PROCEDURES FOR EVALUATING UTILIZATION POTENTIAL AND QUALITY IN PROCESSING TOMATOES AND TOMATO PRODUCTS

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Abstract

This is a collection of procedures to evaluate color, solids, serum viscosity, acidity, consistency potential and other attributes of tomatoes and tomato products. These procedures were compiled to provide a standardized set of methods to yield objective, reproducible, and comparative data within and among growing seasons, areas and varieties.

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1. SAMPLING PROCEDURE

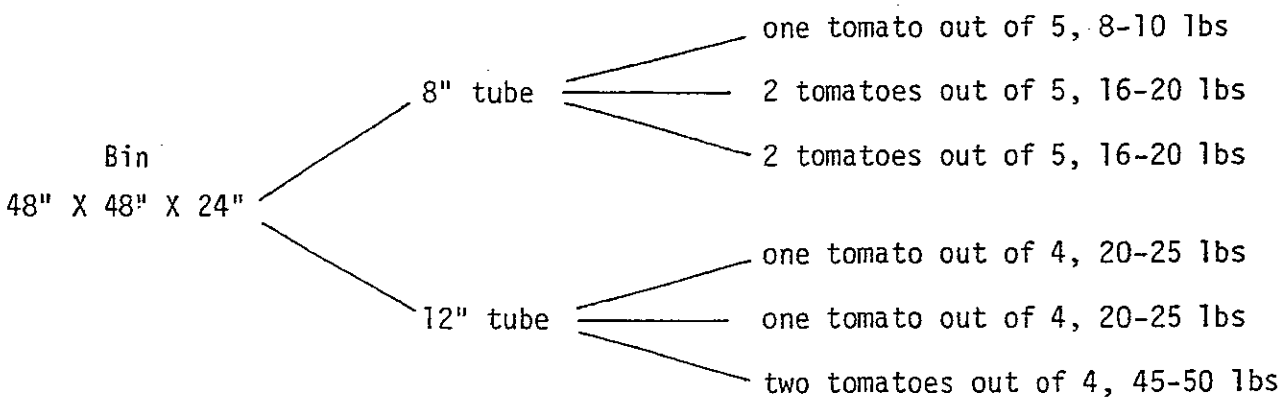
Abstract:

For any of the procedures in this collection to be meaningful, testing must be performed on samples which are representative of the lot being evaluated. This section illustrates a method for obtaining a representative sample of the desired size by repeatedly subsampling a larger sample.

Procedure:

Manual core sampling can be very effective in loads which do not exceed the workable fill depth, about 24 inches. Place a rigid tube on top of fruit in box (50 lb. unit) or bin (1/2 ton unit) and remove tomatoes within perimeter of tube, gently pushing tube down to keep remaining tomatoes from displacing those removed. Sample weight will vary with tube diameter and fill depth. With a 24 inch fill, an 8 inch tube yields a sample approximately 40-50 lbs., and a 12 inch tube yields a sample closer to 100 lbs.

Subsampling can be accomplished by subdividing core sample as it is taken, by alternately placing individual tomatoes into several containers. For example:



Sample weights are approximate but illustrate potential flexibility. The above random samples could be used separately or in various combinations.

2. EVALUATION OF TOMATO CONDITION AND QUALITY

Abstract

Tomato quality and damage are evaluated. The load's suitability for peeling or crushing is estimated as defined within tomato condition.

Procedure

TOMATO CONDITION may be estimated by the following visual system to provide the desired information:

Peelable tomatoes, No. 1. Well colored [cut surface <40 on the Agtron E5M (Magnuson Engineers, Inc., San Jose, CA.)], whole (undamaged) tomatoes which are larger than 1½ in. diameter and have the round, or characteristic shape of the variety. The tomatoes are firm and free of scars and defects. Stem scars don't exceed 5/16 in. diameter.

Peelable tomatoes, No. 2. Same as No. 1 but with the following imperfections allowed:

The tomato may have yellow eye which does not exceed 1/8 in. beyond stem scar at any point. The tomato may have an aggregate combined sunburn and green and yellow discoloration not exceeding 3/4 in. diameter. Stem scar may not exceed 1/2 in. diameter.

Peelable tomatoes with cracks: Tomatoes are defined as peelable (No. 1 or No. 2) but have minor breaks in the skin. These tomatoes may be easier to peel, however, the peeling losses for these tomatoes can be 33-80% higher than for undamaged tomatoes (Sherman Leonard, Ned Vilas and George Marsh, 1967, "Consequence of damage to, and storage of tomatoes." Progress report). Tomatoes more severely damaged should not be considered for peeling.

Products: Well colored and/or fairly well colored undamaged tomatoes that are not suitable for peeling are acceptable for products. Tomatoes may have smaller than 1½ in. diameter, may have odd shapes and may show evidences of sunburn, sunscal green and yellow shoulders, growth cracks and other imperfections which don't requir the removal of more than 20-25% of each tomato.

Product tomatoes with cracks: These tomatoes are defined the same as product tomato except these have cracks in the skins.

Crushed tomatoes: Tomatoes defined as at least suitable for product, except these tomatoes are crushed to the point of misshaping the fruit, and the damage extends into the flesh.

Visible locules: Tomatoes defined as at least suitable for product, except both the skin and flesh are broken through, exposing one or more of the seed cavities.

Bruised: Tomatoes defined as at least suitable for product, except the fruits are bruised, displaying loose skin and soft, mushy condition in corresponding areas. This classification is distinctly different from overripe, commonly called "waterbag", and sunscalded tomatoes.

Definitions listed thus far describe tomato condition in terms of suitability for peeling (the percentage of tomatoes described as peelable is high enough to be economically favorable) or suitability for crushing and processing into juice, sauce and/or concentrate (percentage of peelers too low). Tomato condition is also described in terms of various degrees of damage, i.e.

1. Whole, undamaged tomatoes (Peelable No. 1 and 2 and Products)
2. Peelable tomatoes with cracks
3. Product tomatoes with cracks
4. Crushed tomatoes
5. Tomatoes with visible locules
6. Bruised tomatoes

	major damage	product damage	total damage

which relate to both yield and quality of the resulting products. The information may be used to optimize raw material handling and utilization based on the findings of researchers, or on experience.

TOMATO QUALITY, in California, is reasonably estimated through mandatory inspection of loads of processing tomatoes. The definitions of imperfections

and defects are outlined in the Canning Tomato Inspection Manual of the Fresh Products for Processing, Fruit and Vegetable Quality Control, State of California Department of Food and Agriculture CT54-60 (Rev. 4-73). Descriptions of imperfections and defects are as follows:

DEFINITION OF DEFECTS

"1331-A. Worm Damage. Any worm damage is considered serious when it has penetrated the flesh. Open holes which are clean, and no excreta are present, shall not be considered as worm damage.

1331-B. Mold. A tomato shall be considered as not "suitable for canning purposes" and to have more than "10% of the weight of the tomato" not usable for canning purposes due to the presence of mold when (a) mold has penetrated the wall of the tomato and is plainly visible on the inside of the wall of the tomato, or (b) mold has penetrated into the wall structure but not through to the locule, and the mold has affected in its penetration enough of the volume of the wall of the tomato to make it necessary, as would be done in normal preparation for canning purposes, to remove more than 10% of the weight of the tomato. 'Mold' as used in this section means a breakdown or watery appearance in the flesh of the tomato, or of any mycelium or spores of any type of mold fungus which has affected the tomato.

40844-H. The tomato is green with no visible shade of red color on external surface.

1331-C. Rot. A tomato shall be considered as not suitable for canning purposes, due to the presence of rot, when more than 20% of the tomato shows evidence of rot.

'Rot' as used in this section means dry rot.

1331-D. Sunburn. A tomato shall be considered as not suitable for canning purposes, when more than 25% of the tomato shows evidence of sunburn.

"Sunburn" as used in this section means that the skin or flesh has a white or yellow color, and the flesh has become partially hardened from the effects of sunburning.

1331-E. Sunscald. A tomato shall be considered as not suitable for canning purposes, due to the presence of sunscald, when more than 25% of the tomato shows evidence of sunscald.

"Sunscald" as used in this section means a soft watery condition in the tomato flesh caused by, and typical of, heat damage.

1331-F. Growth Cracks. A tomato shall be considered as not suitable for canning purposes due to the presence of growth cracks, when more than 25% of the tomato is affected by growth cracks.

"Growth cracks" as used in this section means cracks in the skin or flesh radiating from the stem scar, or cracks around the shoulder with the stem scar approximately at the center.

1331-G. Insect Bites. A tomato shall be considered as not suitable for canning purposes, due to the presence of insect bites, when more than 25% of the tomato shows evidence of insect bites.

"Insect bites" as used in this section means punctures or the effect of chewing in the skin or flesh. If insect excreta are adhering to the flesh, the defect shall be considered under Section 1331-A.

1331-H. Green or Yellow Color at the Stem End. A tomato shall be considered as not suitable for canning purposes, due to the presence of green or yellow color at the stem end, when more than 25% of the tomato shows evidence of green or yellow color at the stem end.

"Green or yellow color at the stem end" as used in this section means the skin and flesh has a yellow or green color and the flesh may be partially hardened.

1131-I. Other Imperfections. A tomato shall be considered as not suitable for canning purposes, when more than 25% of the tomato shows evidence of "other imperfections".

Evidence of "other imperfections" is characterized by damage to the tomato, not otherwise specified in Section 40844 of the Food and Agricultural Code; and because of said damage, that portion of the tomato so affected is not suitable for canning purposes.

(Examples of "other imperfections" are "Gray Wall" and "Internal Discoloration" and "Seed Sprouts".)

("Gray Wall" is characterized by dark brown to black discoloration of the vascular bundles in the wall of the tomato when the tomato is cut in half through a cross section. When this condition is observed, immediately contact your supervisor.)

("Internal discoloration" is characterized by whitish, yellowish or greenish areas in the interior of the tomato. Your supervisor should be contacted when this condition is found.)

("Seed sprouts" - A tomato shall be considered not suitable for canning purposes when there is the presence of seed sprouts in three or more cells or if any individual sprout exceeds 5/16 of an inch in any one cell.)

1131-J. Determining the Amount of an Individual Tomato Not Suitable for Canning Purposes. To determine whether the tomato is "not suitable for canning purposes", due to the presence of the defects described in Sections 1131-C to 1131-I, Administrative Code, shall be determined by removing the affected portions, as would be done in the normal preparation for canning purposes.

1131.5. Overripe. A tomato shall be considered as not suitable for canning purposes when most of the flesh is soft and mushy due to overripeness.

1331.6. Shriveled. A tomato shall be considered as not suitable for canning purposes when the tomato has become shriveled and rubbery.

1331.7. Frozen or Frosted. In addition to other evidences of freezing damage, such as breakdown in the flesh, a tomato shall be considered as not suitable for canning purposes when freezing damage, which shows as a glassy appearance, is visible on an aggregate area equal to that of a circle one-half inch in diameter."

Factors listed under quality considerations influence the final quality and quantity of the processed product. They influence direct and indirect losses through processing. Wash losses, trimming losses, sortouts required to meet private, State and/or Federal standards are the more obvious of the losses. The less obvious factors relate to losses in color, solids, flavor and consistency.

3. PREPARATION OF RAW TOMATO JUICE FOR TESTING

Abstract:

Raw tomato juice for consistency, color and solids determination is prepared by macerating tomatoes in a Waring blender, straining to remove skins and seeds and de-aerating under vacuum.

Equipment:

Waring blender, one gallon capacity, model CB6 or equivalent.

Sieve and pan, (Tyler) 8 in. diameter, stainless steel, 0.0469 in. opening.

Scraper (Rubbermaid Commercial), 13-1/2 in. long

Timer

3/4 x 2 in. strip of wood (or other available rigid material) to prop sieve.

Flask, vacuum filtering, 2 liter with rubber stopper.

Funnel, 4 in. plastic, with broad neck to use with 2l. flask.

Beaker, plastic, 400 ml or 1000 ml.

Vacuum source with gauge, capable of reaching a vacuum of 29 in. Hg.

Procedure:

Obtain an 8-1/2 lb tomato sample using a subsampling procedure which yields a representative sample. Fig. 3.1 illustrates equipment used for preparing raw juice for evaluations. Place six tomatoes in the blender container, cover and start blender, rapidly alternating on and off on low speed just until tomatoes are fragmented. Stop blender. Remove cover and add about two-thirds of the remaining tomatoes. Repeat until these tomatoes are fragmented. If bridging should occur, stop blender, stir material with a rubber scraper, cover and re-start on low speed.

Stop blender, add remaining tomatoes (entire sample is now in container), replace cover and blend at low speed for one minute. Measure 400 ml of macerated tomato using a plastic beaker and pour into sieve. If several tests are desired on the raw juice, sieve 1000 ml rather than 400 ml. Tilt sieve, using 3/4" wood block under one edge. Scrape surface of sieve with rubber scraper until liquid portion of macerate has passed into pan below (Fig. 3.2). This can best be accomplished using short brisk forward-backward strokes. Only skins and seeds should remain on screen when this operation is completed (Fig. 3.3). Seeds and skins should be pressed with spatula until no more juice can be removed. Rinse scraper to remove adhering skins and seeds and dry scraper. Separate sieve from pan, and scrape strained material adhering to bottom-side of sieve into pan (Fig. 3.4). Do not permit loose seeds and skins on top side of screen to spill into strained sample. Use funnel to transfer strained material to vacuum flask. Scrape pulp adhering to pan into funnel (Fig. 3.5). Tap funnel several times to move tomato material from funnel into flask.

Turn on vacuum source, (aspirator or vacuum pump). Stopper flask and apply vacuum (Fig. 3.6). When foam (small bubbles) rises in tomato juice, shake tilted flask vigorously to break foam (Fig. 3.7). Start to shake flask when foam has risen ~2 in. above surface of juice. If foam begins to overflow (reaches sidearm), release vacuum by momentarily disconnecting vacuum hose at flask. CAUTION: Do not hit flask against anything hard while shaking it under vacuum. Handle vacuumized flask with care and keep it away from hardware and working surfaces.

Deaeration is complete when, under full vacuum (about 29 in. Hg.) bubbles break spontaneously and no longer rise to fill flask (Fig. 3.8). Release vacuum by disconnecting hose from flask. Juice should be free of bubbles. If bubbles are present, re-connect hose and deaerate further. After deaeration is complete, perform desired tests on juice.

Fig. 3.1. Illustrates examples of equipment used.

A. Blender container, motor and container cover;

B. Sieve and bottom;

C. Scraper;

D. Timer;

E. Strip of wood used for slanting sieve assembly during juice extraction.

F. Sample of tomatoes for evaluation.

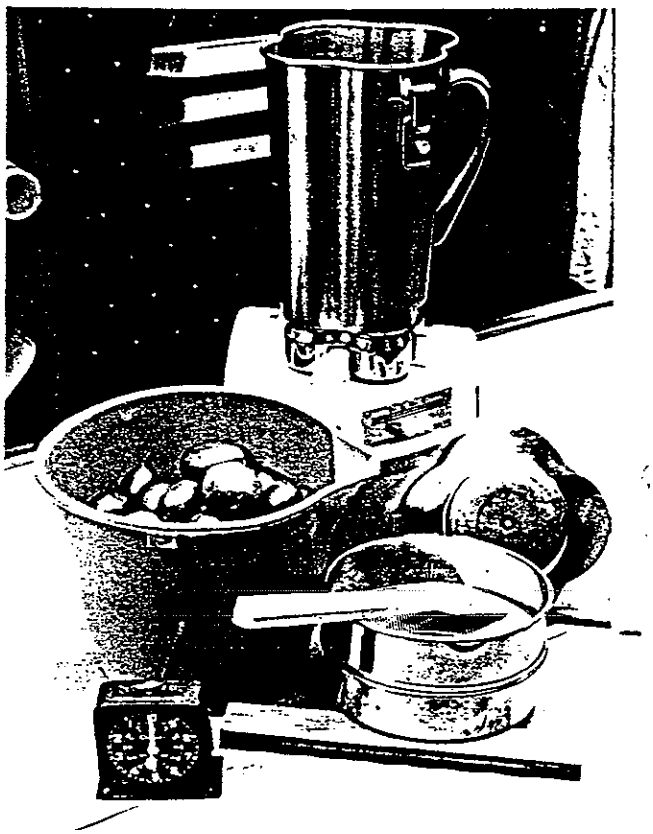


Fig. 3.2. Slanting sieve assembly and rapidly scraping in direction of slant (away from operator) facilitate raw juice extraction.

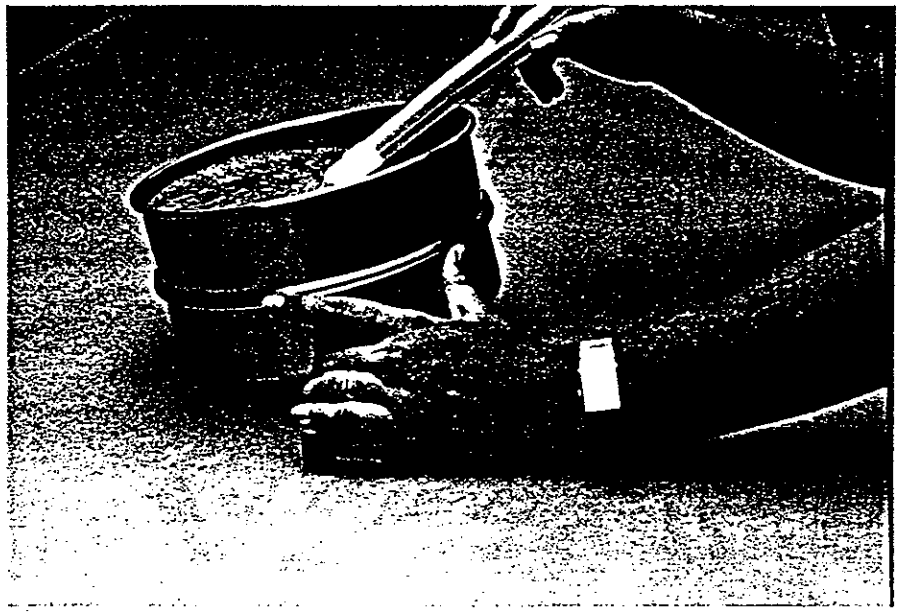


Fig. 3.3. When raw juice extraction is completed, only a small amount of seeds and fragmented skin remain on top of screen. This remaining material is gathered in lower part of sieve and pressed until no more juice can be removed.

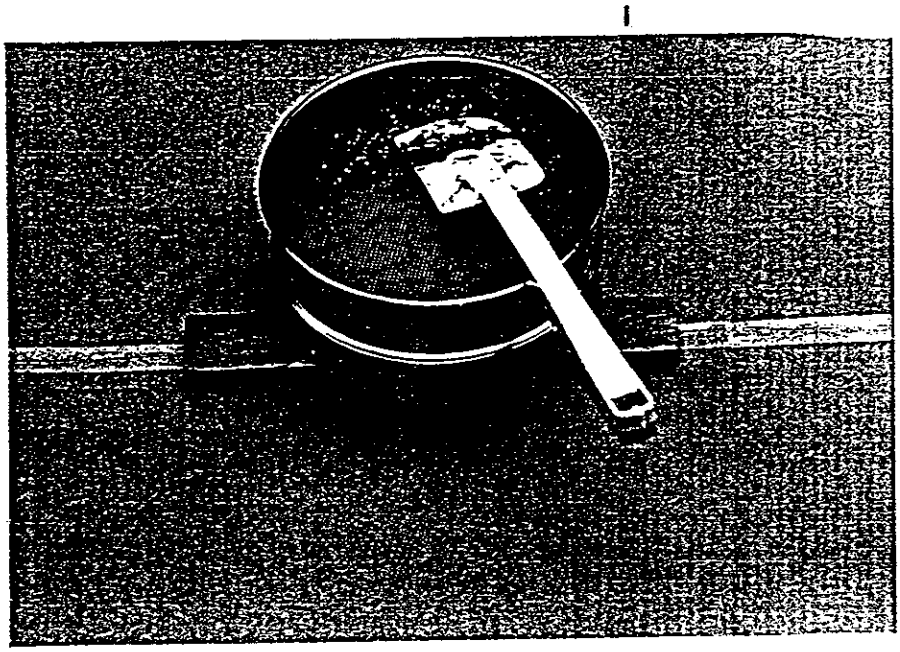


Fig. 3.4. Sieve and pan are separated carefully to avoid spillage. The bottom of sieve is scraped free of pulp with a clean, dry scraper.

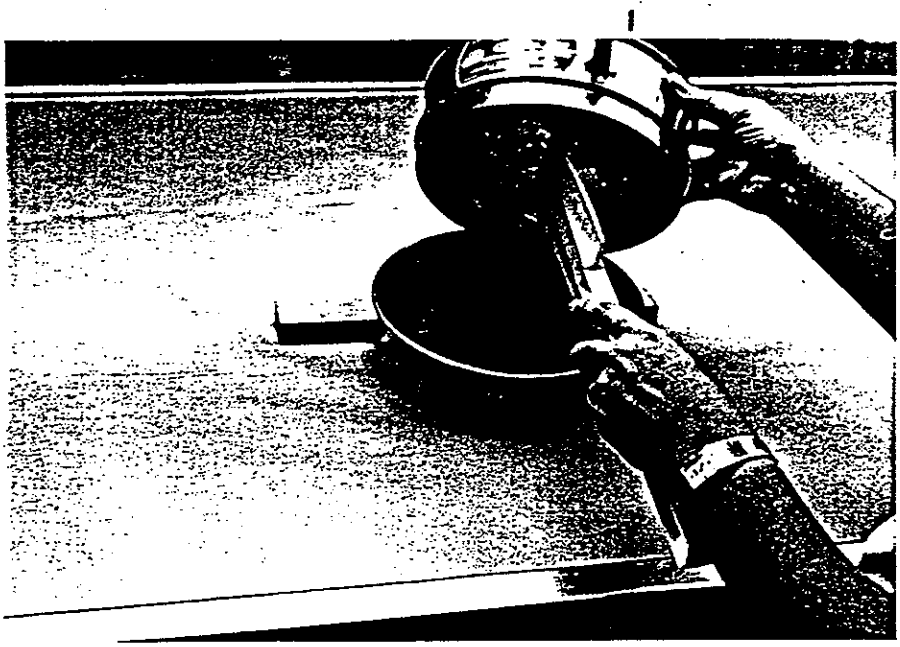


Fig. 3.5. Raw juice is transferred from pan into filtering flask. Pulp adhering to pan is scraped into funnel. Funnel is tapped several times to facilitate complete transfer of adhering pulp into flask.

Fig. 3.6. Vacuum filtering flask with raw juice is attached to vacuum line (aspirator). Gauge (I) is connected to vacuum line with a Y connector and tygon tube. Flask appears opaque due to rising of air bubbles in juice.

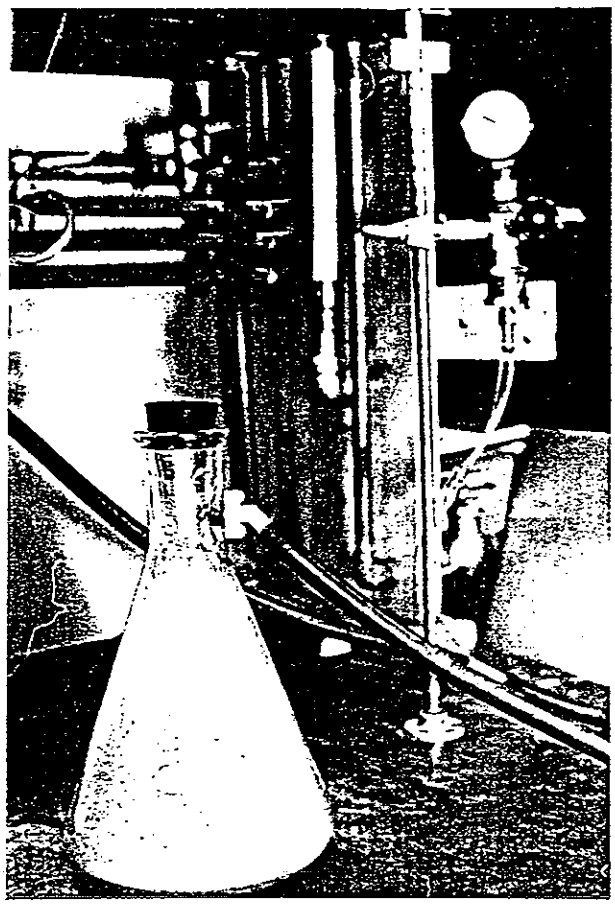


Fig. 3.7. Bubbles are broken by vigorously shaking flask. A short, wrist-snapping, jerking motion, indicated by thickened arrow, facilitates bubble breaking and thus air removal. A grasp which prevents strain on flask side-arm during shaking is demonstrated. Other holds which restrict movement of vacuum hose at side-arm connection are acceptable also.

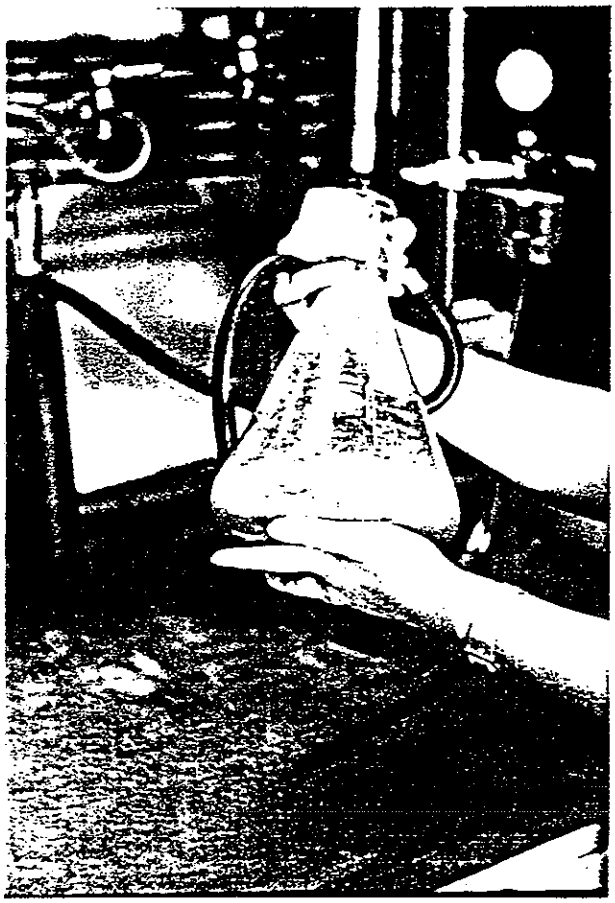
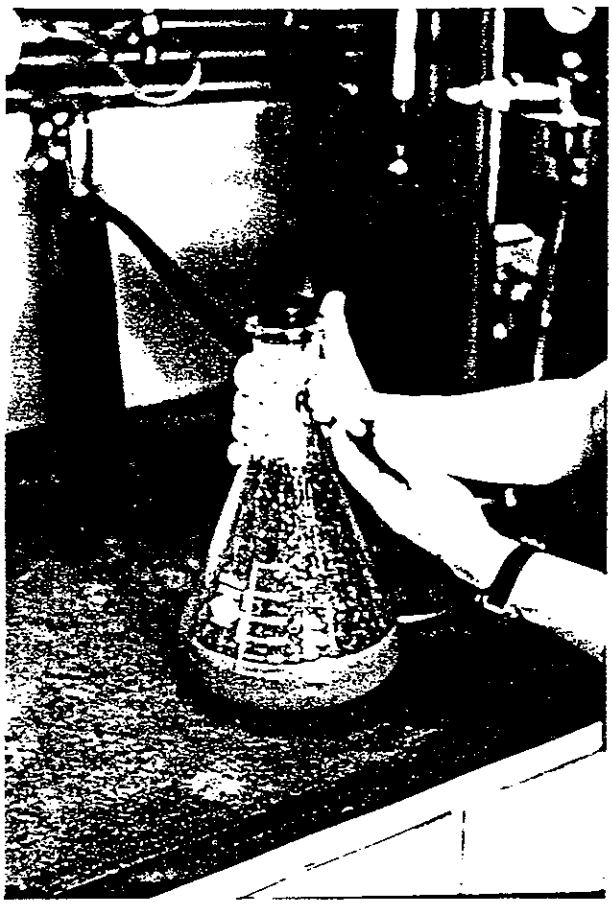


Fig. 3.8. When deaeration is completed, bubbles break spontaneously and do not accumulate. At this time, detach flask first, then turn off vacuum source. This sequence prevents extraneous material (e.g. water from aspirator) from entering sample.



4. CAPILLARY VISCOMETER MEASUREMENTS ON TOMATO JUICE

Abstract:

Tomato juice consistency is determined by measurement of flow time through the Capillary Juice Viscometer.

Equipment:

Capillary Juice Viscometer, AOAC Methods, 12th Edition, 1975, 22.009.

Clamp, Castalloy, Versatile, large, vinyl-covered jaws.

Clamp Holder, Castalloy.

Stand, 20" tall.

Beaker, 400 ml.

Stop timer, seconds and tenths.

Tablespoon, stainless steel.

Thermometer, Centigrade.

Spatula, Stainless steel with straight edge.

Procedure:

Measurements are made on deaerated tomato juice prepared according to Section 3, "Preparation of Raw Tomato Juice for Testing." Approximately 300 ml of juice are required for testing.

Secure capillary viscometer in a vertical position (Fig. 4.1) with a screw clamp.

Stir juice to mix without introducing air bubbles. Adjust temperature to 25.0 $\pm$ 0.5°C. Fill viscometer, pouring juice against inside wall to minimize air bubbles. Let juice flow out through tube until flow is steady, not interrupted with air bubbles (Fig. 4.1). Place finger over end of the capillary tube to stop flow. When tube is nearly filled, examine it for trapped air bubbles. Remove air bubbles by gently stirring. Fill to overflow, and level off with straight edge (Fig. 4.2). Remove finger from

tube and simultaneously begin timing. Record time (± 0.1 sec) for top of meniscus to reach calibration line. Take two or more measurements on each sample. Between measurements, rinse tube viscometer with cool water and dry completely. (Blow capillary tube dry with cleaned compressed air and wipe lucite chamber with a soft tissue. Long tweezers facilitate drying.)

For raw tomato juice the following precautions should be observed:

1. Time lapse from end of sample blending to beginning of first viscosity measurement must be standardized. A 10 minute lapse provides sufficient time for sieving and deaeration.

2. Pectic enzymes are active in the raw juice, and as pectin is degraded viscosity readings will decrease with time. It is the first reading that is recorded, and the second reading is used to check for gross experimental errors such as the presence of lint, air bubbles, or seed or skin particles in capillary tube. A 5% decrease in flow time between the first and second readings is acceptable.

Fig. 4.1. Capillary juice viscometer is secured in a vertical position. The viscometer's principal features are: 1. lucite chamber or reservoir; 2. capillary tube housed in a metallic tube; 3. calibration line used as a reference (end point) in measuring juice flow time.

A sample of juice is poured into tube and allowed to flow out through capillary tube. A smooth flow indicates that air has been removed. With thick juices air removal is indicated by steady discharge of droplets at uniform intervals.

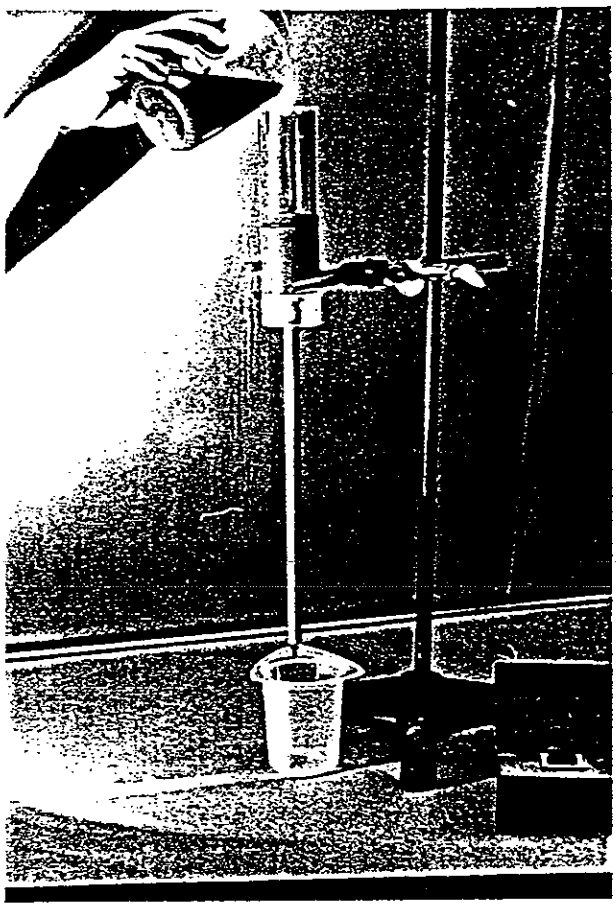
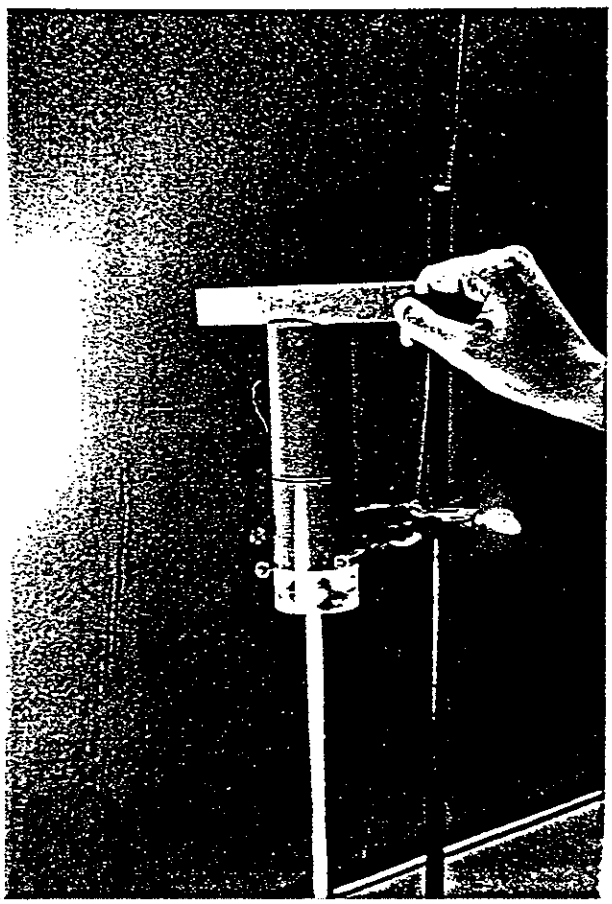


Fig. 4. . The straight edge of a plastic ruler is used for leveling. Juice level may also be adjusted by allowing a little juice to flow out or by adding just enough juice to make juice level coincide with top surface of reservoir.



5. COLOR MEASUREMENT OF TOMATO PRODUCTS

Equipment:

Balance (± 1g)

Beaker, 400 ml

Spoon stainless steel

Syringe 10 cc capacity

Refractometer

Centrifuge

Flask vacuum filtering, 2 liter

Vacuum source or

Stirrer, magnetic with Teflon coated magnetic bar

Sample Preparation:

Approximately 300g. of product is required for color evaluation.

Raw Juice.

Color of tomato juice samples is measured at natural strength. Raw juices are prepared as described in Section 3. Juice has a tendency to separate, therefore it must be stirred just prior to color measurement. The time interval during measurement must be no longer than five minutes to limit the effect of settling. Stirring should be very thorough but no so vigorous as to form air bubbles in product.

Processed Products.

Follow instructions in following report entitled "Color Scoring Tomato Products Objectively".

Operation and Standardization of Colorimeters

Follow instructions in "Color Scoring Tomato Products Objectively" for Agtron E5M, M400 and M500 colorimeters, Gardner XL20 and XL23 colorimeters and Hunter D25 D2 colorimters with A head.

6. SOLIDS DETERMINATION IN TOMATO PRODUCTS

A. DETERMINATION OF TOTAL SOLIDS

Abstract:

Total solids are determined in tomato products by mixing a weighed sample with diatomaceous earth, drying on a steam bath, removing remaining water by drying under vacuum at 70°C and reweighing.

Equipment:

Numbered aluminum dishes with snug, numbered covers, 62 mm dia., 44 mm tall

Rubber policeman

Diatomaceous earth, Supercel or equivalent

Oven, convection type, 110°C

Oven, vacuum, water heated, 70°C

Desiccator

Balance, analytical

Steam bath with 1/8 or 1/4" aluminum, brass, or copper plate surface

Procedure:

Approximately 50 g of juice or <20 g of paste are required for evaluation. Place 0.5-1.0 grams of diatomaceous earth (DE) in each aluminum dish and dry for 2 hours at 110°C in a convection oven. Remove dishes from oven, cover, and place in desiccator for at least 30 minutes to cool. When handling drying dishes, be sure hands are clean and dry. It is advisable to wear light (white) cotton gloves to reduce transfer of moisture and oils from hands to dishes. Weigh a covered dish containing dried diatomaceous earth to the nearest 0.0001 gram and record weight. Stir tomato product well just before sampling. Add proper amount of sample, as shown in the following table, replace lid and weigh to the nearest 0.0001 gram as quickly as possible to reduce error from evaporation of water.

Record weight. If net weight of product in drying dish is extremely low, discard dish and weigh out another sample. Do not attempt to adjust sample size as this will result in error due to evaporation. If net weight of product in dish is too high, sample will not dry properly, resulting in erroneous total solids values. Again, discard dish and weigh out a new sample. Mix sample and DE with rubber policeman, adding distilled deionized water if necessary. Carefully rinse all solids from policeman back into drying dish (Fig. 6.1). Dry DE is very light and has a tendency to blow out of dish if it is stirred too vigorously or if water is added directly on top of DE. To avoid difficulties, allow DE to saturate with moisture from sample or from water added carefully to dish before stirring. Loss of DE after sample has been weighed will result in inaccurate solids determinations. If spattering of DE is observed, discard dish with sample and prepare a new one.

Approximate Sample Sizes for Solids Determination

Sample type, percent solids	Sample weight, grams
Juice 5-6	12-15
Paste, 10	5-6
12	4-5
14	3.5-4.5
16	3-4
18	2.5-3.5
20	2-3
25	1.5-2.5

For obtaining juice samples, a tablespoon is most satisfactory because it can be used to stir sample before each weighing and has the 12 g capacity for one-dip sampling. Use of syringes and similar devices is not recommended for whole

juices which tend to stratify and separate very rapidly. Also, fibrous matter tends to adhere to walls and outlet of syringe producing an unrepresentative sample. Syringes are useful for dispensing serum (soluble solids samples free of suspended particles) and paste samples. Volumetric marks on syringe assist in obtaining desired sample size in each dish.

Samples should be evaluated in no less than triplicate and the results averaged. In practice it is expedient to weigh out replicate dishes of several samples, stir all dishes and place (uncovered) on the steam table plate at the same time. Avoid direct contact of sample dish with steam to prevent burning. Check samples frequently (~5 min intervals) and remove each dish as soon as it appears dry. Fig. 6.2 illustrates samples at different levels of dryness.

When all dishes are dry, place them (uncovered) in 70°C water-heated vacuum oven, (Fig. 6.3), with entire dish bottom contacting heated surface; do not tilt dishes up against side walls or allow lid edges under dishes. Fig. 6.4 shows dishes positioned properly, with lids leaning against their respective dishes.

Evacuate oven, then admit dry air at a rate of 2 to 4 bubbles per second by passing air through conc. H_2SO_4. Oven temperature may drop as low as 65°C at the start of drying but must reach 70 ± 1°C at a pressure not more than 50 mm Hg (50 Torr) before the end of the first hour. After two hours in vacuum oven, replace lids tightly, remove sample dishes, and place them in a desiccator to cool for 30 minutes.

After cooling, weigh to nearest 0.0001 gram and record weight.

Calculation:

$$\% \text{ Total Solids} = \frac{(W_3 - W_1) \cdot 100}{W_2 - W_1}$$

Where:

W_1 = Tare wt. of dish and diatomaceous earth.

W_2 = Wt. of dish, wet sample and diatomaceous earth.

W_3 = Wt. of dish, dry sample and diatomaceous earth.

B. DETERMINATION OF SOLUBLE SOLIDS

Abstract

Tomato serum is prepared from juice by centrifugation and filtration. A weighed portion of this serum is analyzed by a method similar to the AOAC Solids by Drying technique (32.004, 1975).

Equipment: *

Centrifuge, International size 2 Model V, or equivalent

Centrifuge bottles, 250 ml, Nalgene

Filter paper, S&S 520 B½, 12.5 cm diameter

Funnel, Analytical, 60°, 75 mm

* Equipment as listed above are in addition to those used for "A. Determination of Total Solids"

Procedure:

Approximately 100 g of juice, 50 g paste or 25 g catsup are required for this test. Fill 250 ml centrifuge bottle with tomato juice or diluted product, cap, and centrifuge at 2000 RPM for fifteen minutes (Fig. 6.5). For cold break juice, sample should stand 20 min after sieving prior to centrifuging to facilitate filtration. Decant and filter by gravity through S&S 520 B½ filter paper (Fig. 6.4). Following the procedure in "A. Determination of Total Solids" weigh 12 to 15 grams of serum into a tared solids dish which has been dried with DE.

Note: This technique may be used also on tomato paste or catsup diluted to 5-6% solids, using the following procedure:

Using an analytical balance, tare 250 ml beaker containing a spatula or wire whip for stirring, weigh amount of tomato product shown in table below into tared beaker. Add deionized water in small amounts, blending to a smooth paste between additions. When mixture becomes pourable, place beaker on a balance and add water to bring mixture to 100 g. Mix thoroughly, then perform solids analysis as described above.

Sample Type	Weight of Tomato Product	Final Weight After Dilution	Weight Serum to be Used in AOAC 32.004
Catsup	25 g	100 g	12 g
Paste, 12%	50 g	100 g	12 g
Paste, 25%	20 g	100 g	12 g

Multiply calculated percent solids by 4 for catsup, 2 for 12% paste and 5 for 25% paste, to compensate for dilution.

C. DETERMINATION OF INSOLUBLE SOLIDS

Using the methods described previously in this section for % total solids and % serum solids, % insoluble solids is calculated as follows:

% insoluble solids =(% total solids - % soluble solids) / (100 - % soluble solids)

Insoluble solids can be calculated on a dry weight basis as $\frac{\%\text{ insoluble solids}}{\%\text{ total solids}} \times 100$. An alternate method described in 32.005 AOAC (1975) may also be used. In that method a weighed sample is washed repeatedly (4-5 times), centrifuged and the supernatant filtered through a weighed filter paper each time. Insoluble material is transferred to the filter paper which is dried 2 hrs at 100°C, cooled in a desiccator, and weighed. The % insoluble solids is calculated based on original sample weight.

D. DETERMINATION OF TOTAL SOLIDS IN SKINS AND SEEDS

Abstract:

Total solids are determined in skins and seeds extracted from tomato juice during pulping and finishing. From the percentage of total solids and the weight of skins and seeds extracted from a known quantity of raw material,

the percentage of skins and seeds at a constant moisture level can be compared for different tomato varieties or processing treatments.

Equipment:

Numbered aluminum dishes with snug, numbered covers, 90cm dia. X 50 cm high

Oven, convection type, 100°C

Oven, vacuum, water heated, 70°C

Desiccator

Balance, analytical

Steam bath with 1/8 or 1/4" aluminum, brass or copper plate surface

Procedure:

Approximately 100 g. of skins and seeds are required for evaluation. Sample should be covered to minimize evaporation and cooled to room temperature prior to use.

Place aluminum lids and drying dishes (uncovered) in 110°C convection oven 2 hours to dry. Remove dishes from oven, cover and place in desiccator for at least 30 minutes to cool. When handling drying dishes, be sure hands are clean and dry. It is advisable to wear light (white) cotton gloves to reduce transfer of moisture and oils from hands to dishes. Weigh a covered dish to nearest 0.0001 gram and record weight. Add ~25 g of skins and seeds, replace lid and weigh to nearest 0.0001 gram as quickly as possible.

Samples should be evaluated in no less than triplicate and the results averaged. Place weighed samples, uncovered, on steam table. Remove samples when they appear dry. (Drying will be much slower than for liquid samples)

When all dishes are dry, place them in a 70°C water-heated vacuum oven following drying procedure described in "A. Determination of Total Solids". After drying, replace lids tightly, remove sample dishes and place in a desiccator to cool for 30 minutes. Weigh cooled dishes to nearest 0.0001 gram and record weight.

Calculation:

$$\% \text{ Total Solids} = \frac{(W_3 - W_1)}{W_2 - W_1} \quad \text{where}$$

W_1 = tare weight of dry dish

W_2 = weight of dish with wet sample

W_3 = weight of dish with dry sample

Due to lack of homogeneity within the sample, the replicate readings will probably differ more than those for product samples.

Prepare samples for soluble solids following the centrifugation and filtration procedure described in "B. Determination of Soluble Solids." Total solids samples are run "as-is", no additional preparation is necessary. Care should be taken that samples are well-mixed prior to evaluation.

Sample pads are pre-dried in the microwave prior to use. Two pads, one holding and one covering the sample are needed for each determination. Pads should not be reused.

Before pre-drying pads, remove any loose fibers which may detach during handling and cause erroneous results. Place two pads on top of sample cover screen in oven and press "AUTO TIME" button to begin drying cycle. After drying, place the two pads on balance ring. Tare balance by depressing "AUTO TARE" lever until balance read-out displays 0.0000 ($\pm$ 0.0002). Remove pads and deposit proper amount of sample (see table on preceeding page) onto rough side of one pad. For liquid samples (juice or serum), distribute sample onto as much of the pad surface as possible. For less fluid samples (sauce, paste, seed and skins), use a spatula to spread sample as thin as possible. Place second pre-dried pad on top of sample (rough side toward sample). Cover sample with this pad as quickly as possible to minimize evaporation. Invert pads and place on balance ring. Place cover over sample. Place two clean pads on top of cover screen to pre-dry for the next run. Close oven door securely. (If door is slightly open, oven will not operate). Display will indicate increasing weight for a few seconds, then weight will begin to decrease due to evaporation. As soon as weight decreases, press "AUTO TIME" button to begin drying cycle. Top display will indicate time remaining in drying cycle. Balance display will indicate net sample weight during drying.

When drying new products, (particularly high solids samples) watch weight display during drying cycle. The weight should be stable during the last

E. DETERMINATION OF SOLIDS USING A CEM MICROWAVE DRYING MOISTURE/SOLIDS ANALYZER

Abstract:

Total and soluble solids are evaluated by drying in a microwave oven with build-in analytical balance for weighing samples before, during and after drying.

Equipment:

CEM Microwave Drying Moisture/Solids Analyzer, CEM Corporation, Indian Trail, North Carolina 28079

Glass Fiber Sample Pads #20:20015 (CEM Corporation)

Small metal spatula, teflon coated

For soluble solids determination, centrifugation and filtration equipment described in "B. Determination of Soluble Solids" are also needed for sample preparation.

Procedure:

Approximately 20g of juice or 10g of paste are required for evaluation. Using the table below, adjust drying time and % power to proper settings for product to be evaluated.

Drying Schedule for Tomato Products

	Sample Size	% Power	Time
Juice	4g	100%	4 min
Puree (10-15°B)	2g	100%	4 min
Paste (20-35°B)	1g	40%	6 min
Seeds & skins	2g	40%	4 min

minute of drying to ensure that sample is dry. If sample is not dry and it is a high solids sample, prepare another sample for drying, taking care to spread sample extremely thin. Dry this sample, again observing whether weight is stable during the last minute of drying. If sample is not dry, increase drying time and repeat test.

After drying, record percent solids. If 4 decimal place calculation of solids is desired, it is necessary to record initial and final weights for each run. Run quadruplicate determinations for each sample and average the results. Remove used sample pads and check for burn. Burned pads result in erroneous readings. If pads are charred or brown, sample was dried too long, dried at too high a power, or too thick on pad. Make appropriate adjustments in drying schedule and repeat the test until a workable time - percent power combination is attained.

Seed and skin samples, in particular, may require extended drying times. Increasing the power above 40% for these samples generally results in burning and is not advised. These samples are the least reproducible; results for replicates will not be as consistent as for the more homogeneous paste, sauce and juice samples.

To dispense sauce or paste samples, a syringe is helpful in attaining the proper sample size. For these products, remove the plunger and fill the syringe from the top. Syringes can also be used to meter tomato serum samples, but should not be used for juice, which is subject to setting and may have particles which clog the opening.

Fig. 6.1. Dish No. 91 contains diatomaceous earth. No. 43 contains juice sample and No. 55 paste sample. After thoroughly mixing with diatomaceous earth, as in dishes 75 (juice) and 140 (paste), sample is evenly distributed over bottom of dish. (Note sharp reflection of lids, especially in No. 75).

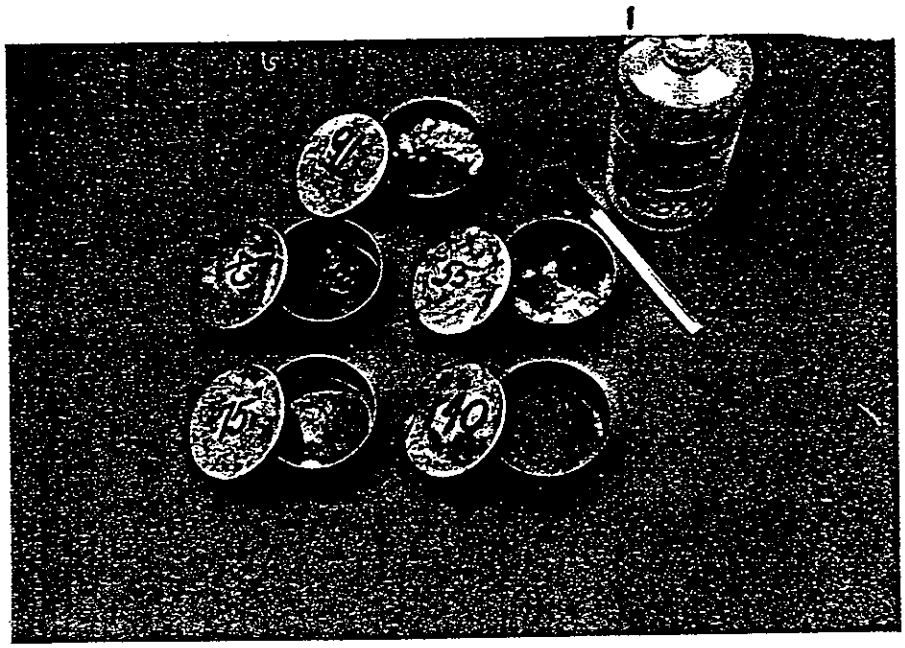


Fig. 6.2. Samples are evaporated to dryness over a steam hot plate. (Surface temperature of hot plate measured 80-83°C in a drying dish half full of heavy mineral oil.) Samples are at different stages of dryness. Dish No. 121 (bottom left center) is dry and has the characteristic vapor-free odor and dry appearance. Samples must be dry enough to prevent shattering of diatomaceous earth/sample cake in vacuum oven, but not overdried (burned) which causes chemical reactions, decomposition and/or evaporation of volatile solids.

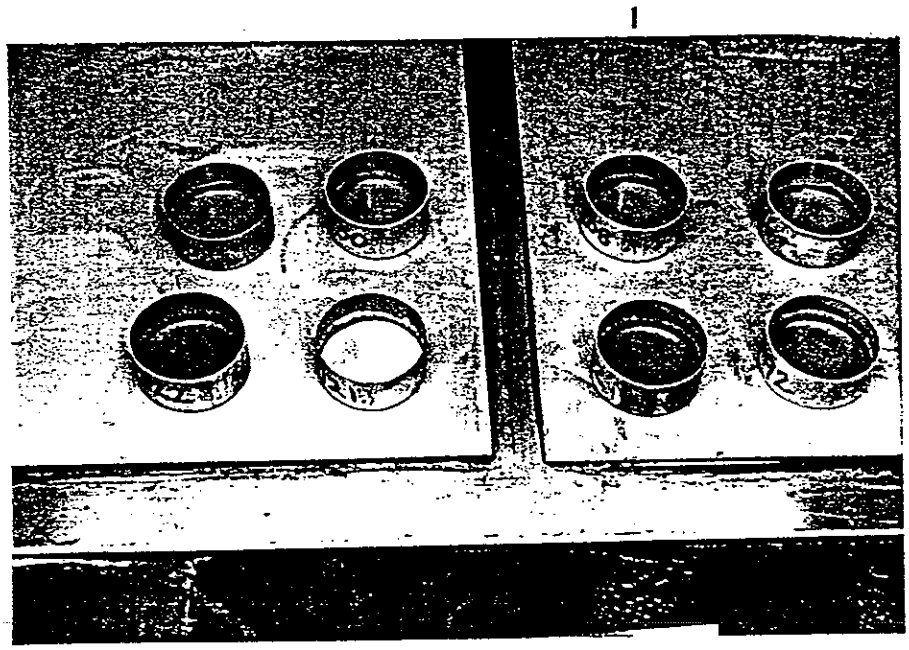


Fig. 6.3. Electric vacuum oven modified into a water heated unit. A. Thermometer B. Vacuum shut off valve C. Vacuum gauge D. Water heated plates. Plates are heated with water, which recirculates from a constant-temperature water bath located outside oven. This method eliminates surface temperature fluctuations normally experienced in intermittent electric heating.

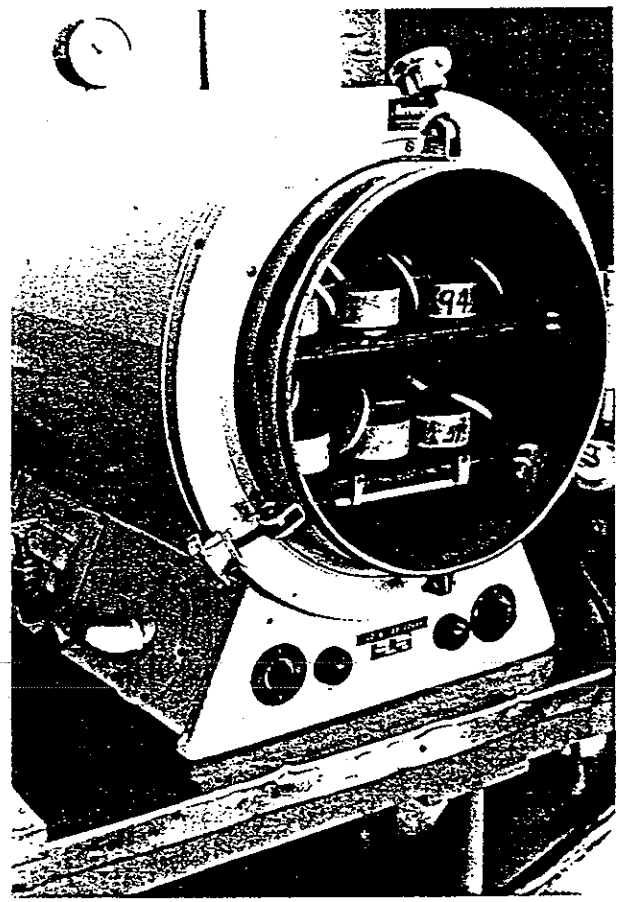


Fig. 6.4. Dishes are placed for maximum contact with heating surface. Lids so positioned can be replaced rapidly after drying. With lids snugly in place, dishes are quickly transferred to desiccators to cool prior to weighing.

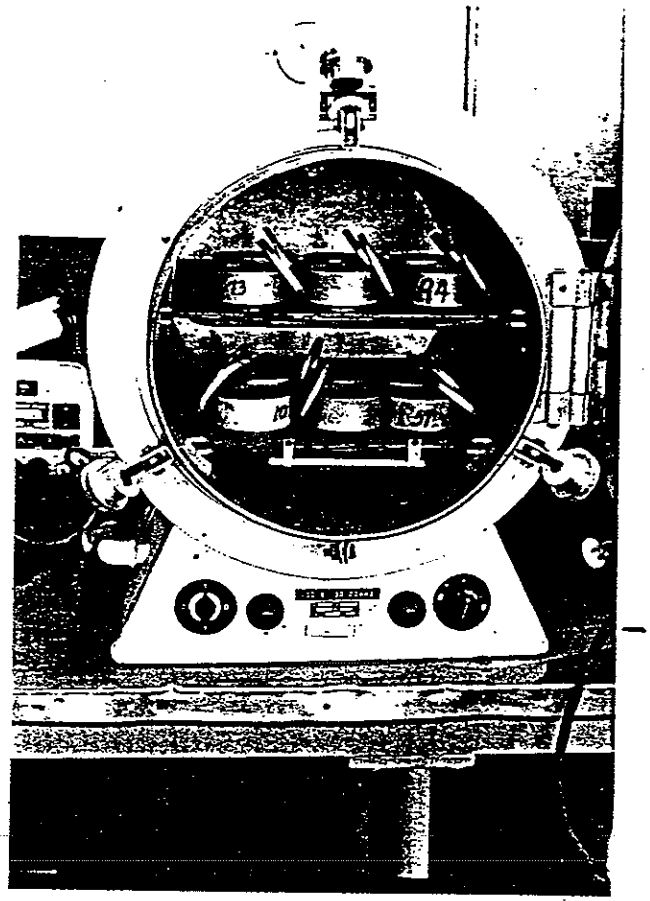


Fig. 6.5. Sorvall SS4 (Ivan Small, Inc. Norwalk, Conn.) centrifuge with interchangable heads and variable speed can be used to prepare serum for color determination, serum solids, or viscosity measurements. Centrifuge head A is used for 50 ml samples (serum color) and B is used for 250 ml samples (serum solids and viscosity measurements).

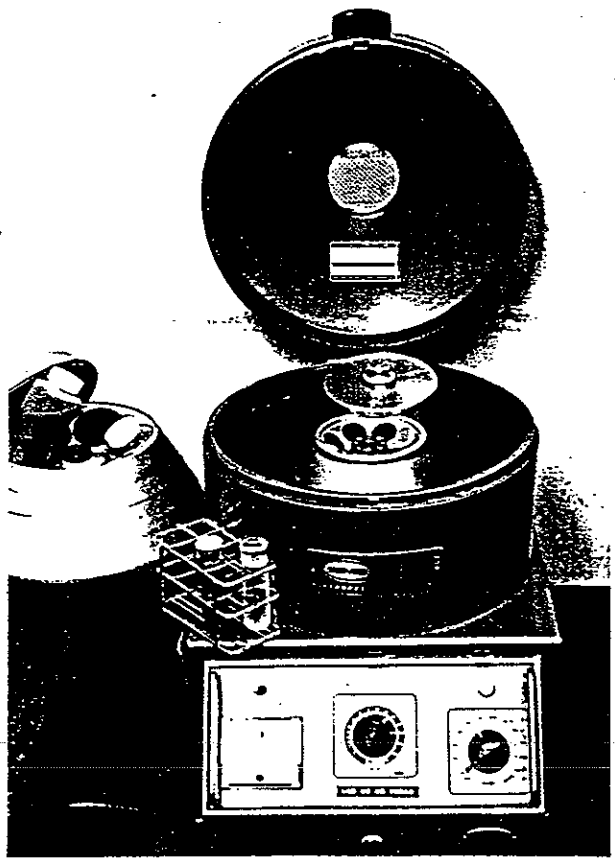
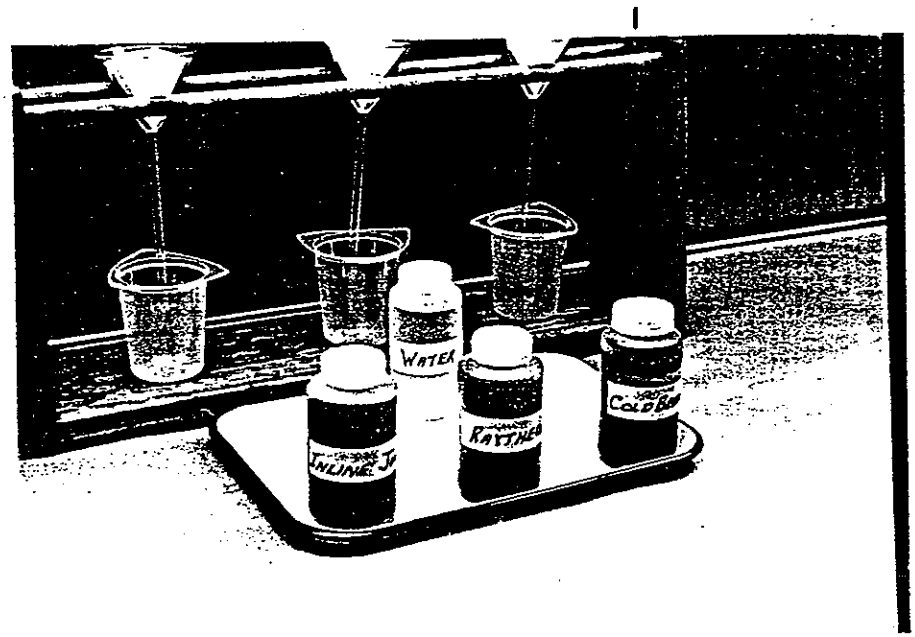


Fig. 6.6. Centrifuged juice samples are filtered to remove floating particulates. Serum clarity and color are influenced by method of sample preparation. Cold break serums are usually clear and straw colored; inline juice serum is usually cloudy and red, especially if steam injection hot break is used. "Raytheon" (microwave oven) serum is usually intermediate. (The "water" bottle was used to counterbalance in centrifuge.)



7. SOLUBLE SOLIDS IN TOMATO PRODUCTS BY THE PECTINOL FILTRATION, REFRACTIVE INDEX TECHNIQUE

Abstract:

Soluble solids is determined by measuring refractive index of serum obtained by filtration. Filtration is made possible through destruction of pectic material by a pectic enzyme.

Reagents and Equipment:

Refractometer, Abbe, with 20°C constant temperature bath

Filter paper, Whatman 12, fluted, 12.5 cm

Funnel, stemless, 75 mm, 60°

Flask, erlenmeyer, 250 ml

Petri dish

Pectic enzyme, pectinol R-10, Rohm & Haas

Beaker, 250 ml

Procedure:

Weigh 75 grams of tomato paste or juice into 250 ml beaker. Add 0.15 grams of Pectinol and mix well. Add 50 ml of water to empty 250 ml erlenmeyer flask. Place funnel with filter paper in neck of flask. Transfer tomato product to funnel and cover funnel with a petri dish. Let several drops of serum fall into water then quickly remove funnel from flask, let one drop fall on refractometer prism and replace funnel on neck of flask. Read refractive index or sugar scale value of serum. Wait five to ten minutes, sample a new drop of serum and measure refractive index or sugar scale. If the two values do not agree ($\pm$ 0.1°B), wait five to ten minutes and measure a new drop of serum.

Perform analysis on blank of 75 grams of sucrose solution which has about the same refractive index as the tomato product being analyzed.

Difference in readings before and after addition of 0.15 grams of Pectinol is the correction for Pectinol. Subtract this value from value obtained for tomato product.

Note:

Soluble solids in raw or processed tomato juice and low concentrates may be determined by refractive index method directly if serum separation is achieved through centrifugation of samples without adding pectinol. Pastes produced from hot break juices do not separate unless diluted. Centrifugation of juices is described in Sections 5, 6, 9 and 10. For correct use of refractometer, consult instrument manual.

8. DETERMINATION OF TITRATABLE ACIDITY IN TOMATO PRODUCTS

Abstracts:

Titratable acidity is determined by titrating diluted tomato product to pH 8.00 with 0.1 N NaOH.

Reagents and Equipment:

Sodium Hydroxide solution, 0.1 N, normality established to ± 0.0001 N.

Beaker, 250 ml, plastic "Tripour".

pH meter, glass-calomel electrode system.

Stirrer, magnetic, with Teflon coated magnetic bar.

Balance, analytical.

Burette, 25 ml, polished glass with two-way Teflon stopcock.

Procedure: Approximately 100g of juice or 50g paste are required for testing.

Weigh 250 ml beaker using analytical balance. Add well mixed tomato product using the following table as a guide for sample size, and reweigh immediately to minimize evaporation loss. All weighings are made to the nearest 0.0001 gram.

SAMPLE WEIGHT

Sample Type	Sample Weight, grams
Juice	25
Paste, 10%	12-15
16%	9-10
25%	5-6

Add distilled deionized water* a few drops at a time, blending thoroughly with a rubber policeman between additions, until sample is fluid and pourable. Add water to bring sample volume to 100 ml as marked on beaker. Introduce a magnetic stirring bar, stir, then titrate with 0.1 N NaOH to pH 8.00. Continue stirring during titration. Titration apparatus is shown in Fig. 8.1. Titration to pH 7.0 can be done quickly by permitting free flow of titrant from burette. When pH 7.0 is reached, flow of titrant is slowed, or it is fed intermittently by rapidly turning stopcock on and off until pH 8.00 is reached.

Calculation:

$$\text{TA (Milliequivalents/100 g sample)} = \frac{\text{ml} \times \text{N} \times 100}{\text{sample wt.(g)}}$$

Percent citric acid = TA x .06404

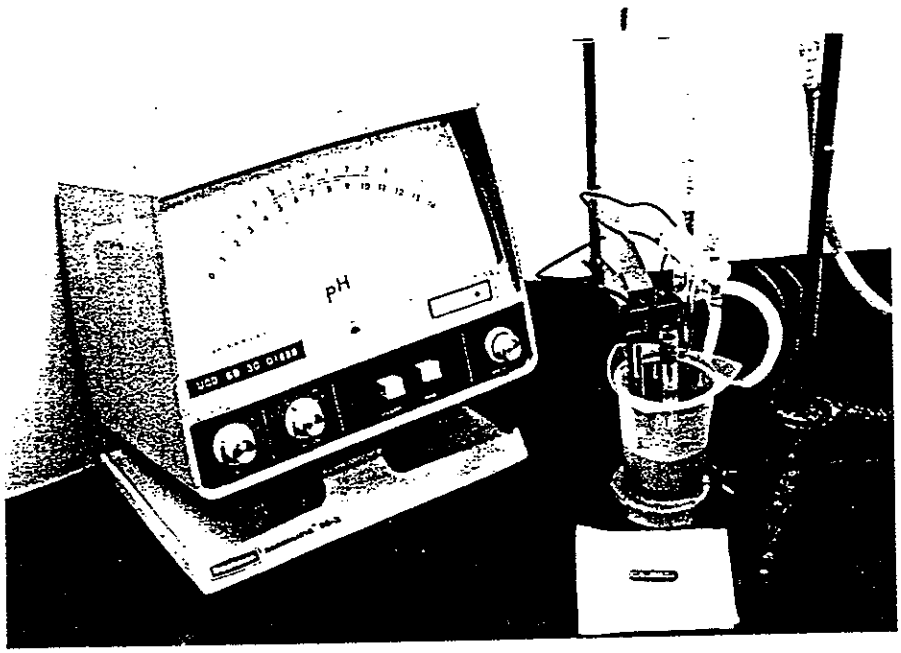
Three separate evaluations are made for each sample, and the results are averaged. If individual determinations differ by more than .0024% citric acid, titrate additional sample.

citric acid 192.12

*Deionized distilled water is tested each day by titrating a 100 ml portion with 0.1N NaOH to pH 8.00. If water requires more than 1-2 drops (0.1 ml) to raise pH to 8.00, deionizer and sample containers may require cleaning, adjusting, or changing.

Fig. 8.1. A basic set up for determining titratable acidity.

A. pH meter; B. Glass-calomel electrode system; C. Burette with 0.1N NaOH; D. Water-driven magnetic stirrer; E. Plastic beaker with sample; F. Teflon-coated magnetic stirring bar.



9. TOMATO SERUM VISCOSITY AND % PECTIN RETENTION DURING PROCESSING

Abstract:

Serum viscosity potential of tomatoes is determined after microwave heating to inactivate pectic enzymes. Tomato serum is prepared from inactivated juice or conventionally processed juice by centrifugation and filtration. Serum viscosity is determined by measuring flow time in an Ostwald-Cannon-Fenske viscometer. Comparison of serum viscosities of microwave enzyme inactivated juice and conventionally prepared juice from the same raw material enable determination of % pectin retention of the conventionally processed juice.

Equipment:

Radarange, Model 1161, 2450 MhZ, two magnetron type, each magnetron 800 Watt or equivalent, (Raytheon Co. Address unknown)

Beaker, glass, 1000 ml

Dish with cover, Pyrex, 3 qt. #026

Balance, 3Kg capacity, accurate to 0.1 gram

Pulper-Finisher, 0.033 screen, Food Processing Equipment Co., Kalamazoo, Mich.

Pan for ice bath, enamel or plastic, 12" x 16" x 4" deep

Centrifuge, International, size 2, Model V, or equivalent

Centrifuge bottles, 250 ml, Nalgene

Filter paper, S&S 520 B½, 12.5 cm diameter

Funnel, analytical, 60°, long stem, 75 mm

Filter paper, glass fiber, 25 mm diamter, Gelman type AE

Syringe filter holder, 25 mm, Gelman #4320

Hypodermic syringe, 25 cc

Water bath, 30 ± 0.5°C

Viscometer, Ostwald-Cannon-Fenske, size 100

Rubber tubing to fit viscometer tube

Timer, ± 0.1 sec.

Pail, plastic, ~1 gal. capacity to receive juice from pulper

Procedure:

Microwave heating to inactivate pectic enzymes. Approximately 2½ lb of clean, dry, whole tomatoes are required for testing. Set 1000 ml glass beaker containing 500 ml distilled water in back of microwave oven chamber to protect magnetrons. Turn oven on so it will be ready to use when tomatoes are prepared. Place 2.5 pounds of tomatoes one layer deep in Pyrex dish (Fig. 9.1), and weigh without lid (± 1 g). Cover dish and place in center of Radarange chamber (Fig. 9.2). Set timer for nine minutes and start oven on "high" setting. After six minutes change setting to "low". When cook is complete tomatoes should be soft, with loose skin (Fig. 9.3). Re-heat in three minute increments on "low" setting if any firm tomatoes remain. Remove dish and place in pan containing approximately 2 in. ice until tomatoes reach 30°C. Ice level should be kept ½-1 in. below rim of dish. If too much ice is used, water may overflow into samples. Remove dish, dry outside, and place (lid removed) on balance. Rinse condensate and tomato splashed on lid into dish and adjust for evaporation loss by adding distilled water to achieve initial weight. Stir and pass this tomato material through pulper two times (Fig. 9.4). It is critical that this juice is not contaminated by raw juice with active enzymes. Juice container, spoons, beakers, centrifuge bottles, funnels and other equipment contacting

the juice should be used only for microwave-treated juice with inactive enzymes. Stir well and take a sample for serum preparation.

Serum viscosity determination. Approximately 100 g of tomato juice is required for testing. Fill a centrifuge bottle with tomato juice and centrifuge at 2000 RPM for fifteen minutes. Decant supernatant serum and filter through S&S 520B ½ paper in an analytical funnel. This filtrate is then re-filtered through a glass fiber filter, as follows (Fig. 9.5). Prepare a filter holder with glass fiber filter disc, and fill a hypodermic syringe with filtrate. Attach filter unit to syringe, then use syringe to force serum through filter, delivering it directly into small arm of inverted viscometer tube until both bulbs and the capillary have been filled. Incorporation of air bubbles into tube can generally be avoided by holding filter and tube together firmly (Fig. 9.6). Do not fill tube more than three millimeters beyond the end of capillary. After filling, quickly turn tube upright, and wipe lip of side arm. Place tube in 30°C water bath (Fig. 9.7). Allow temperature to equilibrate for at least five minutes or until sample drains into reservoir bulb. Attach rubber tubing to small arm of tube and apply a light suction to draw serum above upper timing mark. Do not draw serum more than 5 millimeters above timing mark as this will introduce drainage error. Release suction (leave rubber tubing in place) and measure the time required for meniscus to fall from upper to lower timing mark. Repeat timing, using same sample. Replicate times must check within 0.4 second. Serum viscosity is reported as centistokes (cs) using the following equation:

cs = flow time (sec) x k (calibration constant of viscometer tube)

Note: Centipoise (CP) may be calculated by multiplying cs by density of solution (grams/cc).

It is critical that viscometer tubes are cleaned thoroughly and dried completely between samples. To clean, attach small arm of tube to water aspirator to withdraw serum. After aspiration begins, feed deionized, distilled water into larger arm of tube to facilitate rinsing. Continue aspiration, filling bulbs several times with water until all serum is removed from tube. To facilitate drying, repeat rinsing 3 or 4 times with acetone. Hang tube inverted to dry or attach with hose to dry air source at minimal flow rate. Before attaching to air hose, adjust air flow so that if hose is pinched to restrict flow and held up to your lips only a gentle breeze is detectable. If air flow is too rapid, pressure build-up in viscometer may result in shattering. Tube should be dry and ready for re-use after 20 min.

The manufacturing process for tomato juice may result in dilution or concentration of the product, with a concurrent change in serum viscosity. Using semi-log paper, it is possible to calculate the viscosity of the juice as if it had maintained the raw material solids level, that is, if there were no change in concentration. Figure 9.8 illustrates this procedure. Plot % soluble solids of steam injection sample on linear axis and corresponding serum viscosity on logarithmic axis. Draw a line between that point and 0.0% soluble solids, 0.85 cs (viscosity of water). Using solids level of microwave heated juice, obtain extrapolated serum viscosity for undiluted (raw material) solids level. From this data, calculate pectin retention with the following equation:

$$\% \text{ pectin retention} = \frac{\log_{10} (\text{line juice SV}) - \log_{10} 0.85}{\log_{10} (\text{Raytheon juice SV}) - \log_{10} 0.85} \times 100$$

In the example above,

$$\% \text{ pectin retention} = \frac{\log_{10}(3.34) - \log_{10} 0.85}{\log_{10}(3.41) - \log_{10} 0.85} \times 100 = 98.3\%$$

The microwave-heated juice sample is undiluted and its viscosity is assumed to represent 100% retention of pectic materials. In commercial practice, if pectin retention exceeds 85%, the problem of serum separation in the product will be minimized.

Fig. 9.1. Arrangement of tomato sample in 3 qt dish is illustrated. Largest tomatoes are placed in center and smaller ones toward side. Total weight in grams (without lid) is indicated.

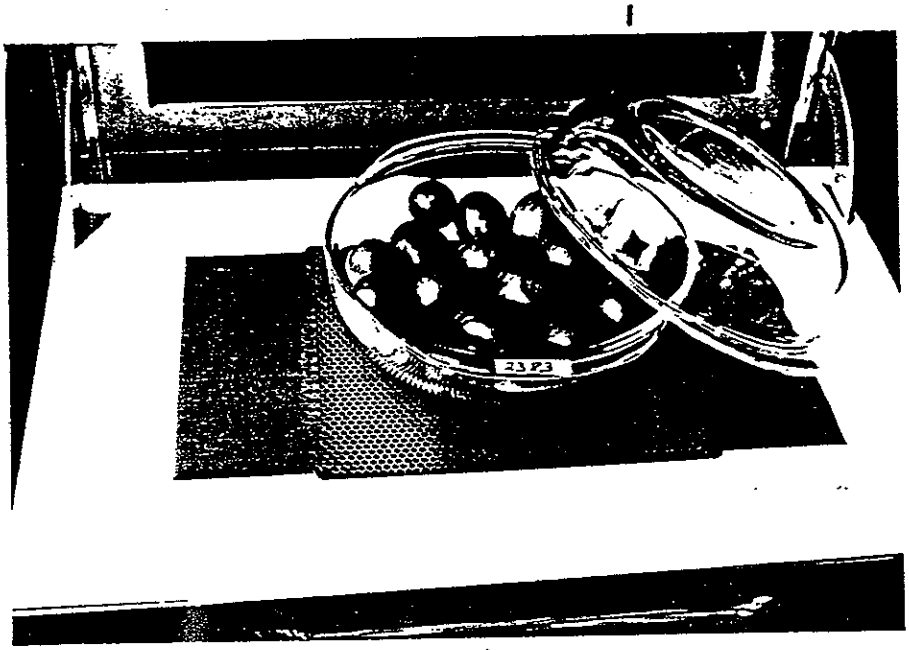


Fig. 9.2 Sample (A) is placed in center of chamber. Water in beaker (B) is a precautionary measure to prevent overload and magnetron burn out.

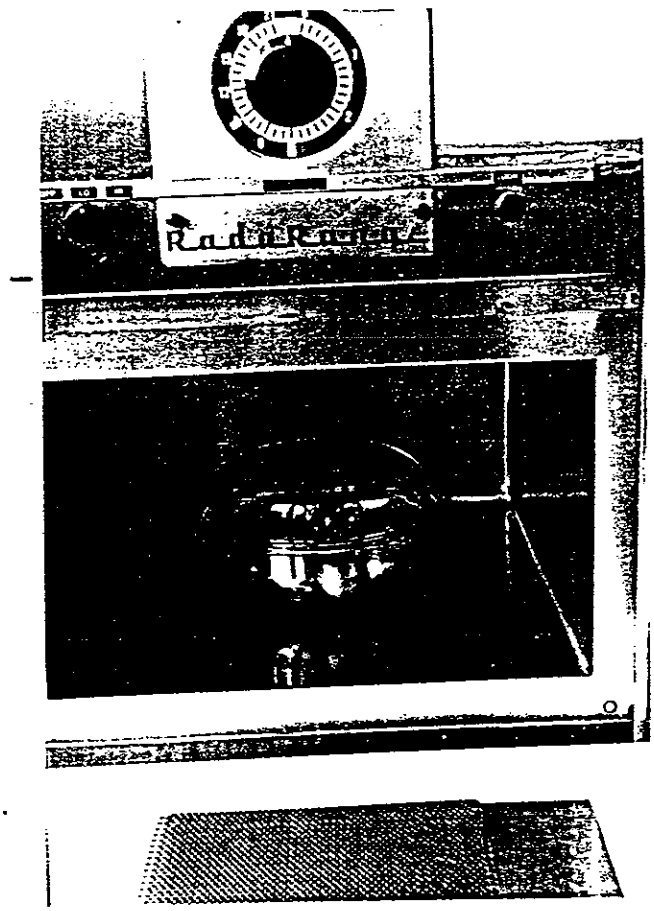


Fig. 9.3. Sample (A) is raw and (B) is completely cooked. Some tomatoes in B appear whole as in raw sample, but they would collapse if touched.

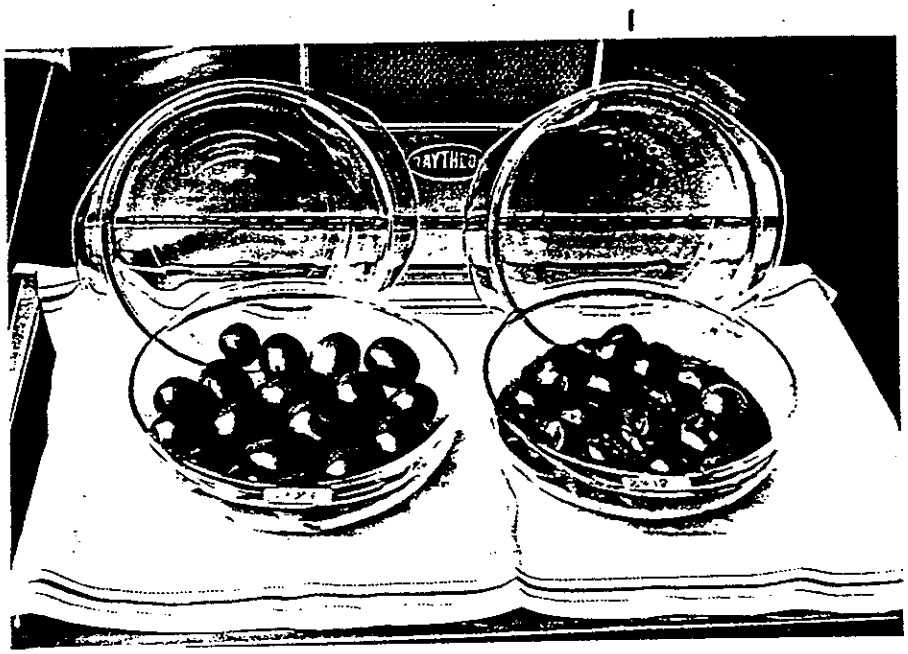


Fig. 9.4. Cooled cooked tomato sample with water added to original weight is fed into funnel (A). Juice exits through B and is collected in container. Seeds and skins are discharged through C and collected. The pulp container is clearly labeled and must not be contaminated with any raw juice which would have active enzymes. In case of possible contamination, container should be blanched or sterilized to inactivate residual enzymes prior to use.

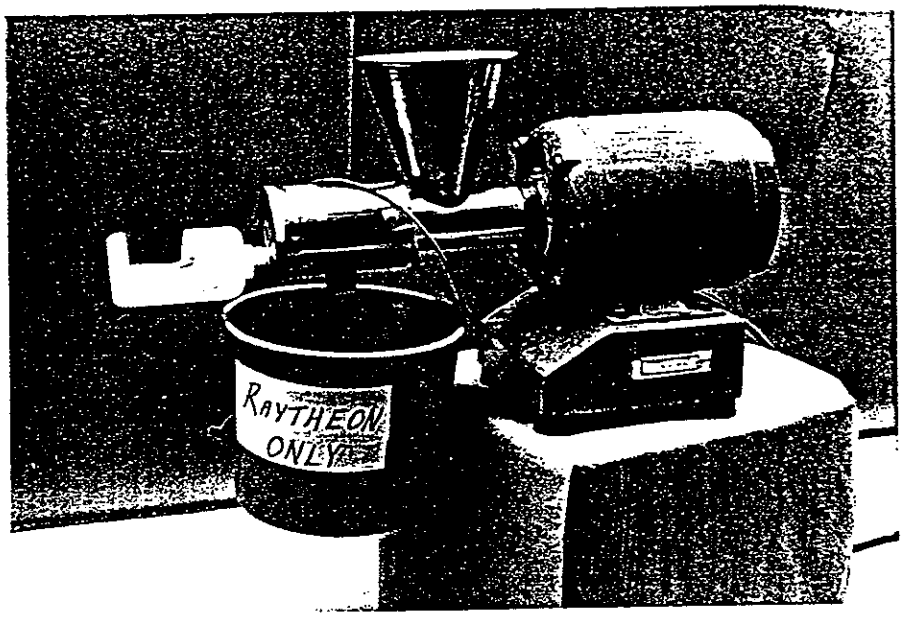


Fig. 9.5. Ostwald-Cannon-Fenske Viscometer (A). 25cc syringe (B) with Gelman filtration apparatus (C) attached. Filtration apparatus is shown disassembled with glass fiber filter in the center (D).

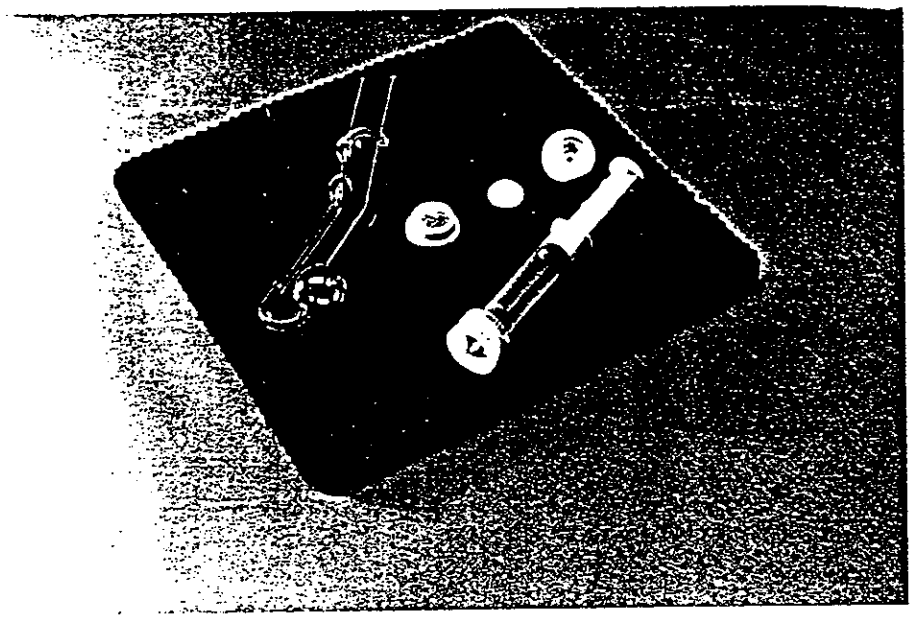


Fig. 9.6. Viscometer is held close to point of filling to minimize strain on sensitive (bended) areas and joints.

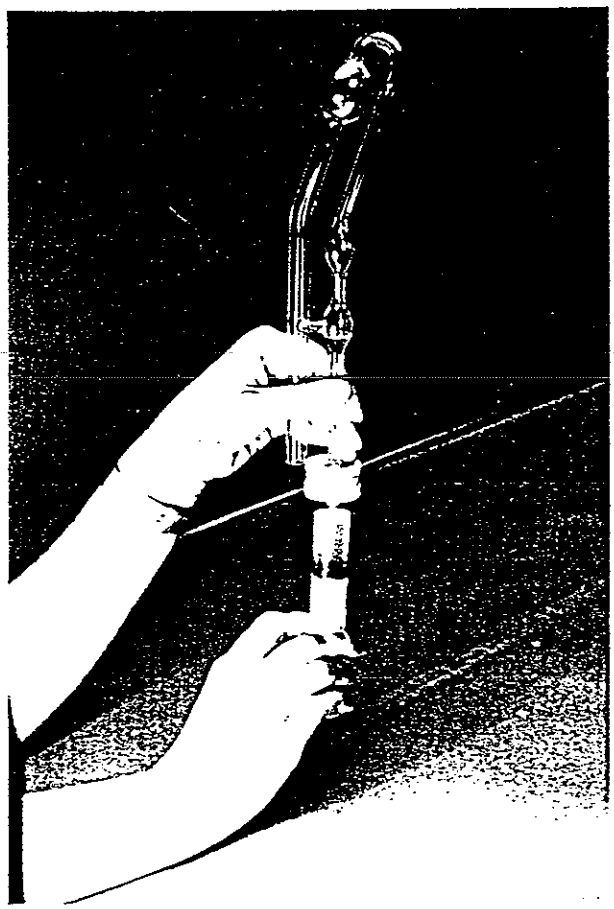


Fig. 9.7. Viscometer (A) in constant temperature water bath. Gentle suction is applied by mouth via attached surgical or similar tubing (B). Examples of timing devices (C), temperature controlling thermometer (D) for constant waterbath, and electric stirrer (E) used to achieve even heat distribution in water bath are shown.

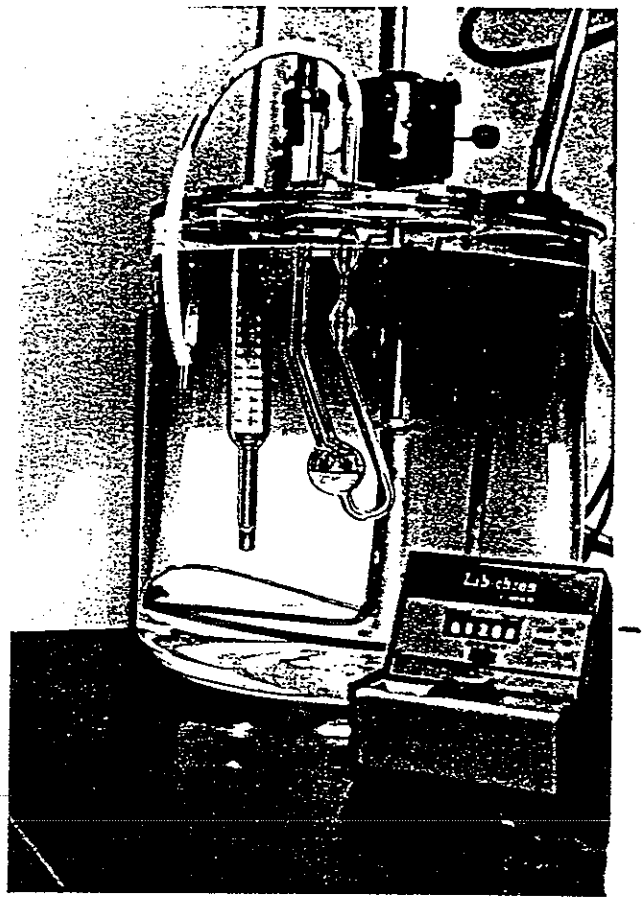
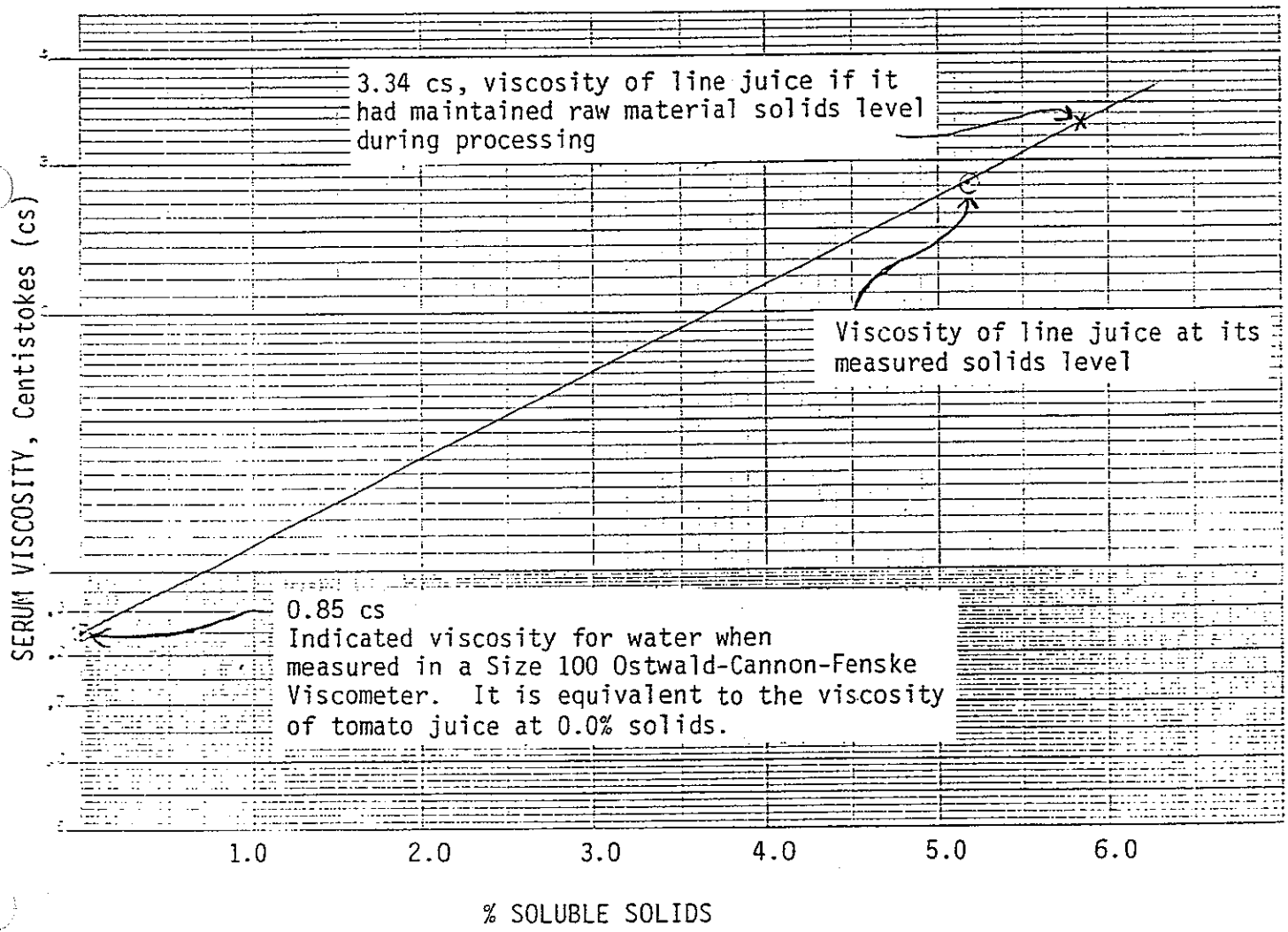


Fig. 9.8 Serum Viscosity and % Pectin Retention

Plot % soluble solids of line juice (linear axis) and corresponding serum viscosity (logarithmic axis). In example, this point is (5.18%, 2.83 cs). Draw a line between that point and 0.0% soluble solids, 0.85 cs (viscosity of water, or tomato juice at 0.0% soluble solids). Using soluble solids of microwave heated (Raytheon) juice, 5.85% in example, obtain extrapolated serum viscosity for undiluted solids level, 3.34 cs.

	Soluble Solids %	Serum Viscosity cs
Raytheon juice	5.85	3.41
Line juice (steam injection hot break)	5.18	2.83



10. DETERMINATION OF TOMATO SERUM COLOR

Abstract:

Tomato serum is prepared from whole juice (or product diluted to 5°B) by centrifugation and filtration. Serum color is determined on a Colorimeter at 420μm in a 1 cm cell.

Equipment:

Centrifuge, Sorvall SS-4, with 50 ml centrifuge tubes and corresponding head and rotors or Adams Ultracentrifuge or equivalent.

Filter paper, Whatman 2, or Gelman GF-E, 1" dimaeter

Filter paper, Gelman Metricel GA-8, 0.2μm, 1" diameter

Syringe Filtration apparatus, Gelman 1" with 25 cc syringe

Colorimeter, B&L Spectronic 70, 1 cm cells

Procedure:

Sample Preparation

Between 10 and 50g of tomato juice or diluted product are required for this test.

Sorvall Centrifuge

Fill centrifuge tube with approximately 45 grams of tomato juice (raw or processed) or diluted tomato product. Tubes must be weighed to balance because of high rotational speed. Centrifuge at 18,000 RPM for 30 minutes. Draw serum into syringe. Attach syringe filter holder which has been assembled in the following order:

1. Outlet screen half
2. Metricel GA-8, 0.2μm filter
3. Whatman 2 or Gelman GF-E glass fiber filter
4. Inlet half

Ultracentrifuge

Fill centrifuge rotor with approximately 10 ml of tomato juice (raw or processed) or diluted product. Centrifuge at 30 psig for 10 minutes. Draw serum into syringe. Attach syringe holder which has been assembled with Metricel GA-8, 0.2µm filter.

Use of Colorimeter

Clean colorimeter cell by rinsing with deionized distilled water, then with acetone. Dry cell with vacuum or cleaned compressed air. Clean outside of cell with soft tissue. Standardize colorimeter and cell at 420µm (100% absorbance with empty cell and 0% absorbance using deionized distilled water). Clean and dry cell. Syringe serum through filters into cell. Serum should be crystal clear. If it is not, remove serum, clean and dry cell and repeat filtration step with new filters. Measure optical density of serum. Clean and dry cell, then repeat optical density measurement with water. If water does not read 0.00% absorbance, check cleaning procedure. If necessary, restandardize and repeat serum color measurement on product. Recheck with water. Higher absorbance corresponds to increased heat damage to tomato product.

11. BOSTWICK CONSISTOMETER DETERMINATION OF TOMATO PRODUCT CONSISTENCY

Abstract:

The Bostwick consistometer is a stainless steel trough with a reservoir and gate at one end. Tomato paste is filled into a reservoir and released into trough by opening gate. Paste flow in the trough after 30 seconds is measured in centimeters and is reported as Bostwick consistency.

Equipment:

Bostwick consistometer

Level, torpedo ~6" length to use in consistometer

Timer, seconds

Thermometer, Weston dial type, 0-50°C

Ice water

Hot tap water

Scraper with straight edge

Spoon, stainless steel

Procedure: Approximately 300g of diluted paste (12% NTSS) are required for this test.

Tomato paste more concentrated than ~15% NTSS does not flow far enough to obtain reliable, discriminating Bostwick values. For consistency determination, the paste should be diluted to 12% NTSS prior to Bostwick determination. At this level, consistency differences resulting from varietal differences, process variations or other factors will be measurable.

A procedure for dilution of paste to 8.5% NTSS is presented in Section 5. Using the amount of paste specified by the following equation, follow that procedure to obtain 310g diluted product at 12% NTSS:

$$\text{g. paste} = \frac{3750}{\%\ \text{NTSS of paste}}$$

Close consistometer gate and adjust leveling screws so bubble indicates instrument is level from side to side. Place a torpedo level in the trough and level from end to end. (Fig. 11.1) It is critical that trough is level. Adjust tomato paste to 25 ± 1°C* using ice or hot water baths. (Fig. 11.2) Stir thoroughly while adjusting temperature, as heat transfer is poor.

Fill reservoir to overflowing with tomato paste, and level paste to top of reservoir using a straight-edge. Clean-up is facilitated by placing disposable plastic wrap on counter beneath reservoir. Fig. 11.3 shows correct method for releasing gate. Timer should be started before reservoir is filled, so starting time can be read immediately since both hands are needed to trip gate. Press gate release and note time. After gate is released, remove both hands from Bostwick. Record the flow distance (to nearest 0.1cm) thirty (30) seconds after release. (Fig. 11.4)

Filling, leveling and releasing must be done rapidly to prevent separation of serum. The separated serum acts as a lubricant causing faster flow. Wash consistometer in room temperature water and dry it very thoroughly between runs. Invert consistometer and shake vigorously to expel water in gate springs. Close gate and check for dryness. If Bostwick is not completely dry, puddles will form at edges of gate.

Run duplicate measurements on each sample. If values differ by more than 0.1cm, take a third measurement. Record average of the readings.

*USDA standards specify a temperature of 20°C. This temperature is difficult to maintain with a large number of samples in a laboratory situation; consequently, the temperature was raised to 25°C.

Plexiglass Juice Consistometer

The commercial metal Bostwick has a 24 cm trough. This distance is adequate for consistency measurement of concentrated product. However, for determining juice consistency a longer trough is necessary. A 50 cm experimental plexiglass consistometer, with other inside dimensions identical to those of the Bostwick consistometer was constructed by shop personnel in our department. Graduations were marked at 1 cm increments to measure product flow in trough. Instead of the spring-actuated gate of the commercial Bostwick, the plexiglass device has a plastic gate which fits into a groove and is removed manually after the reservoir is filled.

Juice measurements using the plexiglass consistometer are made following procedures for the Bostwick consistometer. If raw juice is used, care must be taken to standardize the length of time between grinding samples and measuring flow. The consistometer should be washed in cold water and must be thoroughly dried and leveled before each run. Product temperature must be adjusted to 25° ± 1°C. Duplicate measurements should be taken and the results averaged. If juice values differ by more than 0.5 cm, make a third measurement.

Fig. 11.1. The Bostwick consistometer is levelled using both built-in indicator (A) and torpedo level (B) in trough.

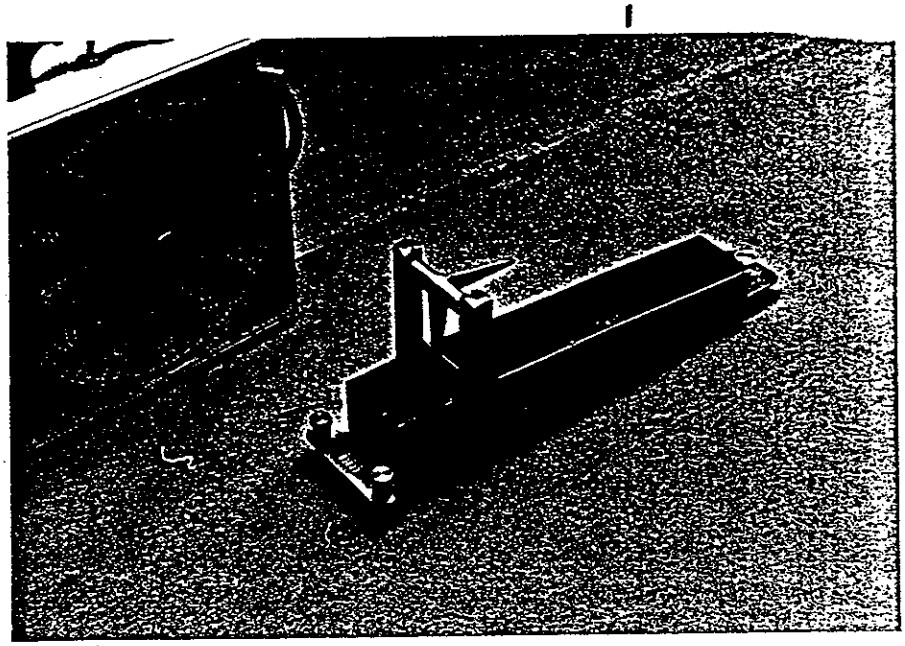


Fig. 11.2. The gate is closed, consistometer is levelled and sample temperature is 25°C.

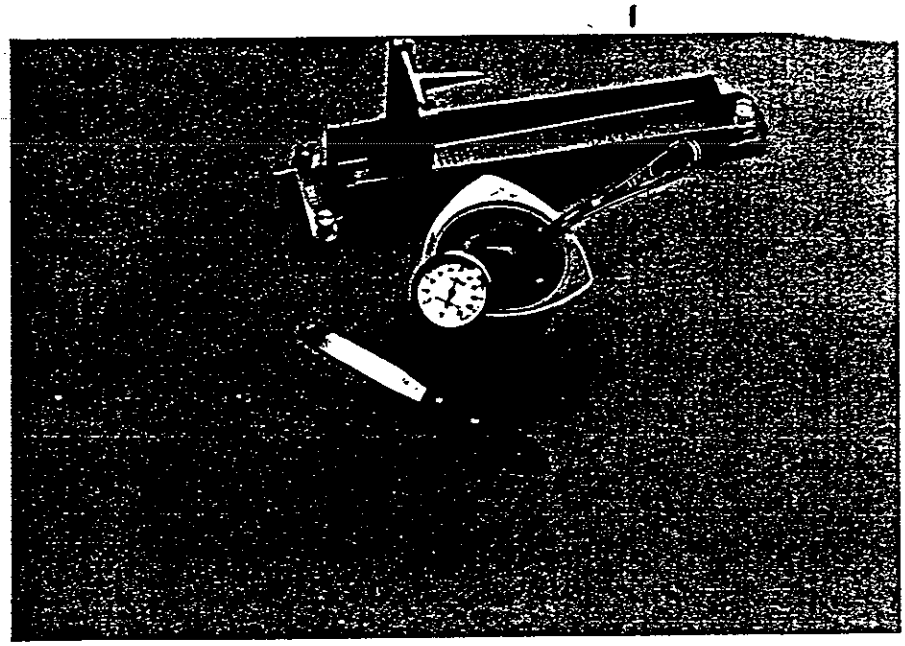


Fig. 11.3. Reservoir is filled and paste has been levelled to top of reservoir. Consistometer is held down with one hand to prevent it from bouncing as gate is released.

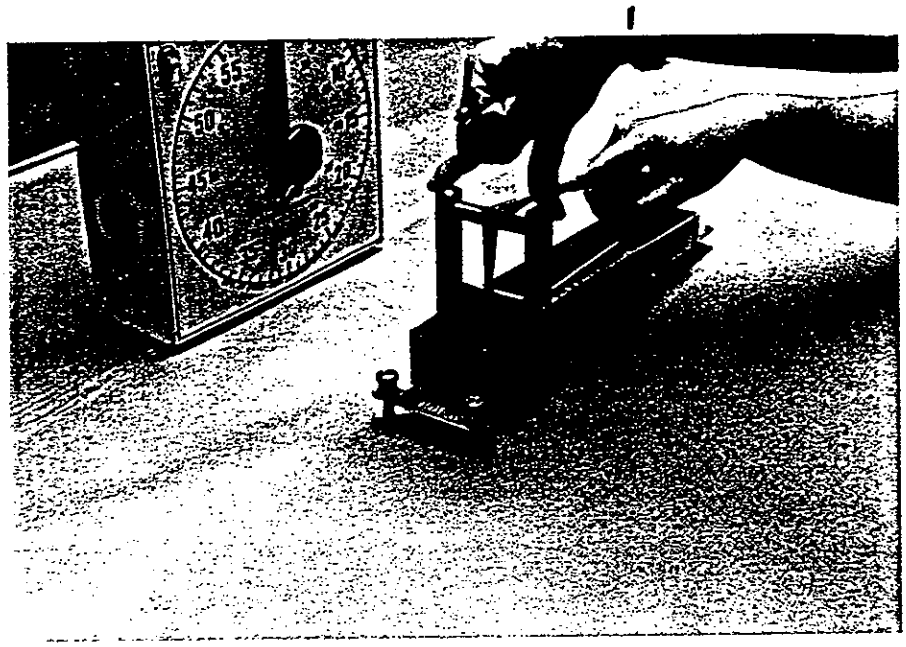
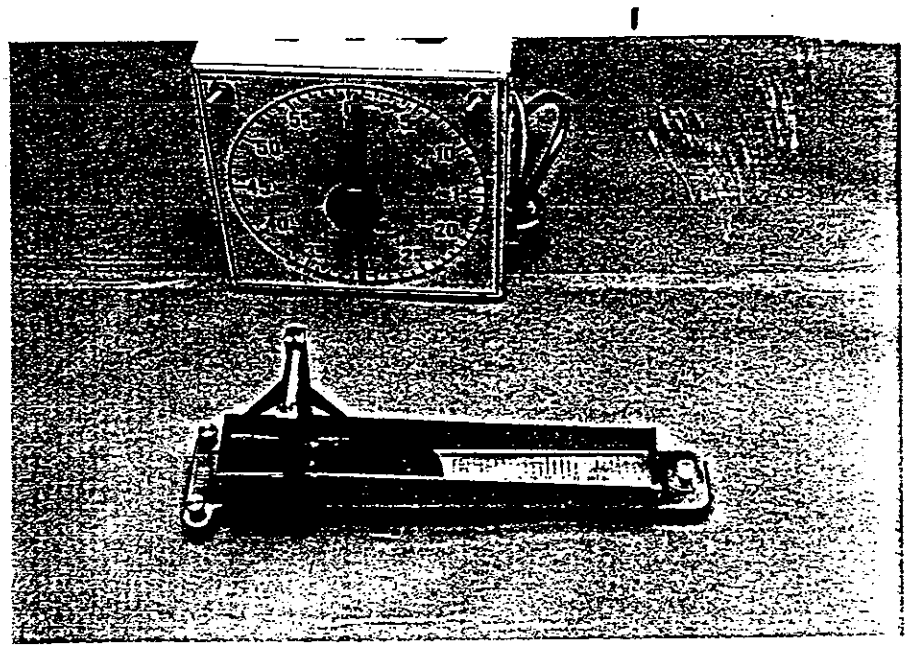


Fig. 11.4. Flow distance thirty seconds after gate release is recorded as Bostwick consistency.



12. BLOTTER TEST FOR SERUM MOBILITY IN TOMATO PRODUCTS

Abstract:

Serum mobility in tomato products is determined by measuring migration of serum from a standardized quantity of product placed on blotter paper.

This method is an easy means to estimate relative amounts of soluble polymers (mostly pectins) in concentrated tomato products. It appears to measure the same qualities in catsup that serum viscosity measures in juice, however, we have not extensively investigated the test for use on tomato puree or paste. Investigations have shown that the method has promise as an in-plant control technique for estimating effectiveness of hot break systems. However, as yet no quantitative relationships have been developed. When using the method for this purpose, solids concentration of tomato product tested must be adjusted to a standard level somewhere between 15 and 20%.

Equipment:

Syringe, 10 ml, plastic, with orifice enlarged to 12 mm.

Blotter paper, 0.6 mm thick, 4-12" squares with 40 mm dia. circle drawn in center.*

Caliper, metric

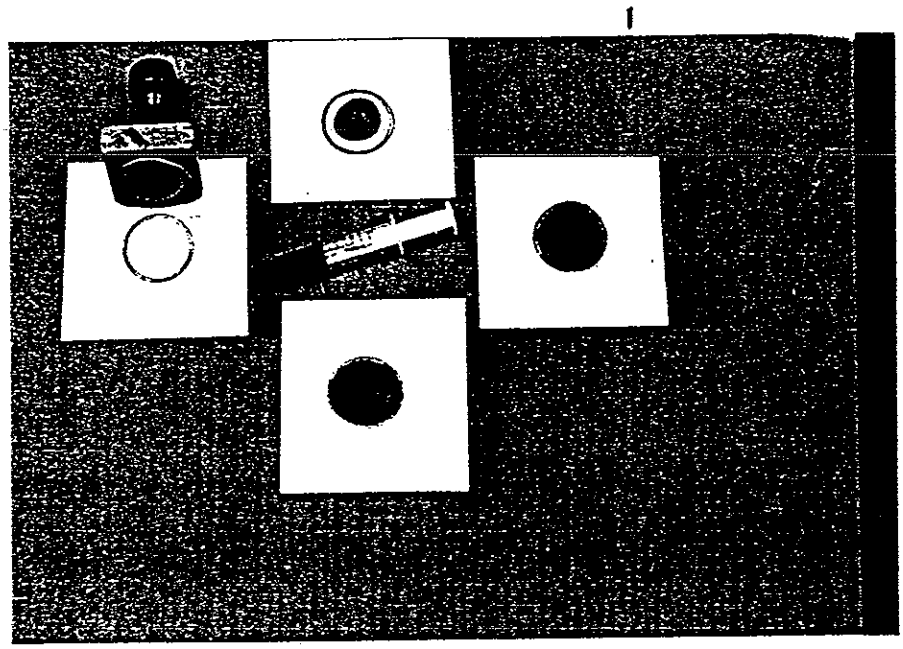
*Blotter paper must be highly uniform in absorptiveness from one lot to another. We recommend that purchases be made in large quantity from a single lot to avoid frequent re-evaluation of the paper. Heavy chromatography paper may be used in place of blotter paper. A custom-made rubber stamp and conventional stamp pad are useful to obtain consistent circles on blotter sheets.

Procedure:

This test requires 5 ml of tomato product. Fill syringe to 5.0 ml with tomato product and deliver material onto center of blotter. Tap or tilt blotter gently to exactly fill circle with tomato product. Leave blotter on a level surface for several days until it has dried, then measure diameter of area wetted by migrating serum along two perpendicular axes. Average these two values. Figure 12.1 illustrates these steps.

To expedite test, readings may be taken at some specified time greater than 15 minutes rather than waiting for blotters to dry.

Fig. 12.1. Initial area for sample is stamped on blotter paper (A). Product (5 ml) measured using a syringe (B). Product is placed on blotter paper (C) which is tilted and tapped until sample material completely fills circle (D). After sample has dried (E), diameter of area wetted by sample and serum is measured.



13. PROCEDURE FOR MAKING STANDARDIZED BATCHES OF CATSUP

Abstract:

This method determines the amount of tomato solids required in a standard formulation to produce catsup batches with 33% total solids which test 6 Bostwick.

Supplies and Equipment:

Balances, Torbal PL-12 or equivalent, minimum capacity 1600 g, accuracy ± 0.1 g Ohaus 311 or equivalent, minimum capacity 1 g, accuracy ± 0.01 g.

Saucepan, thick-walled aluminum, three pint, light enough to be tared on balance with stirrer included.

Stirrer, Wooden, spoon type with straight scraper edge, light enough to be tared with saucepan.

Hot Plate, 8 inch diameter or larger; must produce sufficient heat to bring tomato feed stock to 88°C in eight minutes.

Thermometer, Western metal stemmed dial type, 0° to 100°C.

Consistometer, Bostwick.

Sucrose, cane sugar, standard particle size.

Sodium Chloride, common table salt.

Catsup seasoning, Stange Company #72061.

Vinegar, white, 100 grain.

Timer, seconds.

Glove, cotton, to prevent splatter burns.

Straight edge.

Procedure: To complete this test approximately 1300 g of 24% NTSS tomato product or proportional amounts at other concentrations are required.

Three 800 gm. batches of catsup with 33 percent total solids are produced to complete the test. The first batch is formulated to contain 25 percent

of the 33% total solids as tomato solids, and the second is formulated to contain 40 percent of total solids as tomato solids. From Bostwick values on those two catsups, the tomato solids required to produce 6 Bostwick catsup is calculated. This third batch is produced and evaluated for verification.

Before catsup can be made, the total solids of the paste to be used must be determined. It is important that samples for total solids determination is representative of entire sample of paste to be used for catsup. Therefore, a sufficient number of cans of paste for the three catsup batches should be opened, mixed well and sampled for solids determination. Up to 1300 g of paste (24% NTSS) are required for the 3 catsup batches. Higher solids concentrates will require proportionately less. Generally, cans of paste are opened one day for total solids determination, (Section 6) and remaining paste is refrigerated in closed containers until the following day when catsup is made.

Formulations for the first two catsups are given in Table 13.1.

Table 13.1

Catsup Formulation

(Weights for 800 gram batch)

	Batch 1 25% tomato solids		Batch 2 40% tomato solids	
Tomato	$\frac{6600}{\%\ TS^*\ of\ paste}$	g	$\frac{10560}{\%\ TS^*\ of\ paste}$	g
Sugar	176.9	g	137.3	g
Salt	15.8	g	15.8	g
Vinegar @ 10.22%	45	g	45	g
Spices	0.66	g	0.66	g
Feed stock wt.	580	g	610	g
Final weight	800	g	800	g

* % TS is total solids determined by drying (Section 6).

Tare weigh saucepan and stirrer. Add well-mixed tomato paste to calculated weight. Add water a little at a time to reach feedstock weight. Thoroughly mix in water after each addition to minimize lumpiness.

Weigh sugar, salt, vinegar and spices into separate beakers and cover. Add approximately 10 ml water to spices.

Heat feedstock on hotplate as rapidly as possible, stirring constantly. A wire screen may be placed on top of hotplate to distribute heat more evenly and prevent burning. Feedstock should reach 88°C after five to eight minutes of heating. Adjust heat if necessary to achieve this heating rate. As temperature approaches 88°C, stir very vigorously to minimize splattering. Wear a cotton glove on the "stirring hand" to prevent splatter burns. When product reaches 88°C, remove pan from hotplate, and stir in sugar and salt; when dissolved, stir in vinegar and spices.

Place saucepan in an ice bath and stir catsup from time to time until temperature reaches 25°C $\pm$ 1.0°. Dry outside of saucepan and adjust net weight to 800 grams with water. (Do not forget this step.) Mix well. Measure temperature again to ensure that catsup is exactly 25°C. Adjust if necessary. Determine Bostwick value according to Section 11.

Following this procedure, formulate both 25% and 40% tomato solids catsups and determine Bostwick values for each. Cover and retain these catsups until the third catsup is made and tested. On semi-log paper plot percent tomato solids (25 and 40%) as abscissa (linear scale) and log of respective Bostwick flow as ordinate (log scale). The percent tomato solids required for 6 Bostwick consistency is obtained from the line through these two points, as shown in Figure 13.1. For this example, 38.46% tomato solids is necessary.

An alternative method to determine % tomato solids for the 6 Bostwick batch involves the use of a calculator. Obtain regression equation of line connecting two % tomato solids log Bostwick points from 25% and 40% tomato

batches. Use this equation to obtain predicted % tomato solids for 6 Bostwick consistency. Calculate amount of paste required for 6 Bostwick catsup using equation in Table 13.2.

Formulate 6 Bostwick catsup according to this table and verify that specified % tomato solids does produce 6 Bostwick catsup. If this catsup should fail to measure 6 Bostwick (± 0.1cm), recheck Bostwicks of all three catsups produced. Draw a new "% tomato solids-log Bostwick" line if initial values were incorrect, recalculate 6 Bostwick formulation and formulate a fourth batch using corrected values.

Table 13.2

Formula for producing 6 Bostwick Catsup (800 gram batch)

Tomato	$\frac{\%\text{ Tomato solids from curve} \times 264}{\%\text{ TS in paste}}$
Sugar	2.64 (92-% tomato solids from curve)
Salt	15.8 g
Vinegar @ 10.22%	45.0 g
Spices	0.66 g
Feedstock wt.	770 g - wt sugar
Final weight	800 g

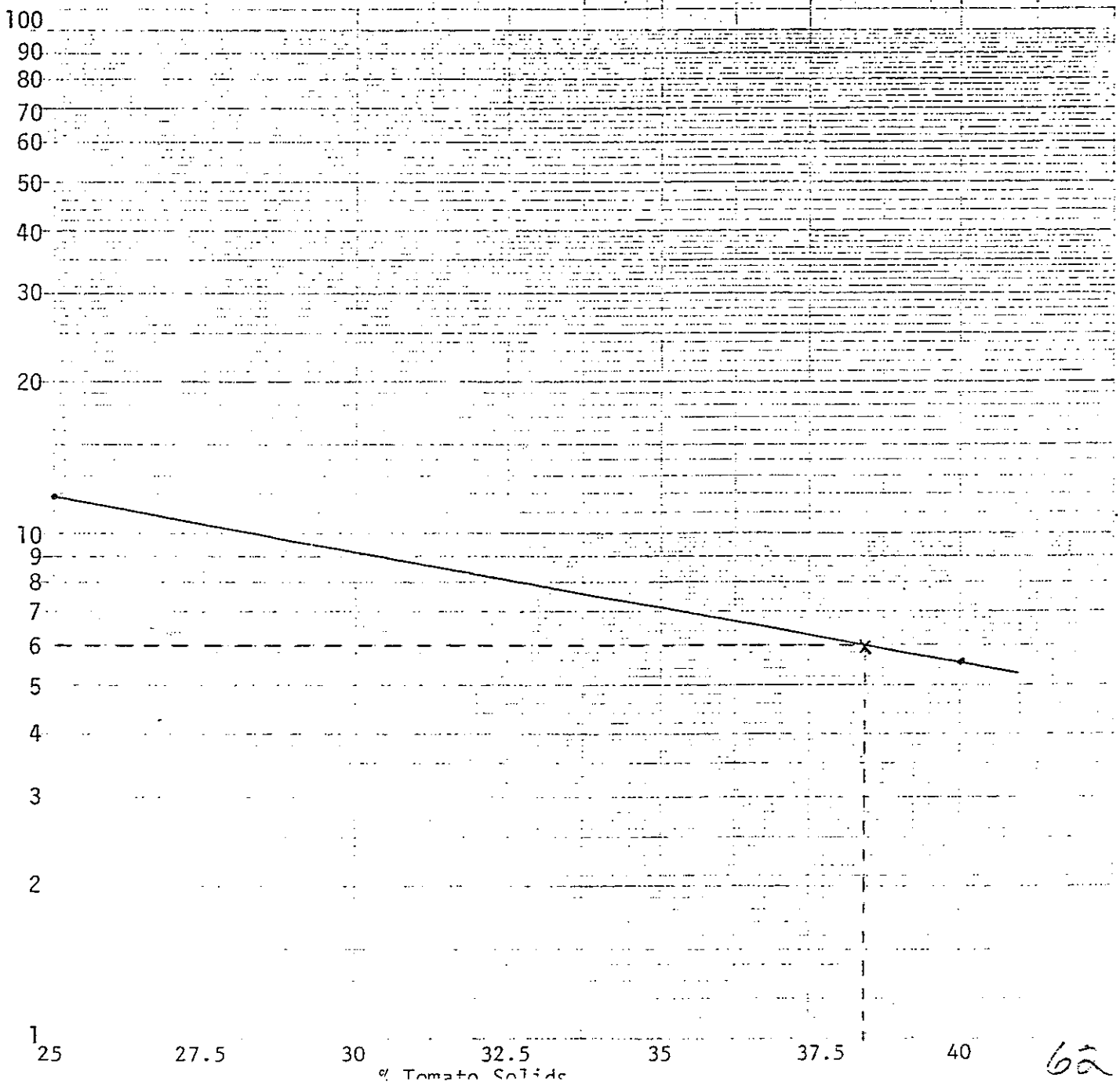
In these formulations for instrumental analyses, tomato solids, sugar and water were varied whereas vinegar, salt, and spices remained constant. For subjective (organoleptic) analyses, it may be desirable to keep the ratio of sugar and vinegar components (in addition to salt and spices) constant so that flavor contribution of the tomato component may be evaluated reasonably. Adjusting vinegar in the formulation to maintain a standard vinegar to sugar ratio would minimize excessive sweetness or sourness.

Fig. 13.1

Determination of % Tomato Solids for 6 Bostwick Catsup

Using semi-log paper, graph % tomato solids (linear axis) and Bostwick (logarithmic axis) for 25% and 40% catsups. Find % tomato solids corresponding to 6 Bostwick on the line connecting these two points. An example follows:

	% Tomato Solids	Bostwick
Batch 1	25%	11.85 cm
Batch 2	40%	5.55 cm
Batch 3	38.46%	6.0 cm



14. HYDROXYMETHYL FURFURAL IN TOMATO JUICE AND CONCENTRATES.

Hydroxymethyl furfural (HMF) was found to be a reliable index of quality in tomato juice and concentrates (B. S. Luh, Sherman Leonard and G. L. Marsh, Food Technol. 1958 12:347). The following factors induce the formation of HMF: Slow cooling (more so when using low temperature breaking procedures).

Elevated storage temperature

Length of storage (if above 77°F)

Reagents and Equipment

Filtering aid, diatomaceous earth, supercel or equivalent

Sodium chloride, reagent grade

Ethyl ether, reagent grade, anhydrous

Ethyl alcohol, U.S.P. 99.9%

Resorcinol, 1% in conc. HCl

Balance, analytical

Centrifuge, International, size 2, model V, or equivalent

Bottles, centrifuge 250 ml

Colorimeter, photoelectric, Klett-Summerson or equivalent

Filter, No. 54, green, for colorimeter

Volumetric flask, 10 ml

Test tube, 10 ml

Funnel, separatory

Funnel, Buchner

Dish, evaporating

Filter papers, Whatman No. 1 and No. 2

Pipettes, 1 ml, 5 ml, 20 ml

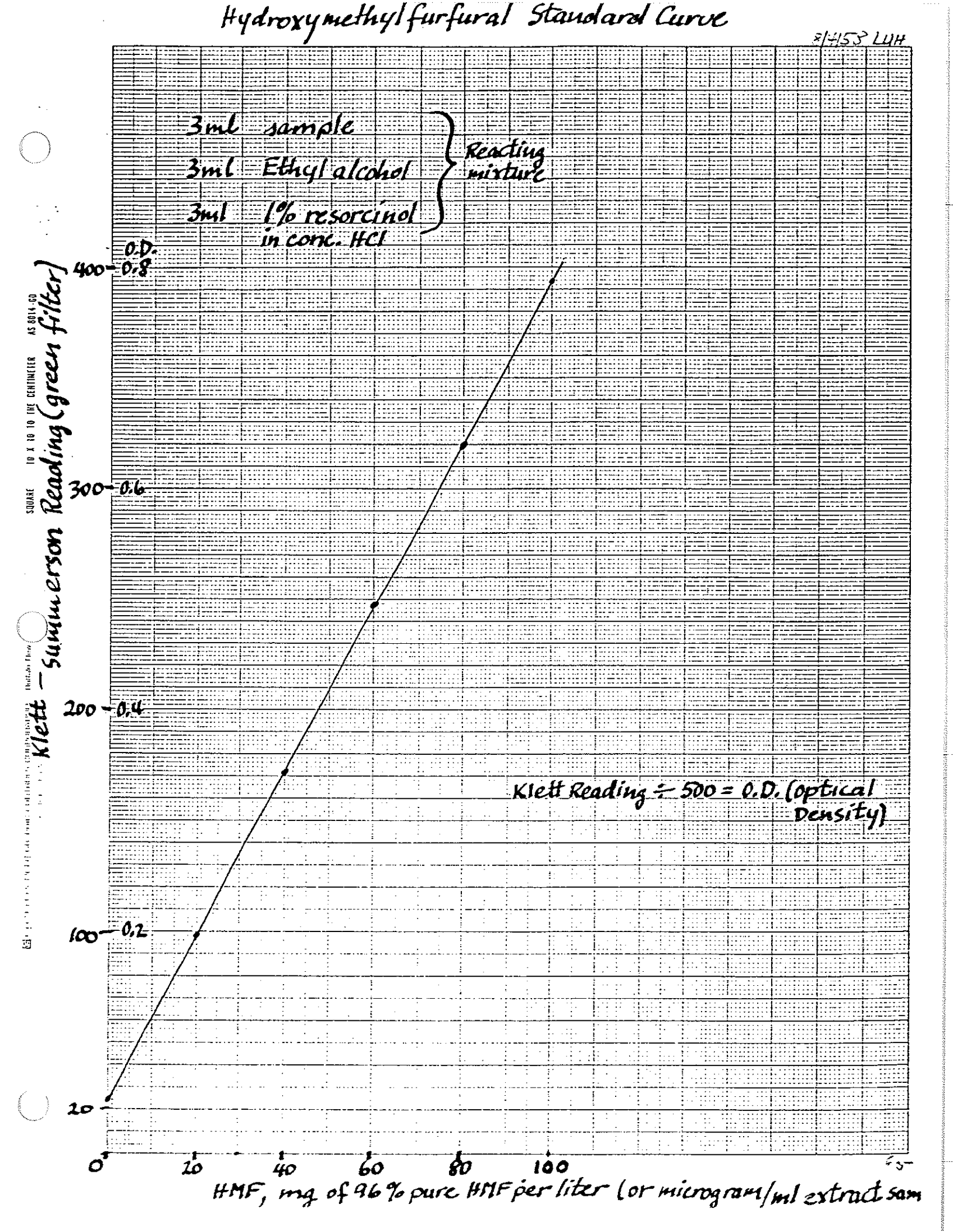
Procedure: Fill centrifuge bottle with juice or diluted concentrate, cap and centrifuge at 2000 rpm for 15 min. (The concentrate should be diluted to

approximate the solids level in the tomato juice.)

Thirty ml of the centrifugate is treated with 0.2 g of supercel. The mixture is filtered through a Whatman No. 2 filter paper in Buchner funnel under slight suction. Ten ml of the filtrate is pipetted into a separatory funnel to which 2.5 g of reagent grade salt (NaCl) is added. The resulting mixture is extracted 3 successive times, each time with 20 ml portions of reagent grade anhydrous ethyl ether. The ether extracts are combined in a porcelain evaporating dish mixed with 1 ml of distilled water, and allowed to evaporate at room temperature under an air draft until almost dry. The residue is dissolved and diluted to 10 ml with distilled water in a volumetric flask. Supercel is added and the solution is filtered through a Whatman No. 1 filter paper. Three ml of the filtrate is pipetted into a test tube followed by 3 ml each of U.S.P. ethyl alcohol (99.9%) and 1% resorcinol in concentrated hydrochloric acid. The contents are mixed and the test tube is stoppered and kept in dark at room temperature for 30 min. The reddish-pink color that develops is measured in a Klett-Summerson photoelectric colorimeter, using a green filter (No. 54). Water blank is used to adjust the instrument for 100% transmittance. The concentration of HMF is determined from a standard curve constructed from data obtained with HMF concentrations varying 0 to 180 µg per ml sample. A curve for 0-100 µg/ml HMF concentration range is attached.

Hydroxymethyl furfural Standard Curve

#1453 LUH



15. Microwave Processing of Tomatoes for Lab Analysis

Abstract:

Whole tomatoes are rapidly heated in a microwave oven to inactivate enzymes. After heating, the tomatoes are cooled then pulped and finished. Juice may be used for solids and/or consistency determinations.

Equipment:

Microwave oven, Litton Model No. 80-52, 1470 watt final output (or equivalent oven. This is a commercial model.)

Microwaveable dish with cover, Pyrex 3 qt., #026.

Balance, 3 kg capacity, accurate to 0.1g.

Pulper-finisher, 0.033 in. screen, Food Processing Equipment Co., Kalamazoo, MI.

Pan for ice bath 12x16x4 in.

Procedure:

Approximately 5 lb. of clean, dry whole tomatoes are required for testing. Place 2-1/2 pounds of tomatoes one layer deep in Pyrex dish. Weigh dish and tomatoes without lid (± 1g). Cover dish and place in center of microwave chamber. Cook 6 minutes on high setting. Cook an additional 6 minutes on medium setting, watching during cooking and adjusting power so that the tomatoes continue to boil during this time. After cooking, the tomatoes should be soft and the skin loose. Reheat in 3 minute increments on medium setting if any firm tomatoes remain.

Remove covered dish from microwave and place in a pan containing approximately 2 in. crushed ice, or ice water. The ice level should be kept 1/2-1 in. below the rim of the dish to prevent water overflow into the samples. Cool

until tomatoes reach room temperature. When cool, remove from ice, dry dish, remove cover and reweigh. Rinse condensate and tomato splashed on lid into the dish and adjust for evaporation loss by adding distilled water to achieve the original weight. Put tomatoes through pulper to remove seeds and skins.
Note: If the juice is to be used for consistency determinations, it is critical that it is not contaminated by raw juice with active enzymes. Juice container, spoons, beakers and other equipment contacting the juice should be used only for microwave-heated juice with inactive enzymes .

For solids determination, samples may be used directly from the pulper after thorough mixing. However, juice must be deaerated prior to Bostwick measurement. This is done in a flask attached to a vacuum pump or water aspirator. Shaking the flask vigorously during deaeration aids air removal, but care must be taken to avoid hitting the flask on a counter and shattering it; the high vacuum level will cause implosion of the glass pieces.

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Abstract:

This method determines the amount of tomato solids required in a standard formulation to produce catsup batches with 33% total solids which test 6 Bostwick.

Supplies and Equipment:

Balances, Torbal PL-12 or equivalent, minimum capacity 1600 g, accuracy ± 0.1 g Ohaus 311 or equivalent, minimum capacity 1 g, accuracy ± 0.01 g.

Saucepan, thick-walled aluminum, three pint, light enough to be tared on balance with stirrer included.

Stirrer, Wooden, spoon type with straight scraper edge, light enough to be tared with saucepan.

Hot Plate, 8 inch diameter or larger; must produce sufficient heat to bring tomato feed stock to 88°C in eight minutes.

Thermometer, Western metal stemmed dial type, 0° to 100°C.

Consistometer, Bostwick.

Sucrose, cane sugar, standard particle size.

Sodium Chloride, common table salt.

Catsup seasoning, Stange Company #72061.

Vinegar, white, 100 grain.

Timer, seconds.

Glove, cotton, to prevent splatter burns.

Straight edge.

Procedure: To complete this test approximately 1300 g of 24% NTSS tomato product or proportional amounts at other concentrations are required.

Three 800 gm. batches of catsup with 33 percent total solids are produced to complete the test. The first batch is formulated to contain 25 percent

of the 33% total solids as tomato solids, and the second is formulated to contain 40 percent of total solids as tomato solids. From Bostwick values on those two catsups, the tomato solids required to produce 6 Bostwick catsup is calculated. This third batch is produced and evaluated for verification.

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Salt	15.8	g	15.8	g
Vinegar @ 10.22%	45	g	45	g
Spices	0.66	g	0.66	g
Feed stock wt.	580	g	610	g
Final weight	800	g	800	g

* % TS is total solids determined by drying (Section 6).

Tare weigh saucepan and stirrer. Add well-mixed tomato paste to calculated weight. Add water a little at a time to reach feedstock weight. Thoroughly mix in water after each addition to minimize lumpiness.

Weigh sugar, salt, vinegar and spices into separate beakers and cover. Add approximately 10 ml water to spices.

Heat feedstock on hotplate as rapidly as possible, stirring constantly. A wire screen may be placed on top of hotplate to distribute heat more evenly and prevent burning. Feedstock should reach 88°C after five to eight minutes of heating. Adjust heat if necessary to achieve this heating rate. As temperature approaches 88°C, stir very vigorously to minimize splattering. Wear a cotton glove on the "stirring hand" to prevent splatter burns. When product reaches 88°C, remove pan from hotplate, and stir in sugar and salt; when dissolved, stir in vinegar and spices.

Place saucepan in an ice bath and stir catsup from time to time until temperature reaches 25°C $\pm$ 1.0°. Dry outside of saucepan and adjust net weight to 800 grams with water. (Do not forget this step.) Mix well. Measure temperature again to ensure that catsup is exactly 25°C. Adjust if necessary. Determine Bostwick value according to Section 11.

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An alternative method to determine % tomato solids for the 6 Bostwick batch involves the use of a calculator. Obtain regression equation of line connecting two % tomato solids log Bostwick points from 25% and 40% tomato

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Table 13.2

Formula for producing 6 Bostwick Catsup (800 gram batch)

Tomato	$\frac{\%\text{ Tomato solids from curve} \times 264}{\%\text{ TS in paste}}$
Sugar	2.64 (92-% tomato solids from curve)
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Feedstock wt.	770 g - wt sugar
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In these formulations for instrumental analyses, tomato solids, sugar and water were varied whereas vinegar, salt, and spices remained constant. For subjective (organoleptic) analyses, it may be desirable to keep the ratio of sugar and vinegar components (in addition to salt and spices) constant so that flavor contribution of the tomato component may be evaluated reasonably. Adjusting vinegar in the formulation to maintain a standard vinegar to sugar ratio would minimize excessive sweetness or sourness.

Fig. 13.1

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Using semi-log paper, graph % tomato solids (linear axis) and Bostwick (logarithmic axis) for 25% and 40% catsups. Find % tomato solids corresponding to 6 Bostwick on the line connecting these two points. An example follows:

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