIONS @ 20° C

Refractive Index	Sucrose Index	Refractive Index	Sucrose Index
1.3330	0.00	1.3338	0.56
1.3331	0.08	1.3339	0.63
1.3332	0.15	1.3340	0.70
1.3333	0.21	1.3341	0.77
1.3334	0.28	1.3342	0.84
1.3335	0.35	1.3343	0.91
1.3336	0.42	1.3344	0.98
1.3337	0.49		

Revised - June 1975

Alternative 1 - Direct Filtration - No Enzyme

1) If the product is easily filtered -- when an abundance of filtrate appears immediately after placing on a filter paper -- make a smear of the filtrate directly on the prism of the Refractometer, working rapidly to prevent evaporation.

2) Convert to RI to Sucrose Value, Table I.

3) Make correction for temperature if other than 20° C (Table II).

4) Deduct for any added salt, as hereinafter outlined under "Correction For Salt".

5) Report as Natural Tomato Soluble Solids

Alternative 2 - Direct Filtration With Dry Enzyme

1) The tomato product does not filter readily so thoroughly mix 1 gram of dry pectic enzyme with 100 grams of tomato concentrate.

2) Place sufficent tap water (room temperature) in the Erlenmeyer flask so that when funnels are placed in the neck of the flask, the water layer will be about 1/2 inch from the stem of the funnel. (To prevent evaporation).

3) Place the bolting cloth or filter paper in the funnel.

4) Fill the bolting cloth or filter paper with sample and cover the funnel with an inverted Petri dish (bottom or top portion). The dish should come in direct contact with the funnel and not rest on the filter paper or bolting cloth.

5) Allow to filter until filtrate becomes reasonably clear. (No more than a slight turbidity should be apparent). Normally this should not require more than 10 to 15 minutes.

6) Quickly remove funnel from Erlenmeyer flask, allow a large drop of filtrate to drop onto refractometer prism, immediately close prism, read and record.

7) Return funnel and sample to flask and allow filtration to continue for 2 minutes or longer.

8) Repeat process and compare with first value. If readings vary by no more than 0.0001, regard as the correct refractive index (R.I.). If second reading varies by more than 0.0001, repeat again after 2 minutes or longer additional filtration.

9) Continue until consecutive readings do not vary by more than 0.0001, and no trend is shown to indicate continuously increasing or decreasing readings. If readings show a continuous drift, one of the following conditions may be responsible:

   a) Prisms not properly cleaned and dried.

   b) Improperly prepared filters.

   c) Filtering process too slow; use another Alternative or a NITEX filter. A reasonable rate is about 5 ml. in 30 minutes.

10) Convert the RI to Sucrose Value, Table I.

11) Make temperature correction if other than 20° C (Table II).

12) Apply a minus correction for the 1 gram of pectic enzyme, by subtracting 1.15 from the sucrose value, in which C = the sucrose value of a 1% pectic enzyme solution and A = 1.

13) Deduct for any added salt as outlined under "Correction For Salt".

14) Report as Natural Tomato Soluble Solids.

Alternative 3 - 1 to 1 Dilution With 1% Enzyme Solution

1) Place sufficient tap water in each of the wide mouth Erlenmeyer flasks so that when the funnels are placed on the necks of the flasks the water layer will be about one-half inch from the stems of the funnel. Place a filter paper (12.5 cm folded paper) or bolting cloth in the funnel and place a Petri dish (bottom or top portion) over the funnel with the rim of the Petri dish extended downward. The Petri dish should come in direct contact with the top of the funnel and not rest on the paper. The filters should be assembled before use and allowed to stand long enough to saturate the air at the base of the funnel, but care should be taken that moisture does not condense on the stem of the funnel. Water and glassware must be at room temperature.

2) Tare a one-half pint Mason jar and weigh into it 100 grams of enzyme solution. Add to this 100 grams of a well-mixed sample of tomato concentrate. The last portion of concentrate should be placed against the side of the jar above the water level so that the weight can be accurately adjusted by adding to or removing concentrate before it contacts the water.

3) Screw the blending assembly onto the flask and shake vigorously for a few seconds to loosen the paste from the sides of the jar. Place jar on blender and mix at low speed for about 15 seconds. Remove and shake vigorously for a few more seconds. Blend for 15 seconds more at low speed, then inspect jar carefully to see if any lumps of product are still sticking to the sides. Shake again, being sure that all lumps of paste are loosened, and blend again at high speed for 15 seconds. Be sure that product is circulating at all times during blending. (A "powerstat" is very useful for adjusting the speed of blending; a setting of from 50 to 60 is equivalent to "slow" speed.)

4) Remove Petri dish from funnel and quickly pour blended mixture onto paper. Replace Petri dish and push down until it contacts rim of funnel.

5) Allow to filter until filtrate becomes reasonably clear (no more than a slight turbidity should be apparent). This should not require more than 10 to 15 minutes.

6) Remove funnel from Erlenmeyer flask and allow a <u>large</u> drop of filtrate to drop onto refractometer prism.

7) Record the refractive index of the serum.

8) Repeat Steps 7, 8 and 9 under Alternative 2.

9) Convert the RI to Sucrose Value (Table I).

10) Apply temperature correction if other than 20° C (Table II) and record as <u>indicated sucrose value</u>.

11) Apply <u>minus</u> correction for the 1% pectic enzyme solution by subtracting 0.55 BC from the indicated sucrose value (Step 10), in which B = 1 and C = the sucrose value of a 1% enzyme solution. This correction factor is referred to as the "Enzyme Correction Factor".

12) Multiply the corrected Sucrose Value (Step 11) by 2 to relate such value back to the original product.

13) Apply a plus correction for the effect of insoluble solids (applicable to all 1 to 1 dilutions). This plus correction factor is ascertained by referring to the following Table:

Degree of Concentration	Correction Factor For Insoluble Solids
25.0%	0.3%
30.0	0.4
35.0	0.5
40.0	0.7
45.0	0.8
50.0	0.9

Do not go to the next higher correction if the calculated result falls anywhere between the ranges. For example, if a sample was found to have a concentration of 38.8%, add the Dilution Correction Factor of 0.5%; not 0.7%.

14) Deduct any added salt from the value obtained in Step 13.

15) Report this final sucrose value (after applying corrections for enzyme, insoluble solids and added salt) as natural tomato soluble solids.

Alternative 4 - 1 to 1 Dilution, No Enzyme Solution

Follow all the steps exactly as outlined in Alternative 3 but do not make a minus correction for enzyme solution since none is used. However, make a plus correction for insoluble tomato solids and deduct for any added salt.

CENTRIFUGE PROCEDURE FOR OBTAINING SERUMS

Background

The ultra centrifuge procedure is an effective and rapid method of obtaining sera from concentrated comminuted or homogeneous products.

The method involves high speed (over 100,000 r.p.m.) centrifugation whereby heavier insoluble tomato particles are spun to the perimeter of a rotor, leaving a well of soluble tomato serum. The degree of concentration of this serum is determined by refractometer and by conversion to the appropriate sucrose value.

When to Use

The centrifuge method may be used whenever a refractive index is needed in order to determine the degree of concentration of a product.

Equipment

Adams Ultra - Centrifuge with special solid rotor containing "O" ring.

[When ordering, specify: "Adams Ultra Centrifuge complete with tomato rotor, Catalog No. -- Like 0610."]

Metal or Plastic spatula

Plastic cocktail straws -- or -- Medicine dropper (Van Waters and Rogers Catalog No. 52950-046 or equivalent).

Nylon syringe 5 cc capacity (VW&R No. 60350-066 or equivalent).

Abbe refractometer (such as Bausch and Lomb, Zeiss Opton, Zeiss Sugar and Oil -- or equivalent).

Distilled water and Cleaning tissue -- for cleaning refractometer.

Procedure

1) Cool (or warm, if necessary) tomato paste to or near room temperature before testing. Mix the sample thoroughly.

2) Unscrew rotor ring and remove plastic cap. Be sure rotor is clean and dry and "O" ring is in position.

3) Fill rotor with paste using spatula or syringe to a level near the top of the rotor, but avoid overfilling.

   A 5 cc capacity nylon syringe is recommended for filling the rotor.

   For highly concentrated products, fill the rotor to complete capacity.

   Remove any excess paste from the "O" ring and top edge of rotor.

   Threads on ring and rotor must be thoroughly clean.

4) Position plastic cap on rotor so that it makes complete direct contact with the "O" ring.

   The raised portion of the plastic cap must be on top and, when the rotor is assembled, must extend through the hole in the rotor ring.

5) Screw on the rotor ring and hand tighten.

   Do not use wrench to tighten rotor.

   If excess friction is encountered in assembling rotor, remove ring and inspect threads for presence of foreign matter.

   Clean carefully and reassemble rotor.

6) Raise protective guard from centrifuge and place rotor in position on stator pad.

7) Close protective cover and tighten retaining screw with the fingers.

8) Rotate pressure regulator control slowly and gradually until rotor is turning smoothly.

   Care should be taken to assure uniform distribution of sample in rotor; such distribution will result in an even, smooth spin of the rotor.

   If rotor spin is wobbly or noisy, remove rotor and redistribute sample to effect even dispersion.

9) Gradually increase air pressure until adequate operating pressure is obtained. The pressure, in turn, will affect the r.p.m.'s of the rotor; the higher the pressure, the greater the r.p.m.'s

For safety reasons the centrifuge should not be operated at a speed higher than necessary to provide good separation of the paste.

Centrifuge time will vary and will depend upon the speed (r.p.m.'s) of the centrifuge and the type and concentration of the paste.

10) When adequate separation of the paste has been achieved decrease the centrifuge speed by lowering the air pressure to about 1 lb. pressure. When the centrifuge has slowed to its equilibrium speed at that pressure, decrease the air pressure gradually until the rotor starts to contact the stator pad; then shut off air pressure completely and allow the rotor to come to rest.

It is important that the rotor come to a smooth stop; otherwise the serum will mix to a certain extent with the tomato pulp and a clear serum will not be obtained.

11) Raise the protective guard, carefully remove rotor and unscrew rotor ring.

If the ring can not be unscrewed by hand, use the wrenches furnished with the instrument to loosen it.

12) Separate ring from rotor and remove plastic cap -- being careful to disturb contents of rotor as little as possible.

13) Use plastic cocktail straw as a pipette. Hold finger over one end of the straw and insert other end into serum until straw extends nearly to the bottom of the rotor.

Avoid contact of the straw with pulpy matter as much as possible.

Remove finger from end of straw and allow serum to enter straw.

Replace finger and carefully withdraw straw from serum.

Transfer a drop from the straw directly to the refractometer prism; immediately close prism and read the instrument, allowing a few seconds for temperature equilibruim to be obtained. The straw is discarded after one use.

The serum should be removed from the rotor as soon as possible.

ALTERNATIVE : Medicine droppers may be used to withdraw the serum from the rotor. If medicine droppers are used, care should be taken that they are thoroughly cleaned and dried before using. The same care should be exercised in withdrawing the serum using a medicine dropper as with the straw.

NOTE :

14) The resulting serum should be reasonably clear, but this does not mean that it will be free of all turbidity or colored matter. Some samples may be a light straw color, but others -- especially those given an efficient hot break -- will be colored red from the presence of colloidal particles of lycopene pigment. These extremely small particles do not affect refractometer reading accuracy or line sharpness, but do reduce the contrast between the light and dark portions of the field. The criteria should be the sharpness of the line and the ability to obtain highly reproducible readings. If a distinct line cannot be obtained, the sample has not been centrifuged for a long enough time or at a sufficiently high speed.

15) Clean all equipment and dry completely before reuse.

ADDED SALT CORRECTION

As previously explained the principle of the revised FDA Standards of Identity is to relate concentration in terms of sucrose value and to include naturally occurring salt as a part of the soluble tomato solids. Therefore, any added salt must be deducted from the final value.

Observe the following procedure in making correction for added salt.

When it is known that no salt is added -

This can only be determined with reliability by in-process inspection.

-- Make no correction for added salt.

When salt has been added, or if in doubt -

This can be determined by in-process inspection, by label declaration - or if in doubt assume salt has been added.

1) Determine the percent salt (Na Cl)--Methods of Analysis, Salt Titration preferably the Potentiometer Method (also File Code 135)

2) Subtract the percent salt, as determined in Step 1), from the Sucrose Value obtained after all corrections have been applied with the exception of Salt.

3) Multiply the Salt-free Sucrose Value (Step 2) by the constant 1.016. The resultant value is considered the percent natural tomato soluble solids.

EXAMPLES

Example 1: Tomato puree of about 10 percent natural tomato soluble solids and in which there is no added salt; no enzyme or dilution.

Test Results:

Refractive Index: 1.3478
Temperature : 17° C

Calculations:

Sucrose Value (RI 1.3478)	=	10.0
Temperature Correction	=	(-) 0.2
Natural Tomato Soluble Solids		9.8%

Example 2: Tomato puree of about 15 percent natural tomato soluble solids to which salt has been added; no enzyme or dilution.

Test Results:

Refractive Index: 1.3560
Temperature : 24° C
Total Salt : 0.6%

Calculations:

Sucrose Value (RI 1.3560)	=	15.2
Temperature Correction	=	(+) 0.3
Corrected Sucrose Value		15.5
Total Salt	=	(-) 0.6
		14.9
Salt Correction Constant		X1.016
Natural Tomato Soluble Solids		15.1%

Example 3: Approximate minimum tomato paste to which no salt has been added, but to which 1.0 gram of dry enzyme has been added.

Test Results:

Refractive Index	:	1.3728
Temperature	:	24° C
Added Salt	:	0.0%
RI of 1% Enzyme Solution	:	1.3336
Sucrose Value of Enzyme	:	0.42

Calculation:

Sucrose Value (RI 1.3728)	=	25.3
Temperature Correction	=	(+) 0.3
Corrected Sucrose Value		25.6
Less Enzyme Correction (1.15) (1) (0.40)	=	0.5
1/ Adjusted Sucrose Value		25.1
Salt Correction		0.0
Natural Tomato Soluble Solids		25.1%

1/ No salt added so no salt correction necessary

Example 4: Concentrated tomato juice of about 22 percent natural tomato soluble solids to which salt has been added and 1 gram of dry enzyme has been added.

Test Results:

Refractive Index of Concentrate:	1.3682
Temperature	23° C
Total Salt (Potentiometric Method) :	0.7%
Refractive Index of 1% Soln. of enzyme :	1.3336 @ 20° C
Sucrose Value of enzyme@ 20° C :	0.42

Calculations:

Sucrose Value (RI 1.3682)	=	22.6
Temperature Correction	=	(+) 0.22
Corrected Sucrose Value		22.82
Less enzyme Correction (1.15 X 1 X 0.42	=	(-) 0.48
Adjusted Sucrose Value		22.34
Less Total Salt	=	(-) 0.7
Salt Free Soluble Solids		21.64
Salt Correction Constant	=	X 1.016
Natural Tomato Soluble Solids		21.98%
Report as		22.0%

Example 5: Approximate 45 percent natural tomato soluble solids tomato paste to which no salt has been added and which has been prepared by a 1 to 1 dilution with a 1% pectic enzyme solution.

Test Results:

Refractive Index:	1.3682
Temperature :	25° C
Added Salt :	0.0%
RI of 1% Pectic Solution @ 20°:	1.3334
Sucrose Value of Enzyme :	0.28

Calculations:

Sucrose Value (RI 1.3682)	=	22.6
Temperature Correction	=	(+) 0.38
Corrected Sucrose Value		22.98
Less enzyme correction (0.55) (1) (0.28)	=	(-) .15
Adjusted sucrose value		22.83
Multiply by 2		X2
Indicated sucrose value		45.66
Plus correction for insoluble solids		(+) 0.8
Total Soluble Solids		46.46
Salt Correction (None)		0.0
Natural Tomato Soluble Solids		46.46
Report as		46.5

Example 6: Approximate 40 percent natural tomato soluble solids tomato paste to which salt has been added, and which has been prepared by a 1 to 1 dilution with water - no enzyme.

Test Results:

Refractive Index: 1.3645
Temperature : 23° C
Total Salt Po- : 0.8%
tentiometric Method)

Calculations:

Sucrose Value (RI 1.3645)	=	20.4
Temperature Correction	=	(+) 0.22
Corrected sucrose value		20.62
Multiply by 2		X 2
Indicated sucrose value		41.24
Plus correction insoluble solids		(+) 0.7
Total Soluble Solids		41.94
Less total salt		(-) 0.8
Salt-free soluble solids		41.14
Salt Correction Constant		X 1.016
Natural Tomato Soluble Solids		41.8%

NOTES ON METHOD

Enzyme Correction Constant

The methodology in the foregoing sections has standardized on the use of

(a) a 1% pectic enzyme solution when a 1 to 1 dilution is followed or

(b) 1 gram of dry pectin per 100 grams when direct filtration is used.

This has been done for standardization purposes only and to simplify calculations. It is possible, however, to use more or less pectic enzyme and still follow the approved method. It would be unlikely to ever need more than a 1% solution or 1 gram of dry pectin.

In the event it is necessary or desired to deviate from the standardized 1% value, correction for added pectic enzyme must be made in accordance with the following as may be applicable:

For Dry Enzyme - No dilution

Subtract from the sucrose value 1.15 AC in which--

A = weight of added pectic enzyme (grams)
C = sucrose value of a 1% solution of pectic enzyme.

For Enzyme In Solution - (1 to 1 Dilution)

Subtract from the sucrose value 0.55 BC in which--

B = weight of pectic enzyme per 100 grams of solution
C = sucrose value of a 1% pectic enzyme solution.

The constants 1.15 and 0.55 are predicated on an average of 12.5 percent of the total tomato solids being insoluble material, thus 87.5 percent being soluble solids. The pectic enzyme has a plus effect on the

No change in text

refractometer thereby adding to the value contributed solely by soluble tomato solids. However, when using the pectic enzyme either dry or in solution it is completely soluble with only the soluble portion of the tomato solids. To correct for enzyme dilution only it is necessary to divide 100 by 87.5 or $\frac{100}{87.5}$ = 1.15 in the case of dry pectin

In the case of a 1 to 1 dilution only half as much enzyme is available and consequently $\frac{1.15}{2}$ = 0.55 (rounded)

Correction For Insoluble Tomato Solids

The table for correcting the effect for 1 to 1 dilution (either pectic enzyme solution or water) is also based upon the fact that the insoluble tomato material does not contribute to soluble solids. Therefore if 100 grams of water is added to 100 grams of tomato concentrate the insoluble solids do not contribute to the refractometer reading and a slightly low reading results. This is compensated for by applying the "dilution correction factor" found in the table on page 12 of this instruction.

Correction For Salt

The constant 1.016 used in making the salt correction is predicated on the assumption that 1.6 percent of the natural tomato solids is naturally occurring salt (Na Cl). Thus 98.4 percent is salt-free solids.

So $\frac{100}{98.4}$ = 1.016 which is the constant used to apply to the salt free sucrose value to compensate for naturally occurring salt.

* Correction

VACUUM OVEN METHOD

Background

The vacuum oven procedure -- described in the AOAC (Methods of Analyses of Official Analytical Chemists) is an official method used by the Food and Drug Administration to determine the solids in many comminuted products. The method involves drying a sample of the product to constant dryness under vacuum and at a specified temperature.

When to Use

The vacuum oven method is used:

> Whenever this method is specifically requested by the packer or applicant.

Equipment

Analytical balance.

Flat-bottomed drying dishes approximately 2-1/2 to 3-1/2 inches in diameter (8 cm)

Vacuum-oven, with necessary accessories.

Desiccator.

[All of the above equipment is obtainable from any reputable chemical apparatus supply house.]

VACUUM OVEN METHOD

Procedure

1) Thoroughly mix the contents of the container by stirring with a dry spoon for approximately 1 minute before removing portions for analysis.

2) Determine approximate natural tomato soluble solids of sample by the refractometric method.

3) Weigh, into flat-bottomed drying dish with tight fitting cover about 15 mg diatomaceous earth filter aid per square centimeter and dry 30 minutes at 110° C.

Example -- [$\pi \cdot R^2 = A$] 3.14159 = π expressed as $\frac{22}{7}$

$$\left[\frac{22}{7}\right] \cdot \left[\frac{\text{Diameter}}{2}\right]^2 = \text{area of dish}$$

Thus, if the measured diamter of a drying dish is 8 cm., the amount of filter aid to use is determined as follows:

$$\left[\frac{22}{7}\right] \cdot \left[\frac{8}{2}\right]^2 = \frac{(22 \cdot (4)^2}{7} = \frac{(22) \cdot (16)}{7} = 50.3 \text{ sq. cm.}$$

Therefore --

50.3 x 15 mg = 754.5 mg (amount of filter aid for this dish)

--Continued on next page --

VACUUM OVEN METHOD -- continuation

4) After cooling in dessicator, weigh (dish and filter aid) and to the drying dish add enough sample so that the equivalent weight of the dry residue of the sample will not be less than 9 mg. nor greater than 30 mg. per square centimeter.

Example.
Assuming the area of the drying dish is 50.3 sq. cm. (See 3 above) and the approximate natural tomato soluble solids is 36% (refractometric method) --

Therefore --

a) 9 mg. per sq. cm. = (9) . (50.3) = 453 mg.
b) 30 mg. per sq. cm. =(30) . (50.3) = 1509 mg.
c) 36% solids is equivalent to 360 mg. dried residue per 1 gram.

d) $\frac{360 \text{ mg.}}{453 \text{ mg.}} = \frac{1 \text{ grm}}{x \text{ grms}}$

$360\ x = 453$
$x = 1.26$ grams (Minimum Sample)

e) $\frac{360 \text{ mg.}}{1509 \text{ mg}} = \frac{1 \text{ grm}}{x \text{ grms}}$

$360\ x = 1509$
$x = 4.19$ grams (Maximum Sample)

} of 36% product to be used in dish of 8 cm diameter

5) Weigh (sample, filter aid, and dish) as rapidly as possible to avoid moisture loss.

6) Mix filter aid and distribute uniformly over bottom of dish, diluting with water, if necessary, to facilitate distribution.

7) Place dish (sample) in vacuum oven at 70° C. with release cock left partly open so that the amount of vacuum is not less than 310 mm. of Mercury (13 inches). Examine dish (sample) at 30 minute intervals and until the remaining moisture is not more than about 50% dry solids. If running more than one sample, remove faster drying samples, cover and place in dessicator until all samples have reached this apparent dryness.

[There are other acceptable methods for obtaining this apparent dryness -- see AOAC]

VACUUM OVEN METHOD -- continuation

Procedure -- continuation

8) Place partially dried sample in vacuum oven with bottoms of dishes in direct contact with shelf. (Oven thermometer is to be in direct contact with shelf and variation of temperature is not more than 2°C.)

9) Close release cock and admit dry air to oven at the rate of 2 to 4 bubbles per seconds by bubbling through concentrated sulfuric acid.

10) Dry samples 2 hours at 70°C. at a vacuum not greater than 100 mm. of Mercury (4 inches).

11) As dried samples will absorp appreciable amount of moisture, on removing dishes from oven, cover quickly and place in dessicator. Weigh as soon as the sample reaches room temperature.

12) Determine the weight of the dry residue, and calculate the percent of total solids

Sample of 1.5429 grams spread uniformly on bottom of dish and dried as specified.

Dried residue = 0.5477 grams.

$$\text{Total solids} = \frac{0.5477}{1.5429} = 35.5 \text{ percent.}$$

13) To adjust total solids to salt-free tomato solids, subtract the % salt from the Total solids, and report the result as "Salt-free Tomato Solids."

Salt content = 0.4 percent (determined analytically)

Salt-free tomato solids = 35.5 minus 0.4 = 35.1 percent.

Report as "Salt-free Tomato Solids = 35.1%"
(Vacuum Oven Method).

SPECIFIC GRAVITY METHOD

Background

This is an official method, described in the AOAC, and is applicable to concentrated tomato products. It is one of the more accurate methods to use for determining specific gravity. It is based on the relation between the weight of equal volumes of water and the product at a specified temperature -- for our purposes, 20° C.

When to use

This procedure, although official, is not used often. In some instances, however, this procedure may be used by packers or requested in buyers' contracts.

Use this method only when specifically requested to report the results as specific gravity. [Do not convert the specific gravity, thus found, to total solids, salt-free solids or any other method of expressing degree of concentration. And do not determine specific gravity of tomato products by the refractometric method.]

STATEMENTS WITHIN BRACKETS [] ARE SUSPENDED DURING EFFECTIVE PERIOD OF BRANCH NOTICES 1420 & 1424 (July, 1971)

Equipment

Specific gravity bottles -- round, wide-mouth two-ounce glass bottles (preferably Pyrex) with a ground top rim and a cover disc ground to fit, obtainable from scientific supply houses.

Balance scale -- accurate to 0.5 gram or less, up to 700 grams.

Analytical balance -- accurate to 0.001 gram at 100 grams.

Laboratory centrifuge -- International, Size 1, Type SB, or similar equipment (capable of 1,000 rpm).

Freshly distilled deaerated water.

Thermometer.

A suitable straight edge.

Funnels, glass -- 2-1/2 inch diameter (for filling bottles).

Alcohol (denatured) or acetone for drying bottles.

Dry towels

Medicine dropper

Procedure

Calibrating the Specific Gravity Bottles

1) Thoroughly clean and dry the bottle with cover disc.

2) Weigh on the analytical balance to the nearest 0.001 gram.

3) Fill bottle to over-flowing with freshly distilled, deaerated water at 20° C. (Centrifuge, if necessary, to remove any entrapped air).

4) Adjust the level of the water exactly even with the top (by means of an eye dropper, if necessary).

5) Slip the cover disc on to top of bottle with care to exclude all air bubbles.

6) Quickly wipe the bottle and cover dry on the outside, and weigh the full bottle on the analytical balance to the nearest 0.001 gram.

7) Subtract the weight of the bottle and cover to determine the weight of water at 20° C.

In the course of routine work, it is a great convenience to construct a table, showing the weight of the full bottle and cover at 20° C. for a series of specific gravities over a normal working range.

Weighing the product and calculating specific gravity

1) Cool the sample to between 16° C. and 18° C.

2) Open container, and stir well for at least one minute.

3) Fill previously calibrated bottle with the product, and centrifuge for 1 minute at about 1,000 rpm.

4) Add enough product to fill bottle to top and centrifuge again.

5) Remove bottle and take temperature of product, inserting thermometer so that no air is introduced.

6) When temperature is just 20° C., remove thermometer, add enough product at same temperature (20° C.) to have bottle slightly over full, and strike off even with top of bottle with straight edge.

7) Clean outside of bottle and weigh at once to nearest 0.001 gram.

8) Specific gravity = weight of product at 20° C., divided by weight of water at 20° C. that same bottle holds.

> The bottles may be conveniently dried after thorough washing by rinsing with denatured alcohol or acetone and centrifuging a few seconds upside down. A very brief air blast will then remove the last traces of liquid from the inside of the bottles.

EXAMPLE

$$S.G. = \frac{\text{Wt. of product at } 20°C.}{\text{Wt. of equal volume of water at } 20° C.}$$

a) Weight of bottle plus water at 20° C. ..... 203.815 g.
Weight of bottle ..... -79.210 g.
Weight of water ..... 124.605 g.

b) Weight of bottle plus product at 20° C. ..... 209.485 g.
Weight of bottle ..... -79.210 g.
Weight of product ..... 130.275 g.

c) $S.G. = \frac{130.275}{124.605} = 1.0455$

d) Report as: "Specific Gravity - 1.0455
(Official Specific Gravity Method)"

TABLE I

Refractive Indices of Sucrose Solutions at 20° C

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3376	3.2	1.3396	4.5	1.3416	5.9
1.3377	3.3	1.3397	4.6	1.3417	6.0
1.3378	3.3	1.3398	4.7	1.3418	6.0
1.3379	3.4	1.3399	4.7	1.3419	6.1
1.3380	3.5	1.3400	4.8	1.3420	6.2
1.3381	3.5	1.3401	4.9	1.3421	6.2
1.3382	3.6	1.3402	5.0	1.3422	6.3
1.3383	3.7	1.3403	5.0	1.3423	6.4
1.3384	3.7	1.3404	5.1	1.3424	6.4
1.3385	3.8	1.3405	5.2	1.3425	6.5
1.3386	3.9	1.3406	5.2	1.3426	6.6
1.3387	3.9	1.3407	5.3	1.3427	6.6
1.3388	4.0	1.3408	5.4	1.3428	6.7
1.3389	4.1	1.3409	5.4	1.3429	6.8
1.3390	4.1	1.3410	5.5	1.3430	6.8
1.3391	4.2	1.3411	5.6	1.3431	6.9
1.3392	4.3	1.3412	5.6	1.3432	7.0
1.3393	4.3	1.3413	5.7	1.3433	7.0
1.3394	4.4	1.3414	5.8	1.3434	7.1
1.3395	4.5	1.3415	5.8	1.3435	7.2

Adapted from the International Scale of Refractive Indices of Sucrose

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3436	7.2	1.3456	8.5	1.3476	9.9
1.3437	7.3	1.3457	8.6	1.3477	9.9
1.3438	7.4	1.3458	8.7	1.3478	10.0
1.3439	7.4	1.3459	8.7	1.3479	10.0
1.3440	7.5	1.3460	8.8	1.3480	10.1
1.3441	7.6	1.3461	8.9	1.3481	10.2
1.3442	7.6	1.3462	8.9	1.3482	10.2
1.3443	7.7	1.3463	9.0	1.3483	10.3
1.3444	7.8	1.3464	9.1	1.3484	10.4
1.3445	7.8	1.3465	9.1	1.3485	10.4
1.3446	7.9	1.3466	9.2	1.3486	10.5
1.3447	8.0	1.3467	9.3	1.3487	10.6
1.3448	8.0	1.3468	9.3	1.3488	10.6
1.3449	8.1	1.3469	9.4	1.3489	10.7
1.3450	8.2	1.3470	9.5	1.3490	10.8
1.3451	8.2	1.3471	9.5	1.3491	10.8
1.3452	8.3	1.3472	9.6	1.3492	10.9
1.3453	8.3	1.3473	9.7	1.3493	11.0
1.3454	8.4	1.3474	9.7	1.3494	11.0
1.3455	8.5	1.3475	9.8	1.3495	11.1

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3496	11.1	1.3516	12.4	1.3536	13.7
1.3497	11.2	1.3517	12.5	1.3537	13.8
1.3498	11.3	1.3518	12.6	1.3538	13.8
1.3499	11.3	1.3519	12.6	1.3539	13.9
1.3500	11.4	1.3520	12.7	1.3540	13.9
1.3501	11.5	1.3521	12.7	1.3541	14.0
1.3502	11.5	1.3522	12.8	1.3542	14.1
1.3503	11.6	1.3523	12.9	1.3543	14.1
1.3504	11.7	1.3524	12.9	1.3544	14.2
1.3505	11.7	1.3525	13.0	1.3545	14.3
1.3506	11.8	1.3526	13.1	1.3546	14.3
1.3507	11.9	1.3527	13.1	1.3547	14.4
1.3508	11.9	1.3528	13.2	1.3548	14.5
1.3509	12.0	1.3529	13.3	1.3549	14.5
1.3510	12.0	1.3530	13.3	1.3550	14.6
1.3511	12.1	1.3531	13.4	1.3551	14.6
1.3512	12.2	1.3532	13.4	1.3552	14.7
1.3513	12.2	1.3533	13.5	1.3553	14.8
1.3514	12.3	1.3534	13.6	1.3554	14.8
1.3515	12.4	1.3535	13.6	1.3555	14.9

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3556	15.0	1.3576	16.2	1.3596	17.4
1.3557	15.0	1.3577	16.3	1.3597	17.5
1.3558	15.1	1.3578	16.3	1.3598	17.6
1.3559	15.1	1.3579	16.4	1.3599	17.6
1.3560	15.2	1.3580	16.4	1.3600	17.7
1.3561	15.3	1.3581	16.5	1.3601	17.7
1.3562	15.3	1.3582	16.6	1.3602	17.8
1.3563	15.4	1.3583	16.6	1.3603	17.9
1.3564	15.5	1.3584	16.7	1.3604	17.9
1.3565	15.5	1.3585	16.7	1.3605	18.0
1.3566	15.6	1.3586	16.8	1.3606	18.0
1.3567	15.7	1.3587	16.9	1.3607	18.1
1.3568	15.7	1.3588	16.9	1.3608	18.2
1.3569	15.8	1.3589	17.0	1.3609	18.2
1.3570	15.8	1.3590	17.0	1.3610	18.3
1.3571	15.9	1.3591	17.1	1.3611	18.3
1.3572	15.9	1.3592	17.2	1.3612	18.4
1.3573	16.0	1.3593	17.2	1.3613	18.5
1.3574	16.1	1.3594	17.3	1.3614	18.5
1.3575	16.1	1.3595	17.4	1.3615	18.6

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3616	18.6	1.3636	19.9	1.3656	21.1
1.3617	18.7	1.3637	19.9	1.3657	21.1
1.3618	18.8	1.3638	20.0	1.3658	21.2
1.3619	18.8	1.3639	20.0	1.3659	21.2
1.3620	18.9	1.3640	20.1	1.3660	21.3
1.3621	19.0	1.3641	20.2	1.3661	21.4
1.3622	19.0	1.3642	20.2	1.3662	21.4
1.3623	19.1	1.3643	20.3	1.3663	21.5
1.3624	19.1	1.3644	20.3	1.3664	21.5
1.3625	19.2	1.3645	20.4	1.3665	21.6
1.3626	19.3	1.3646	20.5	1.3666	21.6
1.3627	19.3	1.3647	20.5	1.3667	21.7
1.3628	19.4	1.3648	20.6	1.3668	21.8
1.3629	19.4	1.3649	20.6	1.3669	21.8
1.3630	19.5	1.3650	20.7	1.3670	21.9
1.3631	19.6	1.3651	20.8	1.3671	21.9
1.3632	19.6	1.3652	20.8	1.3672	22.0
1.3633	19.7	1.3653	20.9	1.3673	22.1
1.3634	19.7	1.3654	20.9	1.3674	22.1
1.3635	19.8	1.3655	21.0	1.3675	22.2

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3676	22.2	1.3696	23.4	1.3716	24.6
1.3677	22.3	1.3697	23.5	1.3717	24.6
1.3678	22.4	1.3698	23.5	1.3718	24.7
1.3679	22.4	1.3699	23.6	1.3719	24.8
1.3680	22.5	1.3700	23.7	1.3720	24.8
1.3681	22.5	1.3701	23.7	1.3721	24.9
1.3682	22.6	1.3702	23.8	1.3722	24.9
1.3683	22.7	1.3703	23.8	1.3723	25.0
1.3684	22.7	1.3704	23.9	1.3724	25.1
1.3685	22.8	1.3705	23.9	1.3725	25.1
1.3686	22.8	1.3706	24.0	1.3726	25.2
1.3687	22.9	1.3707	24.1	1.3727	25.2
1.3688	23.0	1.3708	24.1	1.3728	25.3
1.3689	23.0	1.3709	24.2	1.3729	25.4
1.3690	23.1	1.3710	24.2	1.3730	25.4
1.3691	23.1	1.3711	24.3	1.3731	25.5
1.3692	23.2	1.3712	24.4	1.3732	25.5
1.3693	23.2	1.3713	24.4	1.3733	25.6
1.3694	23.3	1.3714	24.5	1.3734	25.6
1.3695	23.4	1.3715	24.5	1.3735	25.7

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3736	25.8	1.3756	26.9	1.3776	28.0
1.3737	25.8	1.3757	27.0	1.3777	28.1
1.3738	25.9	1.3758	27.0	1.3778	28.2
1.3739	25.9	1.3759	27.1	1.3779	28.2
1.3740	26.0	1.3760	27.1	1.3780	28.3
1.3741	26.1	1.3761	27.2	1.3781	28.3
1.3742	26.1	1.3762	27.3	1.3782	28.4
1.3743	26.2	1.3763	27.3	1.3783	28.4
1.3744	26.2	1.3764	27.4	1.3784	28.5
1.3745	26.3	1.3765	27.4	1.3785	28.6
1.3746	26.3	1.3766	27.5	1.3786	28.6
1.3747	26.4	1.3767	27.5	1.3787	28.7
1.3748	26.5	1.3768	27.6	1.3788	28.7
1.3749	26.5	1.3769	27.7	1.3789	28.8
1.3750	26.6	1.3770	27.7	1.3790	28.8
1.3751	26.6	1.3771	27.8	1.3791	28.9
1.3752	26.7	1.3772	27.8	1.3792	29.0
1.3753	26.8	1.3773	27.9	1.3793	29.0
1.3754	26.8	1.3774	27.9	1.3794	29.1
1.3755	26.9	1.3775	28.0	1.3795	29.1

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3796	29.2	1.3816	30.3	1.3836	31.4
1.3797	29.2	1.3817	30.3	1.3837	31.4
1.3798	29.3	1.3818	30.4	1.3838	31.5
1.3799	29.3	1.3819	30.4	1.3839	31.6
1.3800	29.4	1.3820	30.5	1.3840	31.6
1.3801	29.5	1.3821	30.6	1.3841	31.7
1.3802	29.5	1.3822	30.6	1.3842	31.7
1.3803	29.6	1.3823	30.7	1.3843	31.8
1.3804	29.6	1.3824	30.7	1.3844	31.8
1.3805	29.7	1.3825	30.8	1.3845	31.9
1.3806	29.7	1.3826	30.8	1.3846	31.9
1.3807	29.8	1.3827	30.9	1.3847	32.0
1.3808	29.8	1.3828	30.9	1.3848	32.1
1.3809	29.9	1.3829	31.0	1.3849	32.1
1.3810	30.0	1.3830	31.1	1.3850	32.2
1.3811	30.0	1.3831	31.1	1.3851	32.2
1.3812	30.1	1.3832	31.2	1.3852	32.3
1.3813	30.1	1.3833	31.2	1.3853	32.3
1.3814	30.2	1.3834	31.3	1.3854	32.4
1.3815	20.2	1.3835	31.3	1.3855	32.4

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3856	32.5	1.3876	33.6	1.3896	34.7
1.3857	32.5	1.3877	33.7	1.3897	34.7
1.3858	32.6	1.3878	33.7	1.3898	34.8
1.3859	32.6	1.3879	33.8	1.3899	34.8
1.3860	32.7	1.3880	33.8	1.3900	34.9
1.3861	32.8	1.3881	33.9	1.3901	34.9
1.3862	32.8	1.3882	33.9	1.3902	35.0
1.3863	32.9	1.3883	34.0	1.3903	35.0
1.3864	32.9	1.3884	34.0	1.3904	35.1
1.3865	33.0	1.3885	34.1	1.3905	35.1
1.3866	33.0	1.3886	34.1	1.3906	35.2
1.3867	33.1	1.3887	34.2	1.3907	35.3
1.3868	33.1	1.3888	34.2	1.3908	35.3
1.3869	33.2	1.3889	34.3	1.3909	35.4
1.3870	33.3	1.3890	34.3	1.3910	35.4
1.3871	33.3	1.3891	34.4	1.3911	35.5
1.3872	33.4	1.3892	34.5	1.3912	35.5
1.3873	33.4	1.3893	34.5	1.3913	35.6
1.3874	33.5	1.3894	34.6	1.3914	35.7
1.3875	33.5	1.3895	34.6	1.3915	35.7

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3916	35.8	1.3936	36.8	1.3956	37.9
1.3917	35.8	1.3937	36.9	1.3957	37.9
1.3918	35.9	1.3938	36.9	1.3958	38.0
1.3919	35.9	1.3939	37.0	1.3959	38.0
1.3920	36.0	1.3940	37.0	1.3960	38.1
1.3921	36.0	1.3941	37.1	1.3961	38.1
1.3922	36.1	1.3942	37.1	1.3962	38.2
1.3923	36.1	1.3943	37.2	1.3963	38.2
1.3924	36.2	1.3944	37.2	1.3964	38.3
1.3925	36.2	1.3945	37.3	1.3965	38.3
1.3926	36.3	1.3946	37.3	1.3966	38.4
1.3927	36.3	1.3947	37.4	1.3967	38.4
1.3928	36.4	1.3948	37.5	1.3968	38.5
1.3929	36.5	1.3949	37.5	1.3969	38.5
1.3930	36.5	1.3950	37.6	1.3970	38.6
1.3931	36.6	1.3951	37.6	1.3971	38.6
1.3932	36.6	1.3952	37.7	1.3972	38.7
1.3933	36.7	1.3953	37.7	1.3973	38.7
1.3934	36.7	1.3954	37.8	1.3974	38.8
1.3935	36.8	1.3955	37.8	1.3975	38.8

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.3976	38.9	1.3996	39.9	1.4016	41.0
1.3977	38.9	1.3997	40.0	1.4017	41.0
1.3978	39.0	1.3998	40.0	1.4018	41.1
1.3979	39.0	1.3999	40.1	1.4019	41.1
1.3980	39.1	1.4000	40.1	1.4020	41.2
1.3981	39.1	1.4001	40.2	1.4021	41.2
1.3982	39.2	1.4002	40.2	1.4022	41.3
1.3983	39.2	1.4003	40.3	1.4023	41.3
1.3984	39.3	1.4004	40.3	1.4024	41.4
1.3985	39.3	1.4005	40.4	1.4025	41.4
1.3986	39.4	1.4006	40.5	1.4026	41.5
1.3987	39.5	1.4007	40.5	1.4027	41.5
1.3988	39.5	1.4008	40.6	1.4028	41.6
1.3989	39.6	1.4009	40.6	1.4029	41.6
1.3990	39.6	1.4010	40.7	1.4030	41.7
1.3991	39.7	1.4011	40.7	1.4031	41.7
1.3992	39.7	1.4012	40.8	1.4032	41.8
1.3993	39.8	1.4013	40.8	1.4033	41.8
1.3994	39.8	1.4014	40.9	1.4034	41.9
1.3995	39.9	1.4015	40.9	1.4035	41.9

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.4036	42.0	1.4056	43.0	1.4076	44.0
1.4037	42.0	1.4057	43.0	1.4077	44.0
1.4038	42.1	1.4058	43.1	1.4078	44.1
1.4039	42.1	1.4059	43.1	1.4079	44.1
1.4040	42.2	1.4060	43.2	1.4080	44.2
1.4041	42.2	1.4061	43.2	1.4081	44.2
1.4042	42.3	1.4062	43.3	1.4082	44.3
1.4043	42.3	1.4063	43.3	1.4083	44.3
1.4044	42.4	1.4064	43.4	1.4084	44.4
1.4045	42.4	1.4065	43.4	1.4085	44.4
1.4046	42.5	1.4066	43.5	1.4086	44.5
1.4047	42.5	1.4067	43.5	1.4087	44.5
1.4048	42.6	1.4068	43.6	1.4088	44.6
1.4049	42.6	1.4069	43.6	1.4089	44.6
1.4050	42.7	1.4070	43.7	1.4090	44.7
1.4051	42.7	1.4071	43.7	1.4091	44.7
1.4052	42.8	1.4072	43.8	1.4092	44.8
1.4053	42.8	1.4073	43.8	1.4093	44.8
1.4054	42.9	1.4074	43.9	1.4094	44.9
1.4055	42.9	1.4075	43.9	1.4095	44.9

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.4096	45.0	1.4116	45.9	1.4136	46.9
1.4097	45.0	1.4117	46.0	1.4137	47.0
1.4098	45.1	1.4118	46.0	1.4138	47.0
1.4099	45.1	1.4119	46.1	1.4139	47.1
1.4100	45.2	1.4120	46.1	1.4140	47.1
1.4101	45.2	1.4121	46.2	1.4141	47.2
1.4102	45.3	1.4122	46.2	1.4142	47.2
1.4103	45.3	1.4123	46.3	1.4143	47.3
1.4104	45.4	1.4124	46.3	1.4144	47.3
1.4105	45.4	1.4125	46.4	1.4145	47.4
1.4106	45.5	1.4126	46.4	1.4146	47.4
1.4107	45.5	1.4127	46.5	1.4147	47.5
1.4108	45.6	1.4128	46.5	1.4148	47.5
1.4109	45.6	1.4129	46.6	1.4149	47.6
1.4110	45.6	1.4130	46.6	1.4150	47.6
1.4111	45.7	1.4131	46.7	1.4151	47.6
1.4112	45.7	1.4132	46.7	1.4152	47.7
1.4113	45.8	1.4133	46.8	1.4153	47.7
1.4114	45.8	1.4134	46.8	1.4154	47.8
1.4115	45.9	1.4135	46.9	1.4155	47.8

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.4156	47.9	1.4176	48.8	1.4196	49.8
1.4157	47.9	1.4177	48.9	1.4197	49.8
1.4158	48.0	1.4178	48.9	1.4198	49.9
1.4159	48.0	1.4179	49.0	1.4199	49.9
1.4160	48.1	1.4180	49.0	1.4200	50.0
1.4161	48.1	1.4181	49.1	1.4201	50.0
1.4162	48.2	1.4182	49.1	1.4205	50.2
1.4163	48.2	1.4183	49.2	1.4209	50.4
1.4164	48.3	1.4184	49.2	1.4214	50.6
1.4165	48.3	1.4185	49.3	1.4218	50.8
1.4166	48.4	1.4186	49.3	1.4222	51.0
1.4167	48.4	1.4187	49.4	1.4226	51.2
1.4168	48.5	1.4188	49.4	1.4230	51.4
1.4169	48.5	1.4189	49.5	1.4235	51.6
1.4170	48.6	1.4190	49.5	1.4239	51.8
1.4171	48.6	1.4191	49.6	1.4243	52.0
1.4172	48.6	1.4192	49.6	1.4248	52.2
1.4173	48.7	1.4193	49.6	1.4252	52.4
1.4174	48.7	1.4194	49.7	1.4256	52.6
1.4175	48.8	1.4195	49.7	1.4260	52.8

TABLE I -- continuation

Refractive Indices of Sucrose Solutions at 20° C.

Refract. Index	% Sucrose	Refract. Index	% Sucrose	Refract. Index	% Sucrose
1.4265	53.0	1.4352	57.0	1.4442	61.0
1.4269	53.2	1.4356	57.2		
1.4273	53.4	1.4361	57.4		
1.4278	53.6	1.4365	57.6		
1.4282	53.8	1.4370	57.8		
1.4286	54.0	T.4374	58.0		
1.4291	54.2	1.4379	58.2		
1.4295	54.4	1.4383	58.4		
1.4299	54.6	1.4388	58.6		
1.4304	54.8	1.4392	58.8		
1.4308	55.0	1.4397	59.0		
1.4312	55.2	1.4401	59.2		
1.4317	55.4	1.4406	59.4		
1.4321	55.6	1.4410	59.6		
1.4326	55.8	1.4415	59.8		
1.4330	56.0	1.4419	60.0		
1.4334	56.2	1.4424	60.2		
1.4339	56.4	1.4428	60.4		
1.4343	56.6	1.4433	60.6		
1.4348	56.8	1.4437	60.8		

Corrections for Determining Percent Sucrose in Sugar Solutions by Means of Refractometer when Readings are Made at Temperatures Other than 20° C.

TABLE II

(International Temperature Correction Table, 1936)

TEMP. °C.	Per Cent Sucrose										
	0	5	10	15	20	25	30	40	50	60	70
	Subtract from the per cent sucrose										
10	0.50	0.54	0.58	0.61	0.64	0.66	0.68	0.72	0.74	0.76	0.79
11	.46	.49	.53	.55	.58	.60	.62	.65	.67	.69	.71
12	.42	.45	.48	.50	.52	.54	.56	.58	.60	.61	.63
13	.37	.40	.42	.44	.46	.48	.49	.51	.53	.54	.55
14	.33	.35	.37	.39	.40	.41	.42	.44	.45	.46	.48
15	.27	.29	.31	.33	.34	.34	.35	.37	.38	.39	.40
16	.22	.24	.25	.26	.27	.28	.28	.30	.30	.31	.32
17	.17	.18	.19	.20	.21	.21	.21	.22	.23	.23	.24
18	.12	.13	.13	.14	.14	.14	.14	.15	.15	.16	.16
19	.06	.06	.06	.07	.07	.07	.07	.08	.08	.08	.08
	Add to the per cent sucrose										
21	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08	0.08
22	.13	.13	.14	.14	.15	.15	.15	.15	.16	.16	.16
23	.19	.20	.21	.22	.22	.23	.23	.23	.24	.24	.24
24	.26	.27	.28	.29	.30	.30	.31	.31	.31	.32	.32
25	.33	.35	.36	.37	.38	.38	.39	.40	.40	.40	.40
26	.40	.42	.43	.44	.45	.46	.47	.48	.48	.48	.48
27	.48	.50	.52	.53	.54	.55	.55	.56	.56	.56	.56
28	.56	.57	.60	.61	.62	.63	.63	.64	.64	.64	.64
29	.64	.66	.68	.69	.71	.72	.72	.73	.73	.73	.73
30	.72	.74	.77	.78	.79	.80	.80	.81	.81	.81	.81

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TABLE III

T O M A T O C A T S U P

Refractive Index Corrected to 20° C. -- to Total Solids

R. I.	% Total Solids	R. I.	% Total Solids	R. I.	% Total Solids	R. I.	% Total Solids
1.3589	18.0	1.3682	23.6	1.3778	29.2	1.3879	34.8
1.3592	18.2	1.3685	23.8	1.3782	29.4	1.3883	35.0
1.3595	18.4	1.3688	24.0	1.3785	29.6	1.3887	35.2
1.3598	18.6	1.3692	24.2	1.3789	29.8	1.3891	35.4
1.3602	18.8	1.3695	24.4	1.3792	30.0	1.3894	35.6
1.3605	19.0	1.3699	24.6	1.3796	30.2	1.3898	35.8
1.3608	19.2	1.3702	24.8	1.3800	30.4	1.3902	36.0
1.3612	19.4	1.3706	25.0	1.3803	30.6	1.3906	36.2
1.3615	19.6	1.3709	25.2	1.3807	30.8	1.3909	36.4
1.3618	19.8	1.3712	25.4	1.3810	31.0	1.3913	36.6
.3621	20.0	1.3716	25.6	1.3814	31.2	1.3916	36.8
.3625	20.2	1.3719	25.8	1.3818	31.4	1.3920	37.0
1.3628	20.4	1.3723	26.0	1.3821	31.6	1.3924	37.2
1.3631	20.6	1.3726	26.2	1.3825	31.8	1.3928	37.4
1.3635	20.8	1.3729	26.4	1.3829	32.0	1.3931	37.6
1.3638	21.0	1.3733	26.6	1.3832	32.2	1.3935	37.8
1.3641	21.2	1.3736	26.8	1.3836	32.4	1.3939	38.0
1.3645	21.4	1.3740	27.0	1.3839	32.6	1.3943	38.2
1.3648	21.6	1.3743	27.2	1.3843	32.8	1.3947	38.4
1.3651	21.8	1.3747	27.4	1.3847	33.0	1.3950	38.6
1.3655	22.0	1.3750	27.6	1.3850	33.2	1.3954	38.8
1.3658	22.0	1.3753	27.8	1.3854	33.4	1.3958	39.0
1.3661	22.4	1.3757	28.0	1.3858	33.6	1.3962	39.2
1.3665	22.6	1.3761	28.2	1.3861	33.8	1.3966	39.4
1.3668	22.8	1.3764	28.4	1.3865	34.0	1.3970	39.6
1.3672	23.0	1.3768	28.6	1.3869	34.2	1.3974	39.8
1.3675	23.2	1.3771	28.8	1.3872	34.4	1.3978	40.0
1.3678	23.4	1.3775	29.0	1.3876	34.6	1.3982	40.2

Sucrose Value plus 1%

TABLE V

CORRECTIONS FOR REFRACTIVE INDEX READINGS WHEN DETERMINED AT TEMPERATURES OTHER THAN 25°C. (77°F.)

Temperature		Refractive Index Reading					
°C.	°F	1.3400	1.3500	1.3600	1.3700	1.3800	1.3900
		To be subtracted from reading					
15		.0009	.0010	.0011	.0012	.0013	.0014
16		.0009	.0009	.0010	.0011	.0012	.0012
17		.0008	.0008	.0009	.0009	.0011	.0011
18		.0007	.0007	.0008	.0008	.0009	.0010
19		.0006	.0006	.0007	.0007	.0008	.0008
		.0005	.0005	.0006	.0006	.0007	.0007
21		.0004	.0004	.0005	.0005	.0006	.0006
22		.0003	.0003	.0004	.0004	.0004	.0004
23		.0002	.0002	.0003	.0003	.0003	.0003
24		.0001	.0001	.0001	.0001	.0002	.0002
		To be added to reading					
26		.0001	.0001	.0001	.0002	.0002	.0002
27		.0002	.0003	.0003	.0003	.0003	.0003
28		.0003	.0004	.0005	.0005	.0005	.0005
29		.0005	.0005	.0006	.0006	.0006	.0006
30		.0006	.0007	.0007	.0007	.0007	.0007

TABLE IV

CORRECTIONS FOR REFRACTIVE INDEX READINGS

WHEN DETERMINED AT TEMPERATURES OTHER THAN 68° F (20° C)

Temperature		Refractive index reading					
°C	°F	1.3400	1.3500	1.3600	1.3700	1.3800	1.3900
				To be subtracted from reading:			
15	59.0	.0004	.0005	.0005	.0006	.0006	.0007
16	60.8	.0004	.0004	.0004	.0005	.0005	.0005
17	62.6	.0003	.0003	.0003	.0003	.0004	.0004
18	64.4	.0002	.0002	.0002	.0002	.0002	.0003
19	66.2	.0001	.0001	.0001	.0001	.0001	.0001
				To be added to reading:			
21	69.8	.0001	.0001	.0001	.0001	.0001	.0001
22	71.6	.0002	.0002	.0002	.0002	.0003	.0003
23	73.4	.0003	.0003	.0003	.0004	.0004	.0004
24	75.2	.0004	.0004	.0005	.0005	.0005	.0006
25	77.0	.0005	.0005	.0006	.0006	.0007	.0007
26	78.8	.0006	.0006	.0007	.0008	.0008	.0008
27	80.6	.0007	.0008	.0008	.0009	.0010	.0010
28	82.4	.0008	.0009	.0010	.0010	.0011	.0011
29	84.2	.0010	.0010	.0011	.0012	.0012	.0013
30	86.0	.0011	.0012	.0012	.0013	.0014	.0014