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Title: Development of a Process for Production of Cantaloupe Juice Concentrate and Determination of its Composition and Quality

Abstract approved _____

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Fresh ripe, cantaloupes were processed into juice and juice concentrate. Processing trials were conducted on fresh and frozen fruits with and without rind. The effects of maceration enzymes and fining agents on yield and quality were investigated. Compositional measurement included ^{o}Brix, pH, titratable acidity, formol values, ascorbic acid content, total carotenoids, sugar and nonvolatile acid profiles, browning indices and Hunter color parameters. Considerable ascorbic acid degradation occurred during processing. The high juice yield (80%) and low acidity suggest its potential use as an alternate sweetener source. Sensory evaluation by a trained panel showed that

concentrating the juice samples from flesh and rind can remove the rind aroma and flavor characteristics. Juices obtained from flesh and from flesh and rind were not significantly different ($p \leq 0.05$) except for overall intensity and fresh fruit flavor characters. Single strength juice was significantly different ($p \leq 0.05$) from concentrate on most aroma and flavor characters.

Development of a Process for Production of Cantaloupe Juice Concentrate and Determination of its Composition and Quality

by

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INTRODUCTION

Cantaloupes, Cucumis melo variety reticulatus, are annual or seasonal trailing herbs which are yellow fleshed. Warm weather, sufficient soil moisture, and dry atmosphere are essential requirements for the plants during their early stage of growth. The principal commercial varieties of muskmelon (cantaloupe) grown in the USA require about 80-115 days from the time the seed is planted until first melons are ripe (Seelig 1977). Beattie and Doolittle (1951) stated that:

> "Muskmelon generally do best on well drained, warm sandy loam or silt soils. Some fine melons come from sandy river bottoms and from areas of rich clay loam. The large commercial crop of the Imperial Valley of California is grown mainly on what is known as the Holtville silty clay loam. Warmth, good drainage, an abundance of available plant food, and plenty of humus are the chief requirements of a soil on which to grow muskmelons. The plants will not endure an overflow , and no attempts should be made to grow this crop where water would stand in furrows for extended periods after a rain or the soil washes badly".

Mature fruit weigh from 1-5.3 kg. Production is from several different states in USA with California being the major producer. The main cantaloupe season occurs in June, July, and August with substantial quantities also produced

in May and September. Only minor quantities are grown in the USA in March, April, October, and November (Seelig 1977).

Cantaloupes are good sources of vitamin C, the amount showing considerable variation with variety and maturity. They are also rich in provitamin A because of their ß-carotene content (Philip, 1988). Wide variation in soluble solids among cantaloupe varieties also exists. A range from 10.56 to 12.91 for the variety Aurora was reported by Norton et al. (1985) and a range from 5.7 to 10.7 for the variety "Saticoy" by Dull et. al (1989). A value of 13.1 in the variety Superstar was reported by Evensen (1983).

Consumption and sales of cantaloupe are primarily as fresh market fruit. To maximize returns to growers and processors, there is need for utilization of excess production and sort-outs (misshapen, over and under-sized fruit) in added value products. Production of cantaloupe juice concentrate offers one such possibility.

The major objectives of this research were:

1. to develop acceptable procedures for processing of cantaloupe into juice and juice concentrate.

2. to measure juice quality (color, flavor, nutrient composition) and composition (sugars, nonvolatile acids, amino acids, and ascorbic acid).
3. To assess the quality of the final product and its stability during storage in regards to its potential usage.

LITERATURE REVIEW

CANTALOUPE AND ITS UTILIZATION

General Properties

Cantaloupe Cucumis melo variety riticulatus has been grown for a long time in the USA. The true cantaloupe is Cucumis melo variety cantaloupensis but these are not commercially grown in the USA. They are medium-sized fruits characterized by rough, warty or scaly surface, netted, and are grown in Europe (Seelig, 1977). It has been thought that cantaloupe came to Europe from Persia in the early Christian era. Columbus brought the first cantaloupe seeds to the new world during his second voyage in 1494. In addition to cantaloupe's appealing taste, it is nutritious, low in calories, high in potassium, and low in fat.

The fruit is commonly eaten fresh during its seasonal production. Little could be found in the scientific literature about processing of cantaloupe into juice or juice concentrate except for that Korean study by Shin, et al. (1979). In that study cantaloupe was processed into nonclarified juice. Cane sugar was added to the juice to reach a total soluble content of 11-13 ^{o}Brix. Lactic fermented cantaloupe juice was another form prepared by pasteurizing the natural juice at 90 ^{o}C for 5 min and adding

pure culture of lactic acid bacteria without interference from competing microorganisms.

There has been a major study, however on the production of watermelon juice and juice concentrate in Florida by Huor and Ahmed (1979) and Hour et al. (1980). The Florida study by Huor and Ahmed (1979) utilized the variety Charleston Gray watermelons to produce juice and juice concentrate. The relative percentage of the produced juice was 40 %. Pulp and seeds represented 3% and 1% respectively. Part of their study was the possibility of utilizing the nonclarified watermelon juice concentrate in combination with pineapple, orange, and grapefruit juices. Thermally Accelerated Short Time Evaporation (TASTE) was recommended to concentrate the watermelon juice because it produced the best quality juice in terms of efficiency and overall flavor. Their laboratory and small-scale consumer tests for fruit punches containing reconstituted water melon, pineapple, and orange concentrates, with citric and sugar showed that any juice concentration containing up to 80% watermelon of the juice mixture could be as well accepted as the others.

Cantaloupes, Production and Utilization

California is the major state for cantaloupe production in the USA. Other major states producing cantaloupe are Arizona, Texas, Georgia, Indiana, Colorado, Michigan, Ohio, South Carolina, and Oregon. Estimated production in California 1979-1988 was 104,069,000 CWT (CWT=100 Lb), (California Ag. St. Service 1979-88). The estimated production in Oregon 1980-1989 was 223,230 CWT (CWT=100 Lb) (Miles, 1989). Variation in annual production of cantaloupe in each state occurs as a result of supply and demand.

Muskmelon is grown in Yemen Arab Republic but no statistical data could be found about cantaloupe production. The main growing regions are Marib, Tihamah, and Saadah. Marib's fruits are produced in winter and marketed in January. February and March is the time in which the fruits are produced in Saadah. A large amount is produced in Tihamah but it is subjected to too many diseases (Al-zomair, 1990). Because the storage life of muskmelon is short and the damage during transportation is high, the basic consumption of the fruit is as fresh ripe fruits, but the surplus needs to be utilized.

Different varieties grown in the USA include Hale's Best, Emerald, Top Mark, Aurora, Superstar, PMR-45, and some other new modified varieties. These varieties are commonly

consumed as ripe fresh fruits but there are other uses such as frozen melon balls and acidified canned muskmelon. Utilization of surplus fruit through processing ofvalue-added products will help to make production more efficient and attractive to growers and processors.

Harvesting, Handling, and Storage

It is necessary for the cantaloupes to be picked in a timely manner at the right stage of maturity to be utilized for specific purposes. Cantaloupes signal when they are ripe and ready for harvesting when their vine develops a crack where it is attached to the melon and separates naturally (Brands, 1987). The perishability of muskmelon (cantaloupe) causes problems in handling and storage (Evensen, 1983). Postharvest storage depends on the maturity stage at which the fruits were harvested. Evensen (1983), reported that muskmelon picked at the green half-to full-slip stage of maturity is recommended to be held at 2.2 ^{o}C to 4.4 ^{o}C for up to 2 weeks, while riper, full-slip melons can be held at 0^{o} to 2.2 ^{o}C for up to 2 weeks.

COMPOSITION AND NUTRITIONAL VALUE

Cantaloupe Fruits

Eitenmiller et al., (1985) reported the composition of 100 g of the raw edible portion of cantaloupe flesh as the mean of 24 cantaloupe fruit samples taken from 6 different cities across the USA (Atlanta, Boston, Denver Kansas City, Minneapolis, and Seattle) as follows: moisture, 90.30 %; protein, 0.65 g; fat, 0.15 g; ash, 0.80 g; niacin, 0.61 mg; riboflavin, 0.02 mg; thiamin, 0.03 mg; B_6, 0.18 mg; total ascorbic acid, 27.02 mg; reduced ascorbic acid, 21.05 mg; total folacin, 0.025 mg; free folacin, 10.33 μg; total pantothenic acid, 0.13 mg; free pantothenic acid, 0.05 mg; phosphorous, 9.64 mg; potassium, 237 mg; calcium, 6.45 mg; magnesium, 12.69 mg; iron, 0.16 mg; manganese, 0.03 mg; copper, 0.05 mg; zinc, 0.10 mg; sodium, 8.38 mg; cobalt, 0.003 mg; and chromate, 0.005 mg. Some other nutrient values in cantaloupe fruits include food energy, 30.00 calories; carbohydrate, 7.50 g; and 3400 International Units of vitamin A; were reported by Adams (1975).

Sugars

Sugars are considered as a quality factor in ripe muskmelon (cantaloupe). The amount of sugars differs in fruits based on variety and maturity. Wade (1982) found that sucrose is the major component in mature cantaloupes

while monosaccharide (glucose and fructose) are the major components in the immature fruit. The values 2.5, 1.4, and 1.1 g/100 g were found for sucrose, fructose, and glucose, respectively in ripe Superstar cantaloupe fruits by Cohen and Hicks (1986). This is in agreement with the levels of total sugars (soluble solids content) reported by Bianco and Pratt (1977). They reported that during the early stages of fruit development (0-28 days after anthesis), the total sugars in terms of percent composition on fresh weight basis was approximately 6%. Glucose and fructose were the predominant sugars. In the late stages of fruit development (28-42 days after anthesis) and especially in the last week, sucrose was the major sugar where it accounted for more than 10% of the fresh weight.

Storage time and temperature may affect the soluble solids content of cantaloupe fruits, but this effect depends on variety. Cohen and Hicks, (1986) studied this effect on 'Gold Star', 'Saticoy', and 'Superstar'. They found that storage time and temperature had no effect on the soluble solids content or sucrose concentration but fructose and glucose levels decrease with an increase in storage time and temperature. Dumas and Aubert (1976), in their study on cantaloupe variety Doublon grown in the summer under a plastic tunnel, found that soluble solids content decreased from 24 ^{o}Brix to 12 ^{o}Brix when the fruits were stored at 25

^{o}C for four days. They also found that the soluble solid content of the same variety (grown in the winter in controlled green house) decreases from 13.1 ^{o}Brix to 11.3 ^{o}Brix when the fruits were stored at 25 ^{o}C for five days. They reported no changes in soluble solid content after fifteen days in both samples when fruits were stored at 4 ^{o}C.

Nonvolatile Acids

A considerable number of organic acids occur in foods and they are often major constituents of plant foods (Palmer and List, 1973). Knowledge of nonvolatile acids composition is important because they influence food flavor and stability. They are used as indicators for quality, maturity, ripeness, or spoilage. Some of them could be added to foods as acidulants or flavor modifiers. Precise determination of food acids is often required for quality control or nutrition labeling purposes (Coppola, 1984).

Nonvolatile acids in cantaloupe have not been extensively investigated. However Pratt (1971) identified malic and citric acids as the major acids in some muskmelon varieties. Acetic, formic, glycolic and oxalic acids were found to be minor components. Another study by Sweeney et al. (1970) showed that citric and malic and succinic acids were the major acids in some cantaloupe varieties. Total

titratable acids in cantaloupe were also reported by some workers. The mean % values for total titratable acids in two successive crop years reported by Sweeny et al. (1970) were 0.06 and 0.08 respectively. Esebua and Abdurazakova (1971) reported a range of 0.14-0.19% in seven melon varieties in Tashkent USSR. pH is another important compositional parameter and it has been reported in unknown varieties by some investigators. Esebua and Abdurazakova (1971) reported a pH range from 6.2-6.6, Lee (1975) reported a pH value of 5.3, and Nath and Ranganna (1977) reported a pH range from 5.3-6.1.

Volatile Compounds

Because of their importance indicators of cantaloupe's odor and flavor, volatile compounds have received more attention than nonvolatile acids. Extensive studies were conducted to identify volatile compounds in muskmelon. The major classes identified through the literature were mainly esters, aldehydes, and alcohols. Kemp et al. (1971, 1972, 1973, 1974) identified more than fifty volatile compounds in muskmelon fruit including a series of alcohols and aldehydes that contain nine carbon atoms. Kemp et al. (1972) reported that cis-6-nonenal had an intense melon-like aroma. It is probable that the large quantities of highly volatile esters also play a critical role in the integrated flavor of melons

and are necessary for the strong and characteristic fruity aroma (Yabumoto and Jennings, 1977).

Horvat and Senter's results (1987) confirmed the presence of the volatile compounds reported by the previously cited investigators and identified additional volatile compounds which can contribute to the odor-flavor of the cantaloupe variety "Saticoy". Those compound are ethyl (methyl thiol) acetate, (Z)-6-nonenyl acetate, (Z,Z)-3,6-nonadienyl acetate, benzyl propionate, benzyl alcohol, cinnamyl acetate, a sesquiterpene hydrocarbon and an isomer of 3,4-dimethoxyacetophenone.

Recent work by Schieberle et al. (1990) showed that the esters methyl 2-methyl butanoate and ethyl 2-methyl propanoate and the aldehydes (Z)-hexenal and (E)-2-hexenal are the primary odorants of melon flavor but the aldehyde (Z)-6-nonenal identified previously by Kemp et al. (1972) is not an important odorant of the fruit.

Amino Acids Content

Amino acids have a great importance in foods and food products from two points of view, nutrition and browning reactions. It is generally known that the necessity for protein in animal and in human nutrition is primerlly a requirement for the essential amino acids which can be

possessed from different foods such as fruits and vegetables (Sutaria and Diego, 1982). Degree of browning is an important quality factor in fruit juices, and amino acids play a key role in nonenzymic browning reactions. Kennedy et al. (1989) stated that different theories have been proposed to explain the browning mechanism in fruit juices; among these, it has been suggested that the browning reaction takes place between amino acids and reducing sugars present in the juice.

Very little information about amino acids in cantaloupe was found in the literature. Flores et al. (1970) identified 14 amino acids in cantaloupe melon and reported that there was 292.3 mg total free amino acids/100 g fruit. Alanine represents 36.7% of the total. Glutamate, aminobutyrate, aspartate and glycine were also major ones. This value (292.3) is high compared with other fruits. For example Flores reported (as mg/100 g fruit) 1.5 for blueberry, 3.3 for apple, 31.1 for pear, 71.2 for kiwi, 113.1 for pineapple, 147.8 for watermelon and 172.8 for white grape. Some other fruits reported really high in free amino acids include prune (imperial) 880.6 mg/100 g fruit and figs, 436.3 mg/100 g fruit. The formol titration is used to measure the total amount of free amino acids. The formol value has been used as an indicator of browning potential as well as an index for adulteration in fruit

juices. A low formol value may indicate that a fruit juice has been excessively diluted with water (Ooghe and Waele, 1982).

Formol value is generally expressed as milliequivalent /100 mL juice. Many investigators have reported the total amount of free amino acids as formol value in many fruits and vegetable juices but not in cantaloupe. Wrolstad et al. (1989) reported the formol value (meq/100 mL) in some fruit juices, e.g ripe Bartlett pears (0.110), ripe Comice pears (0.039), white grape (0.205) and apple (0.07). Bielig et al. (1987) reported the median formol value (meq/100 mL) in a number of fruit juices e.g apple (0.45), grape (1.5), pear (0.4), grapefruit (2.0) and raspberry (1.5).

Ascorbic Acid

Fruits and vegetables are the main source of ascorbic acid, which is an essential vitamin and also has significance as a quality index for fresh and processed food, and as an antioxidant. Ascorbic acid content is highly affected in processed fruits and vegetables, and it could be used as an indicator for the retention of other nutrients (Ashoor et al.,1984). Its loss could be used as indicator for browning in fruit juices. The degradation of ascorbic acid can occur in the presence or absence of oxygen by enzymic and nonenzymic catalysts. Some studies have

demonstrated that certain fruits containing ascorbic acid have enzymes which can cause degradation of ascorbic acid during processing in the presence of oxygen (Zilva, 1934; Johnson and Zilva, 1937; and Stone, 1937).

Nonoxidative and nonenzymic degradation of ascorbic acid can also occur and cause browning in fruit juices. Under acid conditions in absence of oxygen it degrades to furfural, which can subsequently lead to brown color formation (Kurata and Sakurai, 1967). Browning processes would be favorable to proceed also in juice concentrate if the pH were high. Because of the importance of the nutrient content of fresh and processed food, information about vitamin C content is necessary for nutritional and labeling purposes.

The ascorbic acid content in cantaloupe has been reported in a few references in the literature. A value of 45 mg per 100 g fresh fruits was reported by Pratt (1971). Approximately 33 mg ascorbic per 100 g fruit was reported by Adams (1975). A value of 42.2 mg per 100 g fresh fruits was reported by Gebhardt et al. (1981). Eitenmiller et al. (1985) reported that 100 g of fresh fruits at times of maximum availability in the market contains 28.77 mg of ascorbic acid. The amount of ascorbic acid in cantaloupe fruits depends on variety, stage at which the fruits are

harvested, and storage time after harvest. Norton et al (1985) found wide variation in the amount of ascorbic acid among different varieties e.g 50 mg/100 g fruit in variety Mainstream, 65 mg/100 g fruit in Aurora, and 80 mg/100 g fruit in Chilton. Evensen (1983) pointed out that melons harvested at green full-slip and half-slip stages of maturity had higher ascorbic acid content compared with the riper melons. Evensen (1983) reported approximately 64% ascorbic acid loss occurred in melons over fifteen days of storage at 4.5 ^{o}C plus one day at 13 ^{o}C.

Carotenoids

The carotenoids are a group of mainly lipid-soluble compounds responsible for many of the yellow and red colors of plant and animal products (Francis 1985). Color is an important quality factor in fruit and fruit juices and cantaloupe is noted for its orange flesh. Pratt (1971) stated that the predominant pigment of the orange flesh muskmelon cultivars is ß-carotene. This was confirmed by Philip and Chen (1988) when they reported ß-carotene as the major pigment in cantaloupe. An increase in the amount of carotenoids content along with ripening was also discussed by Pratt (1971). He stated that pigment formation starts in the center of the fruit and progresses outward through the pericarp until the flesh is uniformly orange at maturity.

ß-carotene has been long recognized as a vitamin A precursor. Burton and Ingold (1984) stated that ß-carotene is believed to have antioxidant action by trapping radicals, so it might be an anticancer agent. Carotenoids content varies from one cultivar to another, e.g Persian, PMR-45, and Crenshaw cultivars were reported, by Pratt (1971), to have 25, 16.5, and 8 mg/kg for fresh tissue, respectively.

JUICE CONCENTRATION METHODS

The growth in fruit juice drinks consumption has stimulated production of fruit juices in several different forms, e.g., clarified, pulpy, "natural", blended juices, ciders, pasteurized single strength, and concentrates. Fluid foods are concentrated to reduce their volume and weight; this reduction results in lower costs of packaging, storage and transportation (Rao, 1989). Concentration also reduces microbial spoilage due to lower water activity in the concentrate (Potter, 1973). The ideal goal of concentration is to reach a product which, when reconstituted, is equal in quality to the original raw material. So various concentration methods are being used in the juice industry to obtain juice concentrates of different fruits and vegetables. These methods can be

generally divided into two broad classes, evaporative concentration and freeze concentration.

Evaporative Concentration

Direct contact of the juices with medium heat causes water evaporation and concentrate can be obtained this way. This kind of evaporation is called flash evaporation. This evaporation method was reviewed in detail by Hide and Casten (1961) and Potter (1973). Foods which are sensitive to heat are most commonly concentrated in low temperature vacuum evaporators (Potter, 1973). In this method, as described by Potter, maximum use of heat is made but some disadvantages still exist, e.g, high costs and loss of aroma compounds.

Thermally Accelerated Short-Time Evaporation (TASTE) is another type of flash evaporation method which is commonly used to concentrate citrus juices. In this method, juice is conventionally preheated to about 90 ^{o}C, then flashed through evaporators with progressively lower pressures (Hour, 1979).

Freeze Concentration

In this method the juice is basically subjected to a very low temperature, which serves to develop ice crystals. These crystals can be removed mechanically from the remaining concentrate by press, centrifugation, a wash

column, or combination. Reviews dealing with concentration by freezing (advantages and disadvantages) have been done by Joslyn (1961) and Rao (1989). Another review about concentration by freezing of juices other than citrus has been done by Torrey (1974).

It is primarily food aroma that distinguishes the flavor of one food from that of another, and aroma quality often determines the acceptability of a food (Bomben et al., 1973). The main feature of freeze concentration is the retention of the aroma compounds in the produced juice. That factor has made this method attractive, but recovery of volatile compounds with evaporative concentration methods has made evaporative methods more popular and acceptable than freeze concentration methods because of their speed and high efficiency.

Other methods used for concentration in juice industry are: reverse osmosis, a combination of vacuum and reverse osmosis, ultrasonic high frequency vibration, and dialysis. Reverse osmosis was reviewed by Potter (1973), Torrey (1974) and Rao (1989). The others were reviewed by Torrey (1974).

SENSORY EVALUATION

Sensory tests of course have been conducted for as long as there have been human beings evaluating the goodness and badness of food and other things that can be used and consumed (Meilgaard et al., 1988). Appearance, aroma, flavor and texture are important attributes in foods. Some instruments such as the gas chromatograph have been used to identify and classify odors. However, using humans as instruments for sensory evaluation is the most common and available technique.

Sensory evaluation is techniques may be used to determine a commodity's acceptability and preference, but the factors which influence the sense of perception should be considered. Although it is difficult to control all factors that affect the panelists' judgments, efforts must be devoted to providing the panelists with an optimal setting in order to secure unbiased judgments. Perception differs from one panelist to another based on sex, age, origin, ethnic group, income and physiological condition. These factors in addition to other factors in the experimental design, such as number of samples, panel size, nature of product, experience of panelists, and type of test, are important.

Sensory descriptive analysis can be used as an analytical tool to define, describe, and measure sensory attributes of a product by using trained panelists. The objectives in the sensory evaluation of a new product frequently involve description of each experimental sample and reporting in detail the changes that have been made, grading of each sample according to established standards, or establishing that one of several experimental products has acceptability equal to, or better than, the standard (IFT committee on sensory evaluation, 1964). The number of panelists required for such a test is not perfectly fixed, but Meilgaard et al. (1988) suggested 5 to 100 panelists.

RESEARCH OBJECTIVES

There were three major objectives in this research project. First, was to develop and evaluate processing procedures for producing a clarified, cantaloupe juice concentrate. Unit operations to be investigated include mechanism for juice extraction, whether or not pulp is to be separated from the rind, unit operations of blanching, the type and quantity of commercial clarification enzymes to be added, and the concentration method to be used. The anticipated end use of clarified cantaloupe juice concentrate is as an alternative replacement for syrups to be added to canned fruits. It is not anticipated that

clarified cantaloupe juice would be competitive with other pure fruit juices. One would not expect clarified cantaloupe juice to be an attractive beverage in the commercial marketplace because of its low acidity and high pH. Thus end-use product development was not a major objective of this investigation.

It is important that the quality of the juice concentrate be determined, however. Therefore a second objective was to measure and evaluate quality factors such as color, flavor, and nutrition. Compositional parameters to be measured include sugars, nonvolatile acids, amino acids, and ascorbic acid. It is also important that the flavor characteristics of the product be described and evaluated. The flavor profile technique is a useful tool for such purposes.

Potential commercial users of clarified cantaloupe juice concentrate will be interested in its stability during storage. Browning and haze, and how they are influenced by storage, are particularly important and they will need to be measured and compared with alternative sweeteners. That was the third objective.

MATERIALS AND METHODS

PROCESSING CONDITIONS

Fruit Source

Ripe cantaloupe fruit (Superstar variety) provided by the Hermiston Agricultural Research and Extension Center, Hermiston, Oregon were used for all processing trials. Two lots (120 kg each) of cantaloupe fruits were shipped by refrigerated truck from Hermiston Agricultural Research and Extension Center to Oregon State University, Food Science and Technology department. The fruits were stored at 4 ^{o}C for 20 hours before processing.

Juice Processing

Pretrials were carried out on a lab bench scale to examine the possibility of making cantaloupe juice from flesh and from flesh and rind. ROHABECT MAC, ROHAMENT K (source ROHM TEC, Inc.) and Ultra Sp (source NOVO) maceration enzymes were tried to select the best enzyme in yield production. Clarified and nonclarified cantaloupe juice were produced. The nonclarified juice was subjected to high temperature short time (HTST) treatment in order to examine its stability and to determine the effect of HTST on color, aroma, and flavor. The clarified juice from flesh and from flesh and rind were subjected to concentration by

rotary evaporation in order to examine the effect of the concentration process on the juice concentrate's color and flavor.

Figure 2 shows the unit operations used in the major processing trails. Four lots of cantaloupe fruits 50 kg each were used to carry out the juice processing, two lots with rind and two lots with flesh only. Fruits used with rind were cut into quarters, seeds removed by hand then fruits were ground by Comminuting machine model D with 1/4 inch screen wide (speed was 285 RPM). Maceration enzyme (Ultra SP L, source--NOVO) was added as 100 mL/1000 kg and the sample held 55 min at 23 ^{o}C. Ground materials were pressed into juice using a Willmes Press at 60 PSI and 4 ATM. Pectinex 3X enzyme (source NOVO) was added to the juice which, was then held at 54 ^{o}C for 55 min. Juices were then heated in an APV HTST unit to 85-90 ^{o}C for 90 sec and cooled to 18 ^{o}C. Juices were fined with bentonite at a dosage rate of 500 mg/L. The juice was stored at 4 ^{o}C overnight and filtered with 1% Supercell DE (Manville, Denver, Co) before bottling. Fruits used without rind (flesh only) were processed in the same manner, but no maceration enzyme was used, and the flesh was frozen for two days at -35 ^{o}C before grinding. The single strength juices were then transferred into one-gallon containers and held at -30 ^{o}C for concentration.

Juice Concentration

Cantaloupe juice samples (single strength) were thawed at room temperature and then concentrated by using a centrifugal film evaporator (Centritherm CT-1B) under vacuum (-0.88 Kg/cm^3). Two passes through the Centritherm were required to concentrate to ca. 68 ^oBrix. Table 1 lists the conditions for concentration process.

ANALYTICAL DETERMINATIONS

Determination of pH, ^oBrix and Titratable Acidity

^oBrix and pH were determined on the raw materials by using a Bausch & Lomb refractometer and a Corning pH meter 125, respectively. Titratable acidity was determined as citric acid (g/100 mL juice) as described by Amerine and Ough (1979).

Ascorbic acid Determination

Ascorbic Acid (mg/100 mL) was determined by:

a. The indophenol method (Loeffler and Ponting, 1942).
b. Enzymic procedure determination of L-ascorbic acid, (specific enzyme kits, Boehringer-Mannheim).
c. An HPLC procedure described by Dennison et al. (1981) with the following modifications:

1. High performance Liquid Chromatography (HPLC) - Varian Model LC 5000 equipped with UV 50 variable wavelength detector (Varian Instrument group, Walnut Creek, CA) and LC-100 Perkin Elmer Laboratory Computing Integrator (Perkin Elmer Corp., Norwalk, CT).
2. Econosphere NH_2 54 column, 250 X 4.6 mm id fitted with an NH_2 4cm X 4.6 mm Micro Guard column (Alltech/Applied Science Co.) were used.
3. Samples were centrifuged and filtered through 0.45 μM type HA millipore filter (Millipore Corp., Bedford, MA) before injection.

Total Carotenoids Determination

The procedures described by AOAC Official Methods of Analysis (1984) were followed for extraction and determination of pigments. A standard curve was prepared by serial dilution of 10 μg of grade pure beta carotene (Sigma Chem. Co.) in 100 mL of acetone-hexane (1+9) solution to give a range of 1-10 μg/mL. The absorbance at 449.6 nm of each standard (in duplicate) was recorded and a standard curve was determined by plotting absorbance versus concentration. Total carotenoids were calculated by interpolation on the standard curve and by application of the dilution factors the total carotenoid content of the sample was expressed as part per million (ppm).

Table 1. The condition for cantaloupe juice concentration by evaporation process.

	Rate Liter/min	°Brix	Temp. °C
Feed single strength			
a. flesh only	0.5	9.5	25
b. flesh & rind	0.5	8.5	23
Juice concentrate (first pass)			
a. flesh only	0.5	38	57
b. flesh & rind	0.5	42	52
Juice concentrate (second pass)			
a. flesh only	0.5	62	58
b. flesh & rind	0.5	68	58

HPLC Determination of Sugars

Apparatus:

High Performance Liquid Chromatograph (HPLC)- Varian Model LC 5000 equipped with a column heater and a Varian Refractive Index detector (Varian Instrument Group, Walnut Creek, CA.) and a Model HP 3380 integrator (Hewlett-Packard Corp., Avondale, PA.).

Bio-Rad Aminex HPX-87c column, 300 x 7.8 mm id fitted with a Bio-Rad Carbo C 4cm x 4.6-mm Micro Guard column (Bio-Rad Laboratories, Richmond, CA.).

C_{18} Mini column C_{18} SEP-PAK (Waters Associates, Milford, MA.). To activate, 5 mL of methanol was passed through the cartridge followed by 5 mL of distilled water.

Disposable Poly-prep chromatography columns. Graduated 0.8 x 4-cm columns holding up to 2 mL chromatographic media and including an integral 10 mL reservoir (Bio-Rad Laboratories).

Reagents:

Sugar standards were prepared by adding 1.000 g of reagent grade glucose, 1.000 g of reagent grade sucrose, 1.200 g of reagent grade fructose, and 0.100 g of reagent grade sorbitol to a volumetric flask and dilution to volume with distilled water.

Sugar internal standard was prepared by adding 6.000 g of reagent grade mannitol to a 250 ml volumetric flask and dilution to volume with distilled water.

Mobile phase was prepared by adding 200 mg of $Ca(NO_3)_2$ to 1000 mL of glass distilled water and filtration through a

0.45 μM type HA millipore filter (Millipore Corp., Bedford, MA).

Analysis and quantitation:

The procedures by Spanos and Wrolstad (1988) were followed.

HPLC Determination Of Nonvolatile Acids

Apparatus:

HPLC-Varian Model LC 5000 equipped with a Varian Refractive Index Detector (Varian Instrument Group. Walnut Creek, CA) and an LC-100 Perkin Elmer Laboratory computing Integrator (Perkin Elmer corp., Norwalk, CT).

Bio-Sil ODS micro guard column (Bio-Rad Labs, Richmond, CA) followed by Spherisorb ODS-2 5 μM micron particle size, 25 cm x 4.6 mm ID (Alltech/Applied Science Co.) connected to a Spherisorb ODS-1 5 μM micron particle size, 25 cm x 4.6 mm ID (Alltech/Applied Science Co.).

Activated C_{18} Mini column and disposable poly-prep chromatography column as in above procedure for sugars.

Reagents:

The organic acid standard was prepared by adding 2.1837 g citric acid, 0.2928 g malic acid (Sigma Chem. Co.), 0.2210

g isocitric and 0.9831 g quinic acid (Sigma Chem. Co.) to a 100-mL volumetric flask and diluting to volume with distilled water.

Mobile phase was prepared by dissolving 27.2 g of KH_2PO_4 in 1000 mL of glass distilled deionized water and adjusting the pH to 2.4 with concentrated phosphoric acid. The solution was filtered through a 0.45 μM type HA millipore filter.

Analysis and identification

The procedures by Spanos and Wrolstad (1987) were followed.

Determination Of Total Free Amino Acids

Total free amino acids (Formol value) was determined by using the AOAC method, (1984).

Browning in Cantaloupe Juice Concentrate

Cantaloupe juice concentrates from flesh and from flesh and rind were stored at 25 ^{o}C for 120 days in the dark. Quadruplicate measurements of each juice sample were taken at monthly intervals. Samples were diluted with distilled water to 10 ^{o}Brix. The samples were then filtered through Whatman filter paper #4. The browning was determined from the absorbance at 420 nm by using a Varian DMS 100

spectrophotometer (Varian Instrument Group, Walnut Creek, CA.).

Determination of Hunter Parameters

Apparatus:

Color Difference meter.- Hunter CT1100 ColorQUEST C5115, (Hunterlab, Hunter Associates Laboratories Inc., Reston, VA).

Procedures:

Procedures described by Rommel and Wrolstad (1988) were followed to measure Hunter L, a and b color parameters and percent transmission haze of single strength juice and rediluted concentrates obtained from flesh and from flesh and rind. Quadruplicate measurements of redilulted concentrates (stored at 25 ^{o}C for 120 days) were also taken at monthly intervals.

Sensory Evaluation

A descriptive analysis test was carried out to describe the aroma and flavor characteristics of the single strength and concentrated cantaloupe juice obtained from flesh and from flesh and rind.

Samples and sample preparation:

Random samples of cantaloupe juice (single strength and concentrate) from batch 1 (b1) and batch 2 (b2) were stored at -23 ^{o}C prior to sensory evaluation. Samples were assigned the following codes: (SF) for single strength from flesh only, (SR) single strength from flesh and rind, (CF) concentrate from flesh and (CR) concentrate from flesh and rind. In each session the single strength samples were thawed and the concentrated samples were thawed and reconstituted to 10 ^{o}Brix one hour prior to each panel session.

Serving and testing conditions:

Training sessions were conducted in the Sensory Science Laboratory in the Department of Food Science and Technology, Oregon State University. Sample testing was performed in individual testing booths under white incandescent light.

Twenty five-mL samples were served in black covered 227-mL wine glasses at room temperature. Each panelist had one set of four different samples in each testing session in the first week as illustrated in figure 1. Replicates of each sample was served in the following week. Each sample was coded with a three-digit random number.

Descriptive analysis

Ten volunteers (five males and five females) participated on the trained panel to evaluate cantaloupe juice (single strength and concentrate). Panelists were graduate students, faculty and staff from the Oregon State University Department of Food Science and Technology, with varying degrees of sensory evaluation experience. Eight training sessions were used before performing the test. During the training sessions, panelists developed character notes for aroma, flavor and selected standards to represent those character notes (listed in Table 2). Aroma intensity was rated as described by Chavasit (1989).

Figure 1 Number of samples served for each panelist during the testing sessions.

	Day 1		Day 2	
1st week	SFb1	SRb1	SFb2	SRb2
	CFb1	CRb1	CFb2	CRb2
2nd week	SFb2	SRb2	SFb1	SRb1
	CFb2	CRb2	CFb1	CRb1

Statistical analysis

The sources of variation needed to be considered in this study were flesh versus rind (F), single strength versus concentrate (C), panelist (P), replicate (W) and the interactions F*C, F*P, C*P, and F*C*P (Table 11). F, C, P, and W sources of variation were treated as random effects.

The collected data were subjected to analysis of variance (ANOVA), and then the differences between means of the data from each treatment were tested for their significant difference at $p \leq 0.05$ using Fisher's Protected Least Significant Difference (FPLSD) test.

Table 2 Standards used to represent each aroma and flavor descriptor during panelist training for descriptive analysis.

Descriptor	Standard*
Aroma	
Overall intensity (OAI)	No standard
Total Fruitiness (TF)	No standard
Fresh Fruit (FR1)	12 cubes 1x1x1 cm of fresh cantaloupe flesh.
Cooked Fruit (CKD1)	No standard
Caramel (CAR)	4 pieces of Kraft caramel candy (Kraft, Inc. Glenview. IL.)
Honey (HON)	25 mL of U.S. Grade A Clover Honey (Heins Honey Co. Albany, OR. USA.
Total Vegetative (TVG)	No standard
Green/Rind (RND1)	Chopped flesh and rind of fresh cantaloupe fruit.
Straw (STRW)	Dried straw.
Flavor	
Overall Intensity (OAI1)	No standard
Overall Fruit (OAF)	No standard
Fresh Fruit (FR2)	Fresh Cantaloupe (flesh only).
Cooked Fruit (CKD2)	No standard
Rind (Vegetative) (RND2)	Chopped flesh and rind of fresh cantaloupe fruit.
Sweetness (SWT)	6 gm Sucrose/100 mL distilled water.

* Standards were served in a covered 227-mL wine glass at room temperature.

RESULTS AND DISCUSSION

JUICE PROCESSING

Figure 2 shows the juice processing steps which were followed to obtain single strength cantaloupe juice and cantaloupe juice concentrate from flesh only and from flesh and rind. Preliminary trials showed that Ultra SP maceration enzyme was the enzyme gave the highest yield (80%) from flesh and rind of the three enzymes tested. Fruit without rind (flesh only) treated with maceration enzyme gave a high yield (75.6%), but it was extremely difficult to filter even after depectinization, High Temperature Short Time (HTST) treatment and fining with bentonite.

Pressing with the rind was effective in producing high yield because the rind acted as a press aid, which would be very practical for industrial applications. Preliminary testing of the freshly pressed juice revealed that juice from fruit pressed with the rind possessed a rind characteristic and flavor. More details about sensory evaluation will be discussed later in this study.

Freezing the flesh at -35 ^{o}C with subsequent thawing at 4 ^{o}C before processing by the same procedure used for flesh

and rind but without maceration enzyme produced a juice which could be successfully filtered. The yield (70%) obtained by this process was higher than the yield (65.8%) reported by Shin et al (1979). Freezing and thawing may cause rupture of cell walls and help to release the juice but further study is needed to investigate and account for that.

^{o}BRIX, pH, AND TITRATABLE ACIDITY (T.A.)

The ^{o}Brix, pH, and titratable acidity of single strength cantaloupe juice and reconstituted juice concentrate are listed in Table 3. The ^{o}Brix varied from 7.20-7.80 in the juice obtained from flesh and rind and from 8.5-11.4 in the juice obtained from flesh only. This variation could be related to the maturity variability of the fruits used in the experiment and to any water from washing of rind and equipment. The fruits which were mature (ripe) gave the highest ^{o}Brix while those which were immature gave the lowest ^{o}Brix. These results are in agreement with what Dull et al. (1989) reported about soluble solids content in immature cantaloupe, 5.7 ^{o}Brix and in ripe cantaloupe, 10.7 ^{o}Brix. The mean (10.2 ^{o}Brix) in the flesh only (Table 3) was higher than the value recommended as a standard (9.6 ^{o}Brix) by the National Juice Products Association (1989). From this table we can also

see that the °Brix in the juice samples obtained from flesh and rind is significantly lower ($p \leq 0.05$) than the °Brix of the juice samples from flesh only. That could be caused by inclusion of the rind, which would be low in soluble solids but would contain water. Dumas de Valux and Aubert (1976) stated that there is a ratio of 2 to 3 points increase in the refractometer scale from outside to inside toward the center in cantaloupe fruit. Cohen and Hicks (1986) also stated that the inner flesh of a muskmelon has a higher soluble solids content with a gradual decrease toward the rind.

The pH of all cantaloupe juice samples was almost neutral (close to pH 7). It was higher than the muskmelon pH range from 5.3 to 6.1 reported by Nath and Ranganna in (1977), higher than muskmelon juice pH value 6.10 reported by Lee, Y. W. (1975), but close to the muskmelon juice pH ranges from 6.2-6.6 reported by Esebua et. al (1971). The pH of single strength and reconstituted juices obtained from flesh and rind was significantly lower ($p \leq 0.05$) than the pH of single strength and reconstituted juices obtained from flesh only. This could be related to the rind composition, but further study is needed to substantiate that possibility.

All cantaloupe juice samples showed low titratable acidity (T.A) values (0.03-0.05) compared with what Esebua and Abdurazakova reported (1971). They reported T.A range from 0.14-0.19% in raw muskmelon juice and slightly lower than the range 0.06-0.08 reported by Sweeney et al. (1970). The titratable acidity was expressed as citric acid because it was reported as the major organic acid in muskmelon by Pratt (1971). The juice samples obtained from flesh only had slightly higher T.A. values than those of flesh and rind juice samples, but they were not significantly different at ($p \leq 0.05$). Amerine and Ough (1980) pointed out that although pH and T.A. are related, there is no apparent direct or predictable relationship between them. However, Dumas de Valux and Aubert (1976) reported that there is a negative correlation between pH and acidity in cantaloupe.

The pH and titratable acidity of the reconstituted concentrate were not significantly different at ($p \leq 0.05$) from those of the single strength (Table 3). That basically means the processing did not influence these values.

ASCORBIC ACID

Ascorbic acid content of cantaloupe juice is an important quality factor from two points of view, nutritional quality and its role in browning reactions.

Table 4 gives the ascorbic acid content (mg/100 mL) in raw fresh and frozen squeezed cantaloupe juice as determined by the indophenol and enzymatic methods. Results of the two methods showed that the fresh juice was significantly higher ($p \leq 0.05$) in ascorbic acid content than the frozen juice. In several studies it was reported that the ascorbic acid content of the cantaloupes varies based on cultivars, stage of maturity, time and temperature of storage, and the method used for determination. Norton et al. (1985) reported the ascorbic acid content of six different cultivars, and the range was from 50 to 80 mg per 100 g fruit. Evensen (1983) reported the range 39-91 mg per 100 g fruit at three different maturity stages; that content decreases to 25-59 mg per 100 g fruit after 15 days of storage at 0 and 4.5 ^{o}C. In this study, ascorbic acid content of Superstar cantaloupe determined in two different methods showed that they are significantly different at ($p \leq 0.05$). Chapman et al. (1951) stated that the indophenol method can't completely distinguish ascorbic acid from other reducing compounds. But the enzymatic method was specific to measure L-ascorbic acid. This could be a reason why ascorbic acid was lower when determined by enzymic than when it was determined by indophenol.

Pratt (1971) reported that ascorbic acid content in cantaloupe varies based on origin of production;

representitave ranges are reduced ascorbic of 20-40 mg, dehydroascorbic acid 7-10 mg and diketogulonic acid 2-2.5 mg/100 g fruit. Eitenmiller et al. (1985) reported that reduced ascorbic acid in cantaloupe ranges from 17.58-24.66 mg/100 g fruit with a mean of 21.05 mg/100 g fruit. This compares with the values reported by Gebhardt (1982) of 42.2 mg/100 g fruit. This shows that Superstar cantaloupe ascorbic acid results obtained in this study are comparable with those reported in the literature.

Dehydroascorbic acid (DHA) is an oxidative product of ascorbic acid. This oxidative product is biologically active, so assaying DHA is important as nutritive information. Figure 3 A and B show the HPLC chromatogram of reduced and total ascorbic acid in raw frozen squeezed cantaloupe juice. From this figure we can see that a considerable amount of ascorbic acid was in the form of dehydroascorbic acid. Pratt (1971) reported that ascorbic acid oxidase is naturally present in muskmelon fruit, so degradation of ascorbic acid to dehydroascorbic acid could have been caused by this enzyme. Oxygen also plays an important role in degradation of ascorbic acid (Kanner and Shapira, 1989), so ascorbic acid degradation could have occurred during thawing the raw frozen squeezed juices and during processing the cantaloupe into single strength juice in the presence of oxygen.

The ascorbic acid (AA), total ascorbic acid (TAA), and dehydroascorbic acid (DHA) content (in mg/100 mL) of cantaloupe raw frozen squeezed juice and single strength juice from flesh and rind and from flesh only juice are listed in Table 5. All three samples were low in ascorbic acid (AA) but they were not significantly different from each other ($p \leq 0.05$). The dehydroascorbic acid (DHA) content of the raw frozen squeezed juice was significantly higher ($p \leq 0.05$) than the DHA content of single strength obtained from flesh only, but not significantly higher than of that obtained from flesh and rind. This could be due to the degradation of AA to DHA and to 2,3 diketogulonic acid, a reaction that is non-reversible and results in loss of vitamin C activity (Liao and Seib, 1988) during processing the fruits into single strength. DHA content in the three samples are in agreement with what Pratt (1971) reported about DHA content in cantaloupe (7-10 mg/100 g fruit). Dumas de Valux and Aubert (1976) reported a higher amounts of DHA in cantaloupe variety Douplon grown during the winter season in a green house; they found a mean of 16.7 mg/100 g fruit for 39 fruits. They also reported a mean of 33.2 mg/100 g fruit for 30 fruits grown in the field under plastic tunnel. These DHA values are considerably higher than what was found in Superstar cantaloupe in this study but their determination was completely different because Dumas de Valux and Aubert (1976) totally oxidized the AA to

DHA and reported their values as DHA which, was in fact total ascorbic acid.

TOTAL CAROTENOIDS CONTENT

The total carotenoids were determined as ß-carotene, which has been identified as the major carotenoid in cantaloupe fruit by Philip and Chen (1988). The concentration of total carotenoids content in frozen flesh of cantaloupe is summarized in Table 6. The mean value of 12.3 ppm is lower than that (17.6 ppm) reported by Philip and Chen (1988) in an unknown cantaloupe cultivar. Pratt (1971) stated that total carotenoids in muskmelon varies from 8-25 ppm. Total carotenoids content in Superstar cantaloupe determined in this study is in that range. Fruit maturity, extraction method and solubility of carotenoids can also influence the amount of total carotenoids. Freezing the fruits also is one of those factors which can cause loss of carotenoids as stated by (Mitchell et al., 1948). Dumas de Vaulx and Aubert (1976) reported that the carotenoids in cantaloupe flesh in Doublon cultivar were stable in the mature fruits stored at ambient and cold temperature (4 ^{o}C). However Francis (1985) pointed out that the stability of the pigment in the fruits is not the same as in the extracted materials.

SUGAR ANALYSIS

The HPLC separation of cantaloupe melon juice sugars on the Bio-Rad Aminex HPX-87c column with a column heater and RI detector as eluent are shown in figure 4. The required time for separation was less than 20 minutes with very good resolution. Using the anion exchange mini column in the sample preparation procedure removed acids from the samples and the sugars were identified based on their retention times relative to standards. The sucrose peak has a small shoulder in both standard and samples, however, that was not considered as an indication of sucrose hydrolysis because injection of sucrose standard alone in the same condition gave peak with no shoulder of sucrose and no glucose and fructose peaks.

The sugar composition of raw fresh squeezed and reconstituted cantaloupe juice is listed in Table 7. Sucrose, glucose and fructose were the principal sugars found in the samples. Similar results about sugar identification in cantaloupe were reported by Wade (1982). Sucrose was the major component in the raw fresh squeezed juice while glucose was the lowest. Cohen and Hicks (1986) reported similar results about the amount of each sugar in Superstar cantaloupe, where they found 2.5, 1.1, and 1.4 g/100 g fruit of sucrose, glucose and fructose,

respectively. Sucrose being the major sugar in mature cantaloupe fruit confirms Wade's findings (1982).

The total sugar content in the reconstituted juice obtained from flesh only was significantly higher ($p \leq 0.05$) than that of the reconstituted juice obtained from flesh and rind. That was because the flesh in the center of the melon has higher soluble solids content with gradual decrease toward the rind (Cohen and Hicks, 1986) and (Dumas de Valux and Aubert, 1976). Another possibility was the amount of water released from the rind during processing, which could dilute the juice.

Whistler and Daniel (1985) stated that hydrolysis of sucrose to glucose and fructose can be caused by small quantities of food acid or by high temperature. So fructose became the major component in cantaloupe reconstituted juice which was subjected to flash evaporation process to make juice concentrate. Pratt (1971) reported that invertase is one of those native enzymes present in muskmelon juice, so sucrose hydrolysis could also be caused by this enzyme.

NONVOLATILE ACIDS ANALYSIS

A chromatogram of cantaloupe nonvolatile acids using refractive index detection and anion exchange clean up

procedures are shown in figure 5. Two peaks have been well identified, malic (B) and citric (C). Malic acid was tentatively identified on the basis of its retention time and production of symmetrical peak in spiked samples, while citric acid was identified on the basis of its retention time and distinctive shape comparing with the standard. Pratt (1971) reported that citric acid was identified in muskmelon cultivars by Lindner et al. (1963), Ito and Sagasegawa (1952), Jurics and Lindner (1965), and Mori et al. (1967). Pratt (1971) also reported that malic acid was identified in some muskmelon cultivars by Lindener et al. (1963) and Mori et al. (1967). The results of this study confirm those previous reports.

From Figure 5, it is apparent that citric acid is the major acid in Superstar cantaloupe because its peak area is 5 times of that of malic acid. The unidentified peak (A) appears very close to the retention time of quinic acid (12.3 min.). Further work is needed for its identification.

In most fruits, organic acids are lost during ripening (Pilando and Wrolstad, 1986). Commodities that exhibit rapid carbon dioxide production or oxygen consumption rates are generally quite perishable (Haard, 1985). Cantaloupes are highly perishable and they continue to respire and produce heat, the rate being directly related to their pulp

temperature (Seelig, 1977). This in addition to muskmelon being naturally low in acids can be used to account for the low acidity in cantaloupe juice in this study.

BROWNING OF CANTALOUPE JUICE CONCENTRATE DURING STORAGE

The type and level of amino acid compounds, pH of the medium, ascorbic acid content, and type and level of reducing sugars are among those factors which are known to affect the rate of nonenzymic browning. Cantaloupe juice concentrate has a high amount of total free amino acids, almost neutral pH, considerable amount of ascorbic acid and reducing sugars. All these factors appeared to enhance the browning rate in cantaloupe juice in this study. The change in browning of cantaloupe juice concentrate obtained from flesh only and from flesh and rind during storage at 25 ^{o}C for 120 days is shown in figure 6. The plot of the juice concentrate from flesh and rind was zero order. The plot of the juice concentrate from flesh only was zero order also, but it had faster rate after 60 days than between 0 to 60 days of storage. The concentrate obtained from flesh and rind tended to have lower initial browning values but higher browning rate than that concentrate obtained from flesh only. Table 8 shows the initial browning indices, browning rates, and the formol values (meq/100 mL) for cantaloupe juice concentrate samples. The initial browning values for

the two samples were not significantly different ($p \leq 0.05$), so they were not accurate indicator for browning rate or for final browning values. Formol values in concentrate obtained from flesh and rind were a little bit higher than those of concentrates obtained from flesh only, but they were not significantly different ($p \leq 0.05$). These values have been used as indicator for browning potential for other fruits like unripe pears, which were reported by Wrolstad et al. (1989) to have 0.122 milliequivalent/100 mL and have high rate of browning. Formol values in cantaloupe juice concentrate is much higher than those of other fruits reported by Bielig et al. (1987), e.g apple (0.45), grape (1.5), pear (0.4), grapefruit (2.0) and raspberry (1.5). This very likely accounts for at least part of the higher browning rate.

Flores et al. (1970) determined 292.3 mg/100 g as total free amino acids in cantaloupe. Ashoor and Zent (1984) categorized the common amino acids into three groups high browning producing amino acids, intermediate browning producing amino acids, and low browning producing amino acids according to the intensity of Mailliard browning formed when heated in an autoclave at 121 ^{o}C for 10 min, under identical conditions, with each of the sugars D-ribose, D-glucose, D-fructose, alpha-lactose and sucrose. Thirty percent of cantaloupe amino acids (aspartic and

glutamic) fall in the group of low browning producing amino acids, 47% (alanine, valine, leucine, proline, hydroxy proline, and phenylalanine) fall in the group of the intermediate browning producing amino acids and 5.4% (glycine, tyrosine, and lysine) fall in the group of high browning producing amino acids according to Ashoor and Zent categorization (1984). With the type of amino acid and sugars, pH is another factor which can affect the rate of Maillard reaction. Maillard browning intensity is directly proportional to the pH of the amino acid-sugar solution (Ashoor and Zent, 1984).

The ascorbic acid contributes in nonenzymic browning through ascorbic acid oxidative browning, which occurs via dehydroascorbic acid and through the reaction of ascorbic acid breakdown compounds, e.g dehydroascorbic acid with the amino groups of amino acids, protein and other amines (Strecker degradation; Wong and Stanton, 1989). Both of these cases are pH-dependent (Wedzicha, 1984; Eskin et al., 1971). Eskin et al. stated that juices with a higher pH, therefore, tend to be less susceptible to browning. Brown color in the case of ascorbic acid degradative is due to the formation, condensation, and polymerization of furfural (Wong and Stanton, 1989) while brown color in the case of Strecker degradation is due to the formation of melanoidin pigments (Eskin et al., 1971).

Cantaloupe juice concentrate had a considerable amounts of ascorbic acid and high pH (ca. neutral) but appeared to be high in browning rate (Figure 6). This contradicts the previous reports about browning due to ascorbic acid presence in juice samples. However, Eskin et al. (1971) mentioned that a pH of 5.2 was reported to provide an optimum environment for Strecker degradation in cabbage. So in cantaloupe juice concentrates there might be a possibility for this reaction to occur and enhance browning.

HUNTER MEASUREMENTS

Hunter parameters L a b and percent haze readings of single strength cantaloupe juice and reconstituted juice concentrate stored for 120 days at 25 ^{o}C are shown in Table 9. From this table, we can see that the L value (lightness index) in reconstituted juice gradually decreased along with storage time in both samples from flesh and from flesh and rind. This corresponds to the brown color developed along with storage. At zero time of storage the L values of reconstituted samples from flesh and rind were significantly lower ($p \leq 0.05$) than L values of reconstituted juice samples from flesh only. Similar result is also seen in the single strength samples. This could be related to the juice composition which obtained from two different parts of the fruits (flesh and flesh and rind). We also see that the L

values of single strength and reconstituted juice obtained from the same part of the fruits were not significantly different ($p \leq 0.05$).

The Hunter parameter a (redness index) of the reconstituted juices, at zero time of storage, and single strength gave negative values (green). The single strength samples seemed to have more greenish color than reconstituted samples. This could be related to the presence of chlorophyll in the rind which could be affected by concentration. However the a values, in both single strength and reconstituted juices, obtained from flesh only were not significantly different ($p \leq 0.05$) from those of the juice samples obtained from flesh and rind. The a values of reconstituted juice samples, except that of the sample obtained from flesh only after 60 day-storage time, were directly proportional to storage time. This increase of a value along with storage can be referred to the effects of heat treatment during concentration and to browning compounds which can also play an important role in color change because they can associate with redness.

The hunter parameters b (yellowness index) of the reconstituted juice samples, at zero time of storage, and single strength obtained from flesh were not significantly different ($p \leq 0,05$). Whereas b value of the reconstituted

juice samples, at zero time of storage, obtained from flesh and rind was significantly higher ($p \leq 0.05$) than that of single strength obtained from flesh and rind. This could be related to the effect of concentration process on the juice samples. The hunter parameter b values of single strength obtained from flesh and from flesh and rind were not significantly different ($p \leq 0.05$). The hunter parameter b of the reconstituted juice (at zero time of storage) obtained from flesh and rind was significantly higher than that of reconstituted juices obtained from flesh only.

Clarified cantaloupe juice did not contain the pigment responsible for the yellow color ß-carotene because it was removed through fining and filtration. So this yellow color detected in the samples could be related to the water soluble compounds in the juice e.g phenolics. Yellowness could also be a result of concentrating the single strength juice or related to those yellow compounds formed at the intermediate stages of browning.

Haze is an important quality factor in clarified fruit juices. From Table 9, the single strength cantaloupe juice obtained from flesh only gave a mean haze reading of (3) at zero time of storage. This reading was slightly higher than haze reading (2.7) of apple single strength juice reported by Wrolstad et al. (1989) which was reported to have high

clarity. The haze readings in single strength juice obtained from flesh and rind was significantly higher ($p \leq 0.05$) than that of single strength juice obtained from flesh only.

The haze reading, at zero time of storage, in reconstituted juice obtained from flesh only was significantly lower ($p \leq 0.05$) than that of reconstituted juice obtained from flesh and rind but not significantly different ($p \leq 0.05$) from that of single strength obtained from flesh only. The haze reading in reconstituted juice, at zero time of storage time, obtained from flesh and rind was significantly higher ($p \leq 0.05$) than that of single strength juice obtained from flesh and rind. The development of haze formation in reconstituted juice samples (from flesh and from flesh and rind) stored at 25 ^{o}C for 120 days increased along with storage until it reached its maximum at 90 days then slightly decreased after 120 days. Although the haze readings in reconstituted juice samples from flesh and rind were significantly higher ($p \leq 0.05$) than those of the reconstituted juice samples from flesh only, the rate of haze formation along with storage time in both samples was not significantly different. The post haze formation needs further study to see if there is a possibility to use cantaloupe juice as clarified juice.

SENSORY EVALUATION

Fifteen descriptors were selected to describe the aroma and flavor characteristics in single strength and concentrated cantaloupe juice. Table 2 shows the descriptors and the standards used during training sessions.

Main effects:

The F-values (Table 10) for all descriptors of flesh versus rind (F) except for overall flavor intensity (OAI1) and fresh fruit flavor (FR2) were not significantly different at ($p \leq 0.05$), thus implying that differences between juices obtained from flesh and from flesh and rind could not be detected by the trained panel in most aroma and flavor characters. The single strength versus concentrate (C) source of variation was significant in all aroma and flavor descriptors except overall aroma intensity (OAI). Therefore concentrating the cantaloupe juice either from flesh or from flesh and rind caused changes in aroma and flavor which were detected by the trained panel. Panelist source of variation (P) was significant in all aroma and flavor descriptors, due to using different parts of the scale. Panelists are naturally different from each other in their sensitivity to different factors that contribute to response variation. Training by use of intensity standards can help to reduce but not to completely eliminate this

source of variation. Replicate (W) was not significantly different in all aroma and flavor descriptors except in total fruitiness (TF) and fresh fruit (FR1) in aroma and in Overall flavor intensity (OAI1), thus sensory differences among replicates were not high. This demonstrated the consistency of samples preparation and serving conditions during testing.

Interactions:

The F-values for panelists by single strength versus concentrate interaction (P*C) for all descriptors except sweetness were significantly different (Table 10). This significance is caused by panelists disagreeing on how two samples compare. For example, panelist 1 rated sample A higher than sample B while a second panelist rated sample B higher than sample A. Another possible cause of this interaction is when one panelist's rate of change of scale values between two or more samples is different from that of another panelist's. For example, if panelist 1 gave sample A a value of 2 and sample B a value of 3 as compared to a second panelist assigning sample A a value of 2 and sample B a value of 7; because of the difference in the amount of increase of this rating from A to B, an interaction may result. Other juice descriptors can also affect the panelists judgment. For example, when a panelist judges the flavor sweetness in the juice he may be influenced by the

aroma descriptors e.g caramel and honey in this panel, and a high value may result (Table 11).

For each descriptor where a significant P*C interaction resulted, plots of interaction means were constructed and examined. For most descriptors, there was little disagreement among panelists and the interaction, although significant, should not affect interpretation of the main effects.

The means and standard deviations of trained panel aroma and flavor descriptors for the treatments, flesh (F), flesh and rind (R), single strength (S) and concentrate (C) are listed in Table 11. Samples obtained from flesh were not significantly different ($p \leq 0.05$) from samples obtained from flesh and rind in all aroma and flavor descriptors. However samples obtained from flesh were significantly higher ($p \leq 0.05$) in overall flavor intensity (OAI1) and in fresh flavor intensity (FR2). Single strength samples were not significantly different ($p \leq 0.05$) in all aroma and flavor descriptors. Thus implying that concentrating single strength cantaloupe juice caused removal of almost all the flavor and aroma characters responsible for rind characteristics.

SUMMARY AND CONCLUSIONS

"Superstar" cantaloupe was processed into juice and juice concentrate using two processes. Processing trials were carried out on fruits with and without rind. The effects of maceration enzymes and freezing on yield and filtration were examined. The effect of concentration, using centrifugal film evaporator (Centritherm CT-1B), on aroma and flavor characteristics was examined also. Quality of the concentrate (ascorbic acid, browning, haze, and flavor) was evaluated. Results of these investigations show that:

1. Cantaloupes were successfully processed into juice and juice concentrate which can provide an alternative use for surplus fruit.

2. Fruit which had been treated with maceration enzyme gave high yield (80%) with no difficulties in filtration after depectinization, HTST treatment, and fining.

3. Fruits without rind (flesh only) treated with maceration enzyme gave a yield of (75.6%); but it was extremely difficult to filter the juice even after depectinization, HTST treatment, and fining.

4. Substituting the maceration enzyme by freezing the flesh with subsequent thawing at 4 ^{o}C before processing by the same procedure used for flesh and rind gave 70% yield and the juice could be successfully filtered.

5. No statistical differences were found in sensory evaluation of cantaloupe juice concentrates obtained from flesh and from flesh and rind using the centrifugal evaporator (centritherm CT-B).

6. Ascorbic acid degradation occurred during processing and freezing of the fruits.

7. Cantaloupe juice concentrate had a high browning rate comparing with other fruit juice concentrates such as apple, pear, and grape.

8. Post haze formation occurred during storage of cantaloupe juice concentrate, so cantaloupe juice might not be appropriate to be commercially produced as clarified juice.

9. The high yield, high sugar content and low acidity of the juices suggest its use as an alternative sweetener source but browning could be a problem during storage.

Table 3 pH, °Brix, and Titratable acidity (T.A) in single strength Cantaloupe juice (SS) and reconstituted juice concentrate (Recon.).

		Brix				pH				T.A		
samples	n	mean	range	SD	n	mean	range	SD	n	mean	range	SD
Flesh only (SS)	10	10.2a	8.50-11.4	0.99	10	6.52a	6.34-6.83	0.12	5	0.04a	0.03-0.05	0.01
Flesh & rind (SS)	7	7.54b	7.20-7.80	0.21	10	6.33b	6.10-6.52	0.14	5	0.03a	0.03-0.04	0.00
Flesh only (Recon.)					10	6.98a	6.93-7.03	0.04	4	0.04a	0.03-0.05	0.00
flesh & rind (Recon.)					10	6.91b	6.87-6.95	0.00	4	0.04a	0.04-0.05	0.00

Means in the same column with the same letters are not significantly different at p ($P \leq 0.05$)
n: number of samples
SD: standard deviation

Table 4 Ascorbic acid values (mg/100 mL) in cantaloupe raw fresh and frozen squeezed juice as determined by indophenol and enzymic methods.

	Indophenol			Enzymic		
samples	n mean	range	SD	n mean	range	SD
Fresh	4 39.0a	37.0-41.0	1.41	4 25.4a	24.6-25.9	0.48
Frozen	4 22.5b	20.0-24.0	1.54	4 15.6b	13.4-18.1	2.19

Means with the same setters are not significantly different at ($P \leq 0.05$).
n: number of samples.
SD: standard deviation.

Table 5 Ascorbic acid values (mg/100 mL) in cantaloupe raw frozen squeezed juice and single strength juice from flesh and from flesh and rind as determined by HPLC.

samples	n	AA	DHA	TAA
raw frozen (squeezed)	2	0.35 (0.02)	10.2a (0.09)	10.6a (0.08)
flesh & rind	2	0.56 (0.03)	9.40a (0.18)	9.96a (0.15)
flesh only	2	0.54 (0.02)	7.65b (0.02)	8.19b (0.04)

n: number of samples.
Values between parenthesis are standard deviations.
Means with the same letter are not significantly different.

Table 6 Total carotenoids content (ppm) in frozen flesh of cantaloupe fruit.

# samples	Mea	Range	SD
4	12.3	11.9-12.5	0.23

ppm: Part per million.
SD: standard deviation.

Table 7 Sugar composition of raw fresh squeezed and reconstituted cantaloupe juice (g/100 mL) as determined by HPLC.

samples	Sucrose	Glucose	Fructose	Total	Percent of total sugars		
					Suc.	Gluc.	Fruc.
Raw fresh squeezed	1.73 (0.06)	1.23 (0.15)	1.61 (0.23)	4.57 (0.44)	37.9	26.9	35.2
Reconstituted*							
Flesh only	2.12a (0.02)	1.76a (0.04)	2.19a (0.05)	6.07a (0.02)	34.9	28.9	36.1
Flesh & rind	1.42b (0.02)	1.27b (0.05)	2.04b (0.04)	4.73b (0.07)	30.0	26.9	43.1

Each value represents a mean of two replicates.
Values between parenthesis are standard deviations.
* Samples were normalized to 9.6 °Brix.
Means with the same letters are not significantly deferent at ($P \leq 0.05$).

Table 8 Initial browning, rate constant, and formol value of cantaloupe juice concentrate stored for 120 days at 25 °C.

samples*	Initial browning index (A 420 nm)			Rate constant (Zero Order)	Formol value (meq/100 mL)			
	n	mean	range	SD		n	mean	range	SD
Flesh & rind	4	0.18a	0.08-0.29	0.09	0.013	6	4.53a	4.42-4.86	0.15
Flesh only	4	0.25a	0.25-0.26	0.01	0.008	6	4.43a	4.30-4.63	0.14

* Samples were normalized to 9.6 °Brix.
n: number of samples.
SD: standard deviation.
Means with the same letters are not significantly different at ($P \leq 0.05$).

Table 9 Hunter parameters and % haze of single strength cantaloupe juice and reconstituted juice concentrate stored for 120 days at 25 °C.

Sample	Storage time (days)				
Flesh only	0	30	60	90	120
(reconstituted*)					
L	90.50	87.40	85.20	80.60	78.20
	(0.50)	(0.21)	(0.37)	(0.38)	(0.60)
a	-1.78	-2.4	-2.44	-2.04	1.08
	(0.06)	(0.03)	(0.07)	(0.11)	(0.15)
b	8.82	15.90	19.70	23.90	28.50
	(0.42)	(0.44)	(0.31)	(0.39)	(0.63)
haze	3.74	5.10	7.17	10.90	10.60
	(0.42)	(0.14)	(0.29)	(0.96)	(0.68)
Flesh & Rind (reconstituted*)					
L	83.20	83.00	76.60	71.10	67.70
	(1.24)	(0.77)	(1.40)	(1.07)	(0.83)
a	-2.49	-3.17	-2.03	0.57	1.46
	(0.12)	(0.16)	(0.31)	(0.11)	(0.24)
b	13.60	23.00	28.20	28.50	32.70
	(0.14)	(0.29)	(0.38)	(1.41)	(0.23)
haze	15.90	10.10	15.30	23.50	22.60
	(2.38)	(1.27)	(1.79)	(2.16)	(1.26)
Flesh only (single strength)					
L	90.26	-	-	-	-
	(0.64)	-	-	-	-
a	-2.06	-	-	-	-
	(0.15)	-	-	-	-
b	9.60	-	-	-	-
	(0.82)	-	-	-	-
haze	3.00	-	-	-	-
	(0.03)	-	-	-	-
Flesh & Rind (sigle strength)					
L	87.46	-	-	-	-
	(0.57)	-	-	-	-
a	-2.63	-	-	-	-
	(0.17)	-	-	-	-
b	11.00	-	-	-	-
	(0.39)	-	-	-	-
haze	8.21	-	-	-	-
	(1.93)	-	-	-	-

* Samples were normalized to 9.6 °Brix. Each value is a mean of four replicates. Values between parenthesis are standard deviations.

Table 10 F-values for each source of variation of each aroma and flavor descriptor in cantaloupe rated by the trained panel.

SOURCE OF VARIATION	DF	AROMA DESCRIPTORS								
		OAI	TF	FR1	CKD1	CAR	HON	TVG	RND1	STRW
F	1	0.00	1.57	0.00	0.62	0.06	2.29	0.01	0.13	0.31
C	1	0.30	166.91***	387.64***	209.78***	228.06***	86.25***	15.1***	82.31***	22.56***
F*C	1	0.05	1.90	0.23	0.20	0.35	0.63	0.64	0.41	0.02
P	9	24.00***	17.62***	5.47***	11.00***	25.81***	58.71***	27.77***	19.46***	41.80***
F*P	9	0.85	0.59	0.62	0.74	0.63	0.79	0.40	0.96	1.14
C*P	9	5.52***	9.54***	5.14***	3.98***	7.35***	4.75***	14.92***	7.02***	11.30***
F*C*P	9	0.92	1.07	0.65	1.46	0.38	0.49	0.53	0.76	0.39
W	1	2.36	4.03	4.33	0.00	2.57	1.87	0.12	0.41	0.02

		FLAVOR DESCRIPTORS					
		OAI1	OAF	FR2	CKD2	RND2	SWT
F	1	4.20*	2.13*	4.09	0.10	0.95	3.79
C	1	33.52***	5.93**	144.33***	303.36***	10.29**	57.15***
F*C	1	0.71	0.53	2.77	0.10	0.49	1.06
P	9	32.77***	42.11***	22.94***	21.79***	39.33***	39.55***
F*P	9	0.54	0.33	0.49	1.01	1.40	0.33
C*P	9	2.96**	5.00***	2.67**	4.60***	14.84***	1.28
F*C*P	9	1.19	1.40	0.34	1.35	1.43	1.92
W	1	5.82*+	2.50	0.13	2.44	0.02	2.22

Note: *:P≤0.05; **:P≤0.01; ***:P≤0.001
OAI=overall intensity, TF=total vegetative, FR=fresh fruit, CKD=cooked fruit, CAR=caramel, HON=honey, TVG=total vegetative, RND=green/rind, SWT=sweetness.
Flesh vs Rind (F), Single strength vs concentrate (C), Replicates (W).

Table 11 Means and standard deviation of trained panel aroma and flavor descriptors for four treatments of cantaloupe juice single strength and concentrate from flesh and from flesh and rind.

Descriptor	F	R	LSD	ANOVA	S	C	LSD	ANOVA
AROMA								
OAI	8.14	8.33	-	NS	8.34	8.13	-	NS
	(2.55)	(2.16)			(1.94)	(2.72)		
TF	6.16	6.09	-	NS	7.33	4.93	0.40	S
	(2.37)	(2.23)			(1.90)	(2.02)		
FR1	4.01	4.15	-	NS	6.30	1.86	0.44	S
	(2.86)	(2.77)			(2.06)	(1.30)		
CKD1	3.50	3.41	-	NS	1.81	5.10	0.41	S
	(2.46)	(2.39)			(1.81)	(1.73)		
CAR	2.40	2.33	-	NS	1.18	3.55	0.31	S
	(1.90)	(1.88)			(1.17)	(1.71)		
HON	2.64	2.43	-	NS	1.85	3.21	0.36	S
	(2.55)	(2.33)			(1.96)	(2.68)		
TVG	3.71	3.59	-	NS	4.24	3.06	0.43	S
	(2.32)	(2.63)			(2.13)	(2.66)		
RND1	2.68	2.54	-	NS	3.46	1.75	0.39	S
	(2.02)	(1.93)			(1.91)	(1.64)		
STRW	1.54	1.56	-	NS	1.33	1.78	0.26	S
	(1.98)	(2.10)			(1.57)	(2.41)		
FLAVOR								S
OAI1	8.00	7.69	0.41	S	7.23	8.46	0.41	
	(2.21)	(2.30)			(1.83)	(2.46)		S
OAF	6.21	6.01	0.42	S	6.38	5.85	0.42	
	(2.30)	(2.36)			(1.95)	(2.63)		S
FR2	4.65	4.20	-	NS	5.74	3.11	0.43	
	(2.27)	(1.97)			(1.94)	(1.37)		S
CKD1	3.44	3.26	-	NS	1.54	5.16	0.40	
	(2.53)	(2.84)			(1.74)	(2.18)		S
RND2	2.81	3.03	-	NS	3.20	2.64	0.37	
	(2.27)	(2.37)			(1.90)	(2.65)		S
SWT	6.98	6.54	-	NS	5.84	7.68	0.44	
	(2.56)	(2.47)			(2.31)	(2.39)		S

NS: nonsignificant different at $P \leq 0.05$
S: significant difference at $P \leq 0.05$
Values between parenthesis are standard deviations.

Figure 2. Unit operation for processing cantaloupe juice samples.

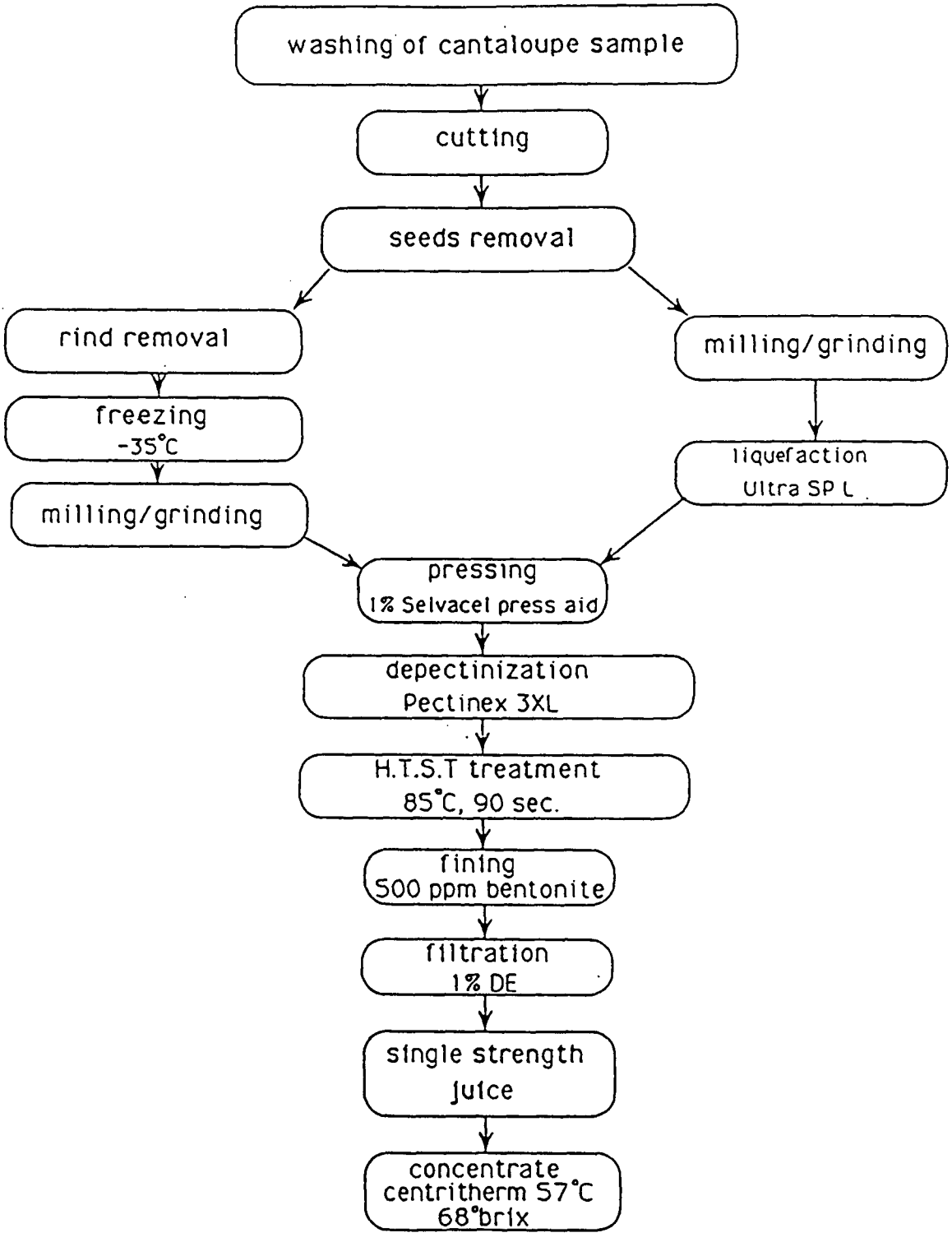
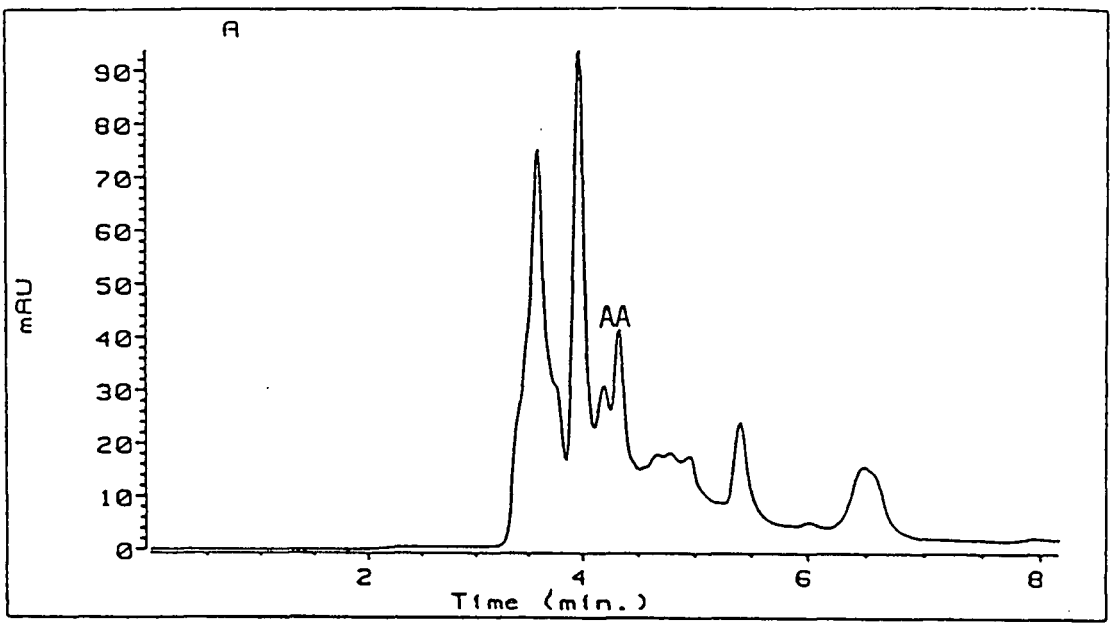


Figure 3 HPLC chromatogram for (A) reduced ascorbic acid, (B) total ascorbic acid in raw frozen squeezed cantaloupe juice.

Peak identification: AA. reduced ascorbic acid, TAA. total ascorbic acid, DLHC. DL-homocysteine.



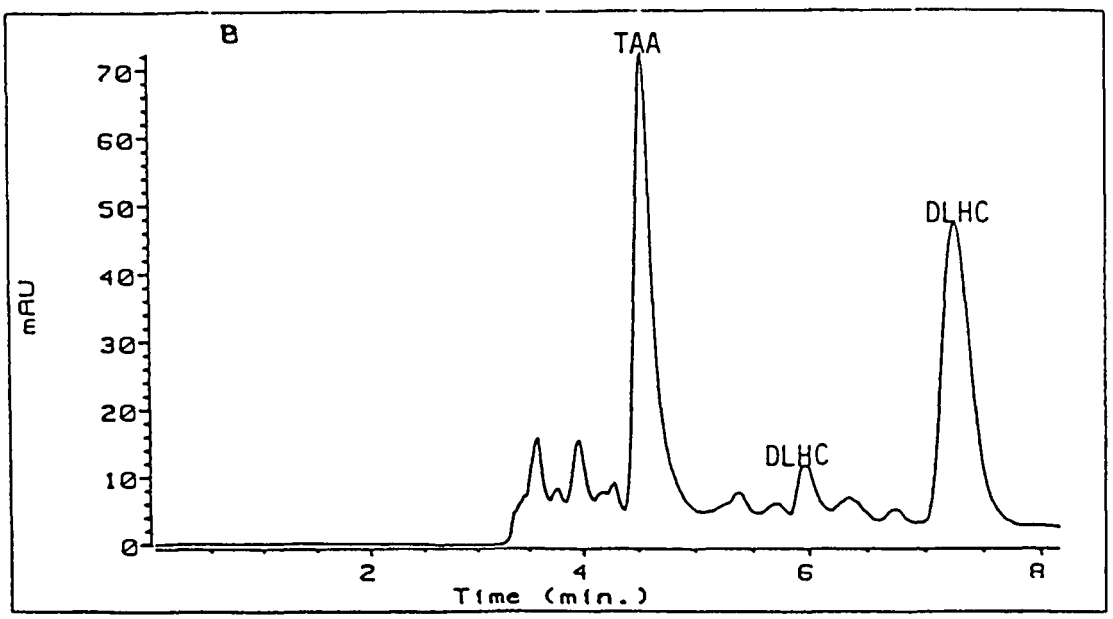


Figure 4 HPLC separation of cantaloupe sugars.

Peak identification: A. sucrose, B. glucose, C. fructose, D. mannitol (internal standard).

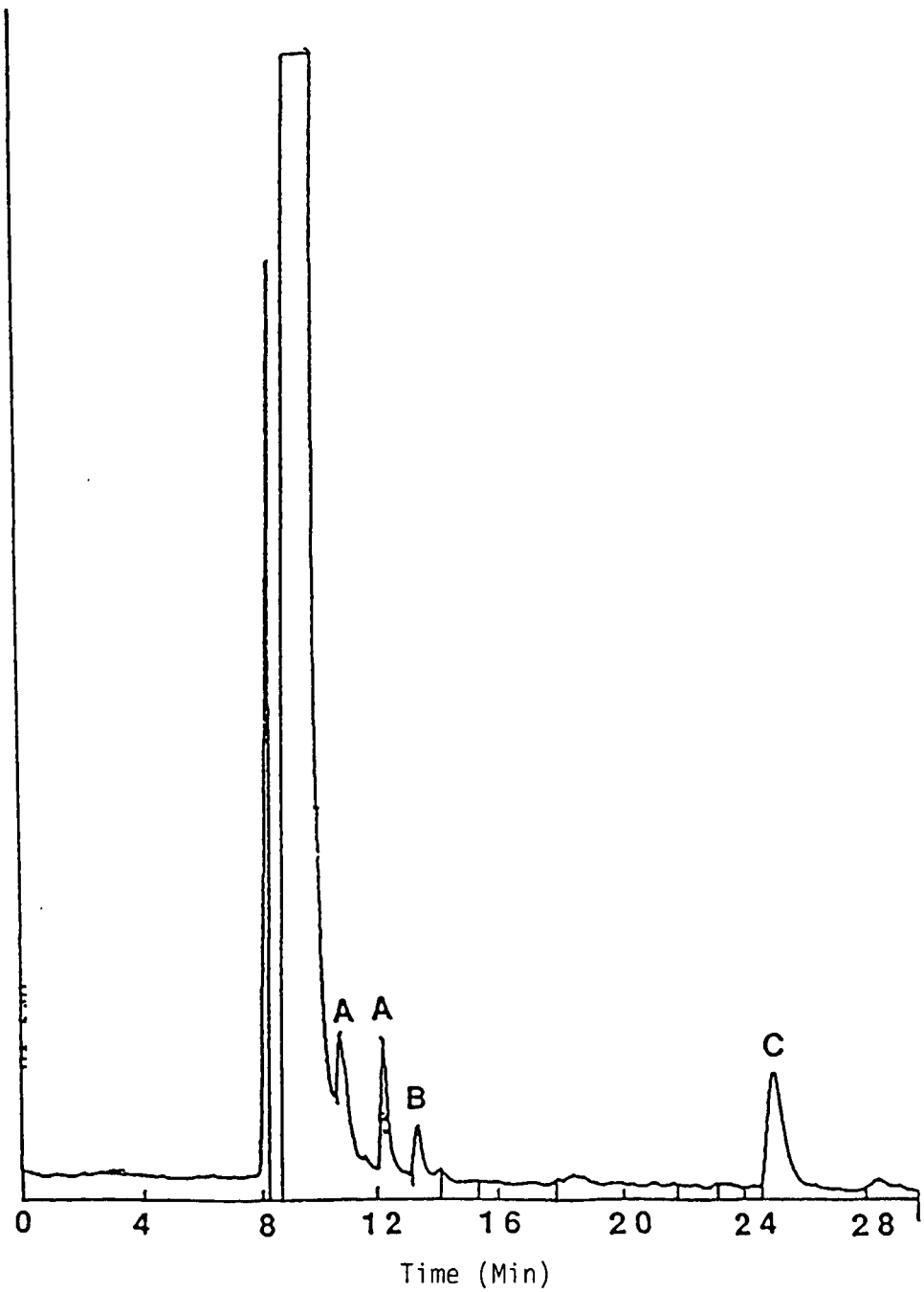


Figure 5 HPLC separation of cantaloupe nonvolatile acids. Detection Refractive Index.

Peak identification: A. Unknown, B. malic C. citric.

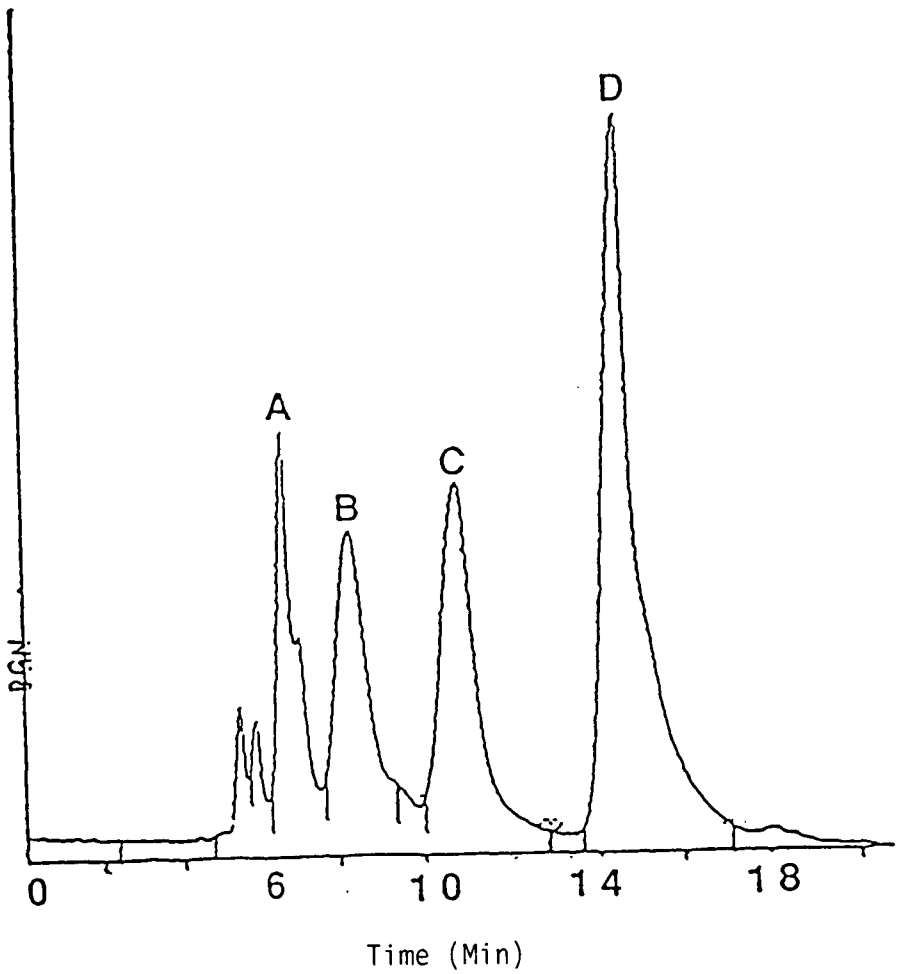
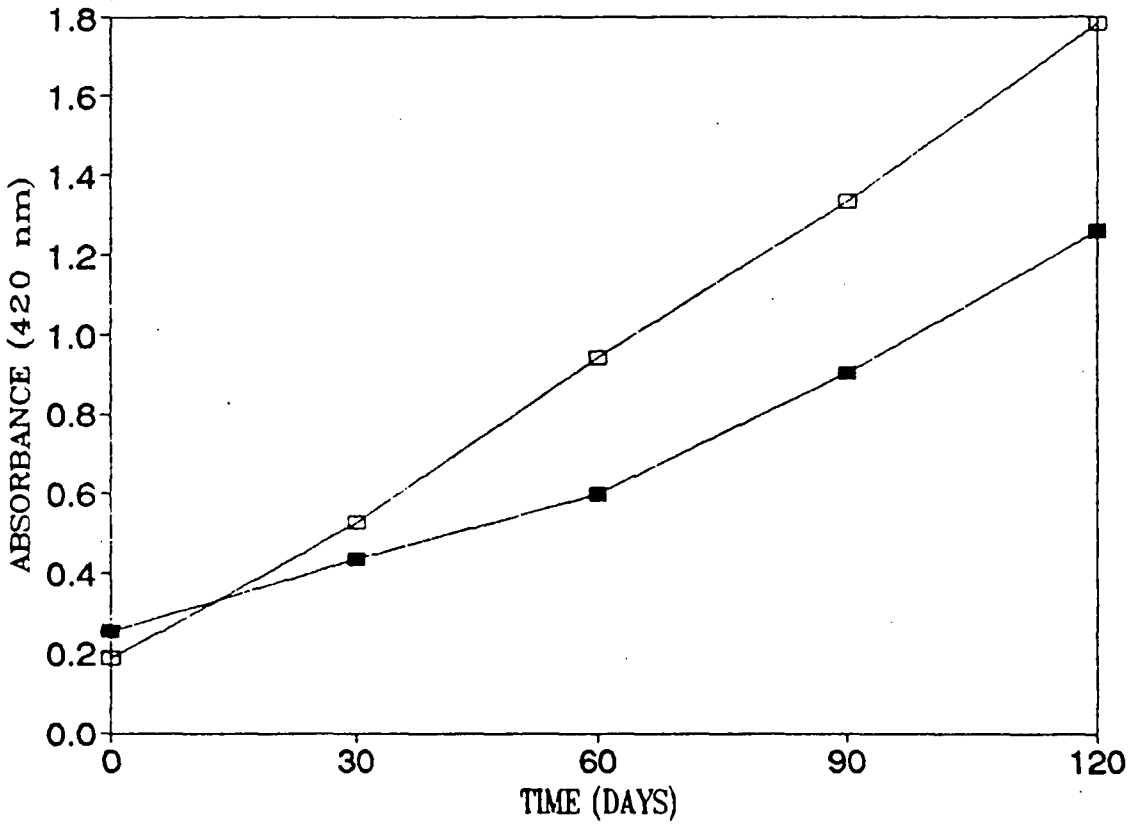


Figure 6. Browning (A_{420}nm) of cantaloupe juice concentrate during storage at 25 °C for 120 days. Samples made from flesh —■— and from flesh & rind —⊟—



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