THE INFLUENCE OF STORAGE ON QUALITY ASPECTS OF SOME LOCALLY PROCESSED FRUIT JUICES DRINKS

By

Najla Mousa Abdel Gader El Tom

B.Sc. Honours (Agric.)

University of Khartoum

1999

A Thesis Submitted in Partial Fulfillment of the Requirements for

M.Sc. of Science in Agriculture (Food Science and Technology)

Supervisor:

Dr. Hassan Ali Mudawi

Food Science & Technology Department

Faculty of Agriculture, University of Khartoum

Department of Food Science and Technology

Faculty of Agriculture, University of Khartoum

June - 200٣

To my dear family

To my dear fiancé

And to my dear friends

With love and respect

Najla

My special praise and unlimited thanks are to Allah for keeping me well and giving me patience to complete this research.

I am greatly indebted to my supervisor Dr. Hassan Ali Mudawi for his supervision, constructive guidance, encouragement, advice and cooperation during this study.

I am grateful to the staff of the factory who provided me with the samples, and my deep thanks is for Manal and Hiba for their assistance.

My thanks are also extended to my Ustaz Abu Elgasim, Gamaa, Eltayb Abass and specially Ustaz Moaz for their help, invaluable assistance and constant encouragement

Last but not least, my deepest gratitude and sincere thanks are to my all members of my family for their support and constant encouragement, specially my brother Alaa.

ABSTRACT

This study is carried out in order to make physical, chemical and microbial evaluation, for three types of natural fruit drinks, namely, orange/carrot, mango and apple, produced by one of the Khartoum State Food Industry Companies and consequently their fitness to the quality specifications. In addition to microbial evaluation of their concentrates.

The three types of drinks which are orange/carrot, mango, and apple were stored under room temperature and market condition for three, six and eight months.

Moisture content, pH, total soluble solids, viscosity, titrable acidity, ascorbic acid, total sugars, reducing sugars and sucrose were determined.

Results showed that there was significant difference between the two storage conditions compared to control. Some changes in physical and chemical properties were observed for the three types of drinks, where some parameters increased and others decreased.

The effect of storage treatment was highly observed in case of vitamin C, where its values for control samples were 72.99, 72.50 and 66.98mg/100ml for orange/carrot, mango and apple drink.

While, vitamin C contents after three months storage were 27.10, 25.2 and 28.63mg/100ml for orange/carrot, mango and apple,

respectively (room temperature), but on market condition vitamin C contents were 26.26, 23.5 and 28.0mg/100ml for orange/carrot, mango and apple, respectively.

Results of microbial analysis showed that no growth of coliform bacteria, yeasts and moulds was observed in all samples of the fruit drinks concentrates, indicating the absence of these microbes in the drinks prepared from these concentrates. The same results were observed in the stored samples.

However, all stored samples showed some total viable Bacterial count. Concerning quality specifications, it was found that orange/carrot drink fulfill the standard specifications.

بسم الله الرحمن الرحيم

خلاصة الأطروحة

أجريت هذه الدراسة لتقييم ثلاثة أنواع من مشروبات الفاكهة المصنعة محلياً بأحد مصانع الأغذية بولاية الخرطوم، فيزيائياً، كيميائياً وميكروبياً ومدي مطابقتها لمواصفات الجودة للعصائر. بالإضافة للتقييم الميكروبي لمركزات هذه العصائر.

تم تخزين شراب الفاكهة الطبيعية والتي إشتملت علي شراب البرتقال/جزر، شراب المانجو وشراب التفاح، تحت ظروف الغرفة العادية وظروف تخزين المتجر لفترات زمنية مختلفة إمتدت إلي ثلاثة، ستة وثمانية أشهر.

تم تقدير محتوي الرطوبة، محتوي الأس الهيدروجيني، المواد الصلبة الذائبة، اللزوجة، الحموضة، فيتامين (ج)، السكريات الكلية، السكريات المحتزلة والسكروز.

أظهرت النتائج أنه لا توجد فروقات معنوية بين ظروف التخزين بالغرفة وظروف التخزين بالمتجر ولكن توجد فروق معنوية في خواص العصائر خلال فترات التخزين عند مقارنتها بالعينة غير مخزنة (الضابط).

عينات العصائر الثلاث تعرضت لتغييرات خلال فترات التخزين المختلفة حيث لوحظ أن بعض قيم الخواص تعرضت للزيادة والبعض الآخر تعرض للنقصان، وقد وجد أن أكثر الخواص تأثراً فيتامين (ج) حيث كانت قيمته في عينات الضابط ٧٢,٩٩، ٧٢,٥٠ و ٦٦,٩٨ ملجم/١٠٠مل لشراب البرتقال/جزر، المانجو والتفاح علي التوالي. بعد ثلاثة أشهر أصبح محتوي فيتامين (ج) ٢٧,١٠، ٢٥,٢ و٢٨,٦٣ ملجم/١٠٠ مل لشراب البرتقال/جزر، المانجو والتفاح علي التوالي (درجة حرارة الغرفة)، لكن تحت ظروف المتجر كان محتوي

فيتامين (ج) ٢٦,٢٦، ٢٣,٥ و٢٨,٠ ملجم/١٠٠ مل لشراب البرتقال/جزر، المانجو والتفـاح علي التوالي.

أظهرت نتائج التحليل الميكروبي لمركبات العصائر الثلاثة خلوها من بكتريا القولون، الخمائر والفطريات ويدل ذلك علي عدم وجود هذه الميكروبات في المشروبات المحضرة من هذه المركزات. بالنسبة لعينات المشروبات التي أخضعت للتخزين فقد وجد أنها خالية تمامـاً من الخمائر والفطريات غير أنها تحتوي علي بعض المستعمرات الميكروبية خـلال جميـع فترات التخزين.

LIST OF CONTENTS

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

Since 1950 consumption of non-carbonated fruit juice drinks-both canned and pasteurized ready-to-serve drinks and concentrates (frozen or pasteurized) – has become increasingly important in the world. These fruit drinks are diluted fruit juices containing added water, sugar and sometime citric acid, gum arabic, artificial colour and flavours (Nelson and Tressor, 1980).

A fruit juice may be defined as the liquid expelled by pressure or other mechanical means from the edible portion of the fruit. It will frequently be turbid, containing cellular components in colloidal suspension with variable amount of finely divided tissue. It may also contain oily or waxy material and carotenoid pigments derived from the skin or rind of the fruit (Hulme, 1971).

In some juices, for instance orange juice, clarification would impair the appearance and flavour, thus such juices were recommended to be consumed in its natural state. In others clarification is required before consumption for e.g. apple and berries juices, but the problem has been to clarify them effectively and to maintain them in a brilliant condition throughout their storage life.

Increasing volume of juices are now converted into concentrates that are both more stable and require less storage space. The concentrates may used as ingredients in the frozen-foods. The manufacture of juices and especially of their concentrates extends the season of fruit consumption and assist in equalizing supplies from one year to another. As a result, it has encouraged on increasing international trade in products for direct consumption and for manufacture.

Juices undergo changes on storage due to chemical reactions between their constituents. Although the reactions are largely non-enzymatic, since any enzymes present have been previously inactivated, the extent to which any initial enzymic change has been allowed to proceed, is likely to be factor in the appearance and stability of the final product. Other factors involved are the amount of residual oxygen in the product, the temperature of storage and the extent of exposure to light (Hulme, 1970).

The loss of nutritional quality during the processing and storage of beverage has become an increasingly important problem with the introduction of nutrition labeling regulations. The loss of some nutrients, including ascorbic acid, may actually become the limiting factor in determining the shelf-life of some products (Laing *et al.,* 1978).

With the increasing complexity of food processing operations and the continuous pressure of competition, quality control is becoming ever more necessary in both large and small processing operations.

Bocklemann and Bocklemann (1988) defined the quality control of a product as its ability to fulfill consumer expectations, needs, wants and to ensure that the raw materials conform with their respective quality specifications. To this end, specifications are first of all needed, they should cover: Physical; and Chemical parameters; as well as microbiological aspects.

This research work aims to investigate:

The effect of storage conditions on the quality of three different locally pasteurized beverages, from the stand point of physical, chemical and microbiological attributes.

CHAPTER TWO

LITERATURE REVIEW

2.1. Types of juices:

The conversion of fruits into juices was originally developed as a method for making use of supplies to the fresh fruit market but, while it still fulfils this function, juice production is now firmly established in its own right (Hulme, 1971).

The product and preservation of fruit nectars, pulpy juices and fruit juice blends are of great commercial importance. Many fruit juices are either too acidic or too strongly flavoured to be pleasant beverage without diluting or blending, or both (Pederson and Beattie, 1943). Often these strong, tart juices are diluted with thin syrup or bland juice. Examples of the juices of this type are apricot, cranberry, currant, guava and plum juice. On the other hand, some juices do not have enough flavour, and they are greatly improved if the entire fruit, is converted into smooth pulpy beverage (Tressler and Joslyn, 1961).

2.2. Definition and classification:

Fruit juices are products for direct consumption and are obtained by the extraction of cellular juice fruit, this operation can be done by pressing or by diffusion. The technology of fruit juice processing will cover two finished product categories.

The first category include:

- Juices without pulp (clarified or not clarified).
- Juices with pulp (nectars).

The second includes:

- "Natural juices" products obtained from one type of fruit; and
- "mixed juices" products obtained from the mix of two or more juices from different fruit species or by adding sugar to the natural juice(Dauthy,1995).

The term "fruit nectars" is used by the industry to designate pulpy fruit juice belended with sugar syrup and citric acid to produce a ready-to-drink beverage. These beverages, although they resemble fruit juices in flavour, cannot be called fruit juices because of the presence of added water, sugar and acid. They vary from clear liquids to mixtures high in suspended solids (Tressler and Joslyn, 1954).

Many fruit nectars contain not less than 50% pure juice, either single-strength or reconstituted concentrates. Essences, vitamins, pectin, sugar and acid may be added. Fruit juices drinks usually contain not less than 20% juice, either single-strength or reconstituted from frozen or canned concentrates. Artificial flavour, colour, acid, pectin and other additives, as permitted by government regulations, may be added.

2.3. Composition and nutritive value of fruits:

The major part of the edible portion of fresh fruits consists of water (75-95% for most types). Fruits are poor sources of protein (0.2-1.3% as N×6.25), but, in general, contain a reasonable amount of carbohydrate. The latter may include varying proportions (according to the fruit type, maturity stage etc) of dextrose, fructose and sucrose and possibly starch (e.g. banana, apple). The principal acids present in fruits are citric, tartaric and malic acids. The pH of fruits varies from 2.5-4.5 with the range of 3-3.5 being in most types)(Egan *et al.*, 1981). The main feature of the composition from the nutritional point of view is that certain fruits, particularly black currants, guava, most citrus fruits and strawberries are good sources of vitamin C, though not very good sources of the B vitamins. Fruits are poor sources of carotene except for mango, papaya, orange and jack fruit. They are fair sources of folic acid (Rechcigl, 1982).

2.4. Composition and nutritive value of fruit juices:

2.4.1. Carbohydrates:

Most fruit juices are high in sugars and they contain large amount of dextrose and laevulose and in many cases sucrose as well (Hsieh and Harris, 1993). Some juices (fore example grape juice) were especially high in sugars, concord juice ordinarily contains 16–17 percent sugar. Passion fruit juice is also very high in sugar. Other juices relatively high in sugars were apple, apricot, orange, pineapple and prune. Sugars are important foods, being digested and yielding energy quickly (Dauthy, 1995).

2.4.2. Proteins:

Most of the common fruits are low in protein. The loganberry is an exception, since it contains approximately 1.5 per cent of protein (dry matter basis). A considerable proportion of the protein content of fruit is insoluble and consequently remains in the pomace, therefore, it is reflected in low contents in juice (Tressler and Joslyn, 1961).

2.4.3. Fats:

Nearly all of fruit juices are very low in fats. Grapes with 1.6 per cent, and black berries and raspberries containing approximately 1.0 per cent are exceptions. Because of the small amount of fat found in fruits, their juices are very low in fat (Tressler and Joslyn, 1961).

2.4.4. Vitamins:

Most fruit juices are excellent sources of vitamin C, several are good sources of carotene and many contain moderate amounts of pyridoxin, inositol, folic acid, and biotin.

Vitamins have a number of important functions in food processing. They may be added to foods to provide specific technical functions, such as protection of the quality of canned or bottled beverages (Tressler and Joslyn, 1961).

All fruits contain more or less some amounts of the antiscorbutic vitamin C. Most of them are good sources and several others are very rich in this vitamin. Fruits especially high in vitamin C include gooseberries, grapefruit, lemons, loganberries, raspberries. Rosehips and the acerola cherry contain large concentration of ascorbic acid. Rose ship syrup and acerole juice, however, are used as natural sources of ascorbic acid to fortify juices lacking in this nutrient. Other fruits commonly used for juice manufacture, considered to be good sources of this vitamin are black berries, cherries, red currants, peaches, and pineapple. The freshly pressed juice of citrus fruits are excellent source of vitamin C (Tressler and Joslyn, 1961).

2.4.5. Minerals:

Fruit juices are rich in potassium, and also contain much calcium, sodium, magnesium, phosphorus, chlorine, sulfur, iron, copper and other minerals needed by the body. Taken as a whole, berries and citrus fruits are higher in calcium than fruits used for juice making (Dauthy, 1995).

2.5. Ingredients used in fruit juice making:

2.5.1. Water:

Water is the basic and integral part of finished products. It is the liquid portion that carries the sugar, flavour, acid and colour. Over 90% of the total volume of finished product is water (Herschodoerfer, 1972).

2.5.1.1. Water treatment:

The water treatment consist of:

- Removal of colour suspended matter.
- Reduction of hardness if present.
- Elimination of undesirable bacteria.

If pure water is already available, polishing by filtration may be the only treatment necessary. High coloured or hard water require a full chemical treatment and general practice is to employ coagulation systems where the impurities in the water are removed by treatment with either salts of aluminum or irons (Woodrof and Phillips, 1974).

Sodium hypochloride and gaseous chlorine is included in the treatment to assist the chemical coagulation condition and to provide an excess of chlorine sufficient to sterilize the water, the chlorine is then removed by carbon filtration. This will also remove any undesirable off-taste and is normally preceded by sand filtration to ensure no contamination (Jacobs, 1959).

Alternative methods of treatment are available including reduction of alkalinity by hydrogen ion exchange, sterilization and colour removal by ozone treatment and more recently, the development of membrane filtration and the reverse osmosis process for demineralization. The final selection of treatment required depends on the quality of water supply to be treated and the economics of the alternative systems available (Matz, 1965).

2.5.2. Sweetening agents:

Sugars contribute to the nutritional and sensory qualities of fruit and fruit juices. Sugar is used to give the desired sweetness and body to the beverage. It must be of a high degree of purity to give maximum benefits (Fuleki *et al*., 1994). Sucrose is commonly present as a sweetening ingredient in fruit juices and drinks. When sucrose is dissolved in water, several physical changes occur of which the most important ones include increase in viscosity, elevation of boiling point, lowering of vapor pressure and increase in both osmotic pressure and temperature (Khalifa, 1989).

2.5.3. Acids:

The flavour and quality of beverage are dependent in some measure on the amount and nature of the acid added. Citric acid is employed in fruit drinks, while tartaric acid is used in grape beverages. Malic and acetic acid are other commonly used acids (Marvin, 1978). When addition of vitamin C is required in fruit juices, ascorbic acid is added. Citric acid is the principal acid used in the beverage industry (Borenstein, 1987).

2.5.3.1. Ascorbic acid:

The primary purpose for the addition of ascorbic acid to any food is to make that food more beneficial to the consumer by enhancing its nutritive value and/or by improving its taste, texture, and colour. This addition can be considered from four approaches: (1) restoration, (2) fortification, (3) standardization, and (4) preservation or enhancement of the food's characteristics. Restoration is adding back the essential vitamins in the amount lost during processing. Fortification is adding the vitamins to certain widely used foods which, although they may be important in the diet, are not good sources of the vitamin. "Standardization" or "uniformization" is adding the vitamin to a food to equalize the varying amounts that occur (a) throughout the harvest and processing season and/or (b) within a class of food products used interchangeably within the diet. Standardization is particularly applicable to fruit beverages. Standardization of the vitamin C content of fruit juices benefits the consumer by providing a significant vitamin C intake regardless of the choice of single fruit juice, blended juice, or fruit drink (Chichester *et al.,* 1970).

2.5.3.2. Citric acid:

Citric acid may be considered as "Nature's acidulant". It is widely used in carbonated and still beverages, to impart a fresh-fruit "tanginess". Citric acid provides uniform acidity, and its light fruity character blends well and enhances fruit juices, resulting in improved palatability. The amount of citric acid used depends on the particular desired flavour (e.g. high-acid: lemonade; medium-acid: orange, punch, cherry; low-acid: grape, black cherry and strawberry).

Commercially citric acid is manufactured under controlled fermentation conditions that produce citric acid as a metabolic intermediate from naturally occurring yeasts, moulds and nutrients.

In processed fruits and vegetables, citric acid performes the following functions:

a. It reduces heat-processing requirements by lowering pH: inhibition of microbial growth is a function of pH and heat treatment. Higher heat exposure and lower pH result in greater inhibition. Thus the use of citric acid to bring pH below 4.6 can reduce the heating requirements.

b. optimize flavour: citric acid is added to canned fruits to prove for adequate tartness. Recommended usage level is generally less than 0.15%.

c. Supplement antioxidant potential: citric acid is used in conjunction with antioxidants such as ascorbic and erythoric acids, to inhibit colour and flavour deterioration caused by metal catalyzed enzymatic oxidation. Recommended usage levels are generally 0.1 to 0.3% with the antioxidant 100 to 200 ppm.

d. Inactivated undesirable enzymes: oxidative browning in most fruits and vegetables is catalyzed by the naturally present polyphenol oxidase. The enzymatic activity is strongly dependent on pH.

Addition of citric acid to reduce pH below 3 will result in inactivation of this enzyme and prevention of browning reactions (Dauthy, 1995).

2.5.4. Flavours:

Flavourings are of great importance to the palatability of all products, which are prepared for human consumption (Merory, 1960). In order to meet all the requirements necessary for a quality beverage, flavour must posses a number of characteristics including complete solubility, compatibility, clean mouth feel without an after-taste, resistance to acid, purity so that drinks will be free of contaminations, resistance to heat, and stability when exposed to light (Khalifa, 1989).

2.5.5. Colours:

Colour is one of the most evident characteristics of food product, which is recognized as an important quality factor. The consumer associates certain colour characteristics with fresh and wholesome quality. Thus, the extent to which original natural colour is presented during processing and in subsequent storage is one important criterion of processing procedures (Eastmond *et al.*, 1951).

Colouring agents are employed to intensify natural colour, produce colours stability, and to render drinks that contain synthetic flavours more eye appeal. The colours may be of natural origin such as caramel (a substance manufactured from burned sugar).

Colouring materials used in the Sudan are caramer, sunset yellow, Tartazine, Chlorophyll, Anthocyanins, extracts from edible fruits and vegetables. In addition to brilliants blue, fast green, Titanium dioxide, Brilliant black and Azarubine (Shabbar, 1981).

2.5.6. Chemical preservatives:

A variety of chemical compounds may be added to foods to prevent their microbial decomposition. In some instances this is done merely to extend the storage life of foods which must also be held at refrigeration temperatures above freezing. Even under these conditions more than one chemical compound may be added. Chemical compounds are sometimes added to food to stabilize these products indefinitely at ambient or room temperature. When this is done other factors than the chemical itself, such as high soluble-solids content or drying to comparatively low moisture content, are used in combination with addition of chemicals to prevent microbial decomposition (Nickerson and Sinskey, 1972).

Benzoic acid and sorbic acid are the commonly used preservatives in the food industry. They are used widely in a variety of food products to inhibit the growth of bacteria, yeast and molds associated with food spoilage (Bennett and Petruns, 1977; BUI and Cooper, 1987).

2.5.6.1. Benzoic acid:

Benzoic acid is used as soluble salts (sodium benzoate and potassium benzoate). Sodium benzoate was the first chemical permitted in foods by the U.S. Food and Drug Administration, and it continues in wide use to day in a large number of foods.

The antimicrobial activity of benzoate is related to pH, the greatest activity being at low pH value. Benzoate is used to acts as a mold and yeast inhibitor although it is effective against some bacteria (Jay, 1986).

2.5.6.2. Sorbic acid:

Sorbic acid is employed as food preservative usually as the calcium, sodium, or potassium salts. These components are permissible at levels not exceed 0.2%. Sorbic acid works best below pH 6.0 and is generally ineffective at pH greater than 6.5. This compound is more effective than sodium benzoate between pH 4.0-6.0. But at pH values of 3.0 and below, the sorbates are the same as sodium benzoate. The sorbates are primarily effective against molds, yeasts and bacteria at a wide range (Nickerson and Sinskey, 1972).

2.6. Preparation of fruit juices and their concentrates:

The consumption of fruit juices which have been preserved in sealed bottles or cans is very great in many countries. Their preparation and preservation are many sided operations, varying according to the nature of the fruit and the type of product required (Morris, 1951). Briefly, fruit juice may be considered under the following headings.

2.6.1. Selection of the fruit:

Fruit juices must be prepared from sound, mature fruits only.

Soft fruit varieties such as grapes, tomatoes and peaches should only be transported in clean boxes which are free from mold and bits of rotten fruit (Dauthy,1995).

2.6.2. Extraction of the juice:

The aim first to disrupt the cells of the juice-bearing tissues so as to release the juice, and secondly to press the juice out. In case of apples, soft fruits, berries, etc., the whole fruit is milled or grated and then pressed in hydraulic or screw presses. With citrus fruits the rinds have a special value of their own, either for direct consumption or for the essential oil and pectin, which they contain. For citrus fruits extraction is carried out by revolving "burrs" or reamers on which the transversely-halved fruits are pressed, for pomegranates and pineapples special presses, cutters and mills have been designed to make the best use of all edible portions (Morris, 1951).

2.6.3. Deaeration:

A review by Morris (1951) the deaeration of juices as early as possible in the preserving process, particularly in the case of citrus juices and tomato juice which develop off-flavours and lose vitamin C very rapidly through the action of oxidizing enzymes or even by chemical oxidation. Therefore, deaeration was carried out either by spraying the juice into a chamber under or by allowing it to enter the vacuum chamber as a thin film traveling over baffles. Added that a preformed precautions against incorporating air in the juice during extraction, should be emphasized.

2.6.4. Straining, filtering and clarification: much

Fruit juices after extraction always contain varying amounts of suspended matter which consists of broken fruit tissues, seeds and skins, and also various gums, peptic substances and proteins in colloidal suspension. Usually coarse particles of fruit pulp, seeds and pieces of skin are removed by the use of screens, practically in all kinds of juices. The presence of these generally causes deterioration in quality. Coarse particles of suspensions in juices are either removed by straining through non-corrodible metallic screens or by sedimentations. Where clear juices are required, complete removal of all suspensions is affected either by filtration or by clarification. This is done by employing fining agents and enzymes (LAL *et al.*, 1960)

2.6.5. Preservation techniques during juice processing:

2.6.5.1. Pasteurization:

Orange juices and other fruits products are often pasteurized to destroy microorganisms and to reduce pectin methyl esterase (PME) activity. Pasteurized juices have longer shelf life and can be adapted to aseptic packaging for the juice to be stored at chilled or ambient temperatures. Pasteurization is commercially done at present by passing the product through a steam or hot water exchanger. The process is time and temperature dependent as described by Eagerman and Rouse (1976). Typical treatment conditions are 91ºC for 10-60 sec. Flow rates must provide turbulent conditions so that the surface layer of the juices is not overheated on the heat exchanger. Overheating leads to an off-flavour of the juice and fouling of the heat- exchange surface (Nikdel *et al*., 1993).

2.6.5.2. Clarification:

A freshly pressed juice contains variable amounts of fine cellular debris with colloidal materials, pectic substances, gums, proteins and other components. Although the colloidal systems in juices are inherently unstable, natural clarification is usually slow and it is necessary to accelerate the process if a clear juice is required. Direct centrifugation or filtration is sometimes possible but is often uneconomic, the presence of soluble pectin renders the juice viscous and filtration is slow. Moreover, unless the juice has been stabilized by heat, further changes leading to loss of clarity are probable. It is used to subject the juice to fining procedures or to depectinization. The juice can then be filtered and stabilized by heat treatment (Hulme, 1971).

2.7. Storage of fruit juices:

Retention of physical quality and palatability are the most important criteria for determining the storage life of canned fruits. The order of breakdown in quality of canned fruits and juices is flavour, colour, texture, and nutritive losses (Irwin and Singh, 1998). The critical storage temperature for most fruits and juices is 27-29ºC, and temperature higher than this should be limited to a few weeks. Brenner *et al.* (1947) and Brenner (1947) studied several representative canned foods used in army rations and reported that apricots had less than 12 month shelf-life at 38ºC. Canned fruit juice will lose half of its vitamin C in 24 months at 27ºC, and in 4 months if stored at 38ºC. Orange juice is acceptable up to 12 months at 21ºC.

Usually, the deterioration is reflected in fading of colour, cloud formation, gelation, staleness, off-flavour and off-odours, non typical

l texture and appearance, and can corrosion. Many of these problems were caused by oxygen and can be protected by tailoring packaging materials, by avoiding prooxidants, or by using antioxidants (Kacem, 1987).

2.8. Concentration of fruit juices:

Although the art of concentrating fruit juices is old, the science of concentrating juices at low temperature and pressure has been developed in the 20th century. Pioneers before 1930 described "vacuum pans" with steam jackets, steam coils and calandria type heaters as well as continuous rising film, side-tube heaters with vapor separations (Tressler and Joslyn, 1954).

Concentration of liquid foods permits economics in packaging, storing and transporting. Concentration permitted the development of new product such as tomato sauces, which had not previously been available. Concentration also permitted the economic utilization of perishable crops during peak harvest periods, contributing to the stabilization of production and consumer prices (Deshpande *et al.*, 1982).

2.8.1. Methods of concentration:

Concentrated fruit juices are important food items and important articles of commerce. The process of concentration results in the removal of water and a consequent reduction in the costs for containers, transportation and storage. It also results in a lower water activity and thus hinders the growth of spoilage microorganisms.

Juices are concentrated either by freezing or by evaporation under reduced pressure at low temperature so that their original flavours are not lost completely (Rao *et al.*, 1984). Despite that Bailey (1943) and Heid

(1943) summarized methods for continuously concentrating citrus juices at temperatures above 100ºF, Heid listed methods for avoiding flatness (due to vaporization of flavor constituents) including:

- Adding unconcentrated "cut-back" juice to the concentrate,
- Fractionally condensing and returning volatile essences, and
- Adding oil pressed from citrus peels.

2.8.1.1. Concentration by freezing:

Freeze concentration involves concentration of fresh juice by partial freezing and separation of the resulting pure ice crystals preferably by centrifuging the frozen juice mass. This concentration contains a substantial part of the sugars of the fresh juice, and also practically all of its volatile flavour .It has been found that these constituents are concentrated in the initial discharge from the centrifuge and hence are practically recovered. Fruit juices that are freeze concentrated exhibit better processing properties than fruit juices that are concentrated by evaporation and reverse osmosis processes.

The major advantages of the freeze concentration processes over the evaporation and reverse osmosis processes are that it concentrates the fruit juices without appreciable loss in taste, aroma, or nutritive value (Deshpande *et al.*, 1982; Ramteke *et al.,* 1993).

2.8.1.2. Concentration by evaporation:

Evaporation is a method of concentration which makes use of a favourable liquid-vapour equilibrium. When the solutes are not volatile the vapour above the solution will contain only water. Evaporators for fruit juices range from simple glass-lined vacuum pans to multiple-effect tubular evaporators and evaporators of the climbing and falling film type with tubes of stainless steel(Nath,1960). The great advantage of evaporation is that it is technically simpler than any other concentration method that might be considered suitable. An evaporator nearly always consists of a heat-exchanger in which heat is supplied to the solution to be concentrated, and of a chamber in which the produced vapour is separated from the remaining liquid. The heating medium is usually condensing steam (sometimes so-called exhaust steam from a power plant), but it is also possible to use other condensing vapours (NH_3, Freon, diphenyl) or a non condensed heat transferring medium such as warm water. An important advantage of condensing vapour is the high heat content at a relatively low temperature (Leniger and Beverloo, 1975).

The chief disadvantage of this method is that volatile flavours and aromas are more or less completely lost and, although the vitamin C may be large retained, the product is usually flat and lacks character (Nath, 1960).

2.9. Packing and storing of concentrates:

Concentrates are preserved by hot filling in small tight containers, pre-sterilizing, cooling and sterile-packing in tight containers, refrigeration, frozen storage and to some extent by solids content unfavorable for growth of spoilage organisms. Concentrated products can be sterilized by "high-short" procedures and aseptically filled in sterile drums and other bulk containers for storage and for shipment to population centers.

Packages used for storing and transporting concentrates vary in size from heat-sealed, one-ounce plastic pouches to tanks with thousands of gallons capacity. Tanks may be stationary or mounted on trucks or in ships. Package materials include plastic films, glass, stainless steel, aluminum, fiber and mild steel with tin plate or plastic coating. Storage temperatures for concentrate range from zero to as high as 80ºF (Tressler and Joslyn, 1961; Nelson and Tresser,1980).

2.10. Deterioration during storage:

During storage of thermally preserved fruit products, many changes may occur that lead to deterioration in quality. The extent of these changes depends on the processing technology, the quality of the raw material and packaging materials, and the storage conditions of the products (Lee *et al*., 1977). New varieties of fruits, improved containers, more rapid pasteurization, lower warehousing temperature, and more rapid delivery to the ultimate consumer have all played an important part in minimizing deterioration in storage. However, juices differ markedly in their respective rates of deterioration in storage. This deterioration is confined for the greater part, but not entirely, to undesirable changes in flavour and appearance rather than to changes in nutritive value. For instance, pineapple and tomato juices change very slowly in storage; pineapple juice is generally considered by the pineapple industry to have a shelf-life of 2 or 3 years even when stored at the prevailing warehousing temperatures of Hawaii. On the other hand, orange and apple juices are not nearly so stable and suffer quite rapid flavour changes under common warehousing conditions (Hulme, 1970).

2.10.1. Stability of vitamins:

The vitamins in canned fruit juices appear to be generally stable. The degree of stability depends upon a number of factors including times, temperature, moisture content, humidity, oxygen content, pH, presence of oxidizing enzymes and/or enzyme inhibitors and the availability of other oxidizable substances capable of assisting in the oxidation of ascorbic acid (Charley, 1950 ;Wanniger, 1972).

Moore *et al.* (1945) found that fresh orange and grapefruit juices on storage at 70ºF for three days, by which time fermentation had begun, retained 97 to 98% of the original ascorbic acid content. On storage at 40ºF. for one week, orange juice retained 96% of the initial ascorbic acid content, grapefruit 98 to 99%. While in juices containing anthocyanin pigments, it appears that the rate of loss of ascorbic acid may be accelerated somewhat by the interaction of the pigment and ascorbic acid. On pasteurization of the expressed juice, colour and flavour changes occur, and on storage at tropical room temperatures, there is an excessive loss of ascorbic acid (Hulms, 1971).

2.10.2. Flavour changes:

The retention of flavour during storage of fruit juices is of prime importance if they are to deserve fine consumer acceptance. This has proved to be a serious problem in the case of orange juice, with other juices undesirable flavour changes do occur during storage but at a much slower rate . Canned citrus juices during storage at room temperature (70º to 80ºF) develop off-flavour in a few months and become rather unpalatable. Orange juice is generally somewhat more stable. Canned citrus juices, stored at 40ºF or below, change in flavour much more slowly than at room temperature and remain quite palatable almost indefinitely. Juices stored at temperature up to 60ºF change in flavour much less rapidly than those stored at room temperature, and are usually acceptable after a year (Tresslar and Joslyn, 1961).

2.10.3. Non-enzymatic browning:

On prolonged storage of canned juices at room temperatures or above, water-soluble brown substances are generally formed. This is readily observed in light-coloured juices such as grapefruit and pineapple. In juices with a relatively high content of carrotenoids, such as orange and tomato the browning is not noticeable, but is apparent on centrifugation or filtration of the suspended pigments. The browning may also be masked by water-soluble anthocyanin pigments, as in grape and blackberry juices, but may be apparent in less-highly coloured juices such as strawberry (Tressler and Joslyn, 1961).

Browning of food is commonly attributed to the maillard reaction. It was found by Maillard 1912 that when sugars and amino acids are allowed to react under certain prescribed mild conditions, a series of reactions occur which eventually result in the formation of dark compounds of quite complex character (melanoidins), with accompanying evolution of carbon dioxide (Bressa *et al*., 1996). Enders and Sigurdsson (1944) showed that the minimum rate of reaction between glycine and glucose to form melanoidin pigment was at about pH 3.2 or less. This is an important fact, as far as storage stability of fruit juice is concerned, since the pH of many of the fruit juices lies near this value. Moreover, temperature, time, moisture content, concentration and nature of reactants are important factors in the Maillard reaction. It has been reported that browning increased exponentially with temperature and heating melanoidins, the dark brown nitrogenous polymers formed in the reaction, for long periods, causes discoloration and fragmentation (Benzing-Purdie *et al.*, 1985).

While it is generally accepted that the Maillard reaction is one of the most important chemical phenomena that may affect quality of fruit juices during processing and storage. However, browning results in deterioration, mainly by producing off-flavours and off-colors, and it may cause loss of nutritional value. It is now believed that other reactions involving ascorbic acid, anthocyanins, sugars, uronic acid, fruit acids, and probably other constituents also play an important role (Yrjö and Himberg, 1994). There is considerable evidence that there is a relationship between loss of ascorbic acid and darkening. There appear to be two distinct ways in which ascorbic acid is involved. In juice packed in glass or in citrus enamel, any residual oxygen may react with ascorbic acid to form dehydroascorbic acid. It has been shown by Koppanyi *et al*. (1945) that dehydroascorbic acid, but not ascorbic acid, reacts in solution at 210ºF with alpha amino acids to form strongly colored compounds. A similar reaction may occur in orange juice, but much slower because of the much lower temperature and considerably lower amino acid concentrations.

Loeffler (1941) found that on storage of pasteurized bottled orange juice darkening could be detected when the ascorbic acid content had decreased only 10 to 15%. The ascorbic acid continues to decrease on storage after all of the oxygen has been consumed. It is probable that in the acid juice the ascorbic acid is slowly converted to furfural, solution of which are known to darken, especially in the presence of amino acids.

Citrus browning is unique to the typical Maillard-type browning since citrus fruit have significant amounts of ascorbic acid; the oxidation of ascorbic acid has been considered the major factor in the browning of citrus products (Lee, 1992). Besides ascorbic acid, large amounts of other organic acids (mainly citric) and their salts create favorable conditions for degradation of sugar, amino acids and phenolics during processing and upon subsequent storage (Lee and Nagy, 1988).

Citric acid appeared to play an essential and characteristic role in the development of browning in the presence of ascorbic acid, irrespective of pH value, and could not be replaced to some extent by other organic acids (Clegg, 1964). Citric acid might participate in chemical reactions leading to the formation of brown pigments under acidic conditions in one or more, of the following ways:

a. It could act as a catalyst to increase the rate of oxidation of the ascorbic acid to reactive carbonyl compounds.

b. Its presence could influence the pathway of ascorbic acid breakdown to a range of carbonyls different from the normal oxidation products of ascorbic acid.

c. Citric acid itself might be fragmented under the incubation condition and make a contribution to the pool of carbonyl compounds.

d. It could act as a catalyst in the build up of brown pigments.

e. It might behave in a similar way to amino acids and react with some of the ascorbic acid oxidation products leading to its incorporation in the brown pigments (Clegg, 1966).

The most practical approach for retarding browning of citrus juice is by cold storage, however this is not always feasible. One study reported temperature as high as 65ºC during warehousing and transporting of canned single strength citrus juice (Smoot and Nagy, 1980).

2.10.4. Changes in pigments:

Numerous plant pigments including anthocyanins, carotenoids, and flavonoids occur in fruit and vegetable juices. These plant pigments are roughly divisible into two major groups: those that are associated with the protoplasmic structure of the cell-the plastid pigments- and the second group which generally exists in solution in the cell sap. The various anthocyanins and flavonoids are generally considered to belong to the latter group while chlorophyll and carotenoids, including lycopene, belong to the former (Tressler and Joslyn, 1961).

Tressler and Joslyn (1954) reported that discoloration of grape juice stored at room temperature was due to combination between two or more substances resulting in a brown colored material or to oxidation of some substances in the juice. He also mentioned that grape juice can be stored under high vacuum or in bottles, containing substantially no oxygen. Thus such juice undergoes very little change even when exposed to light at room temperature with a resultant storage period for up to 20 months. However, juice stored under similar conditions, but in contact with oxygen, lost is deep purple color with few weeks and after 3 months of storage, a heavy brown sediment had formed and the juice turned to a light brick-red color.

The effects of addition of ascorbic acid to fruit juices containing anthocyanin pigments has been reported by several investigators. In most cases it was found that there is a considerable lightening or bleaching of the juice with added ascorbic acid. Pederson and Beattie (1943) suggested that these pigments and ascorbic acid may interact, since the pigments and ascorbic acid are oxidizable. They found that increasing the concentration of ascorbic acid or isoascorbic acid increases the rate of change of color as well as the rate of loss of ascorbic acid. The addition of 50 to 100 mg of ascorbic acid virtually declorizes strawberry and cherry juices but has little effect on grape and blue berry juices (Nebesky *et al*., 1949).

Currant, cherry, grape, strawberry, raspberry, tomato and blueberry juices, as well as the isolated pigments from currants and strawberries, were used to investigate the effect of length and temperature of storage and the relationship of oxygen, light, sugar, pH and ascorbic acid to deteriorative changes in color. Of these factors, storage temperature and oxygen content were the most specific for color injury of both juices and isolated pigments. Exposure to light caused little deterioration in color but it has a bleaching effect on the purified pigments of the strawberry and currant. Adjustment of acidity within the range of pH 2 to 4.5, or sugar addition, had little effect on color retention in fruit juices during storage. Increasing sugar and citric acid concentrations enhanced the storage stability of strawberry fountain syrup. Nevertheless, several sugars (including levulose), and their derivatives, furfural and hydroxyl methyl furfural were reported to enhance the rate of pigment loss in strawberry. The same was true if amino acids were added to strawberry juice (Meschter, 1953; Tinsely, 1958).

2.10.5. Inversion of sucrose:

Inversion of sucrose, is one of the many interesting changes that occur during storage of fruit juices. While this change in itself does not affect the acceptability of the product, it has been used in certain instances as an objective measurement of storage deterioration since the extent of inversion is a rough index of the time temperature storage history of the product. In at least one instance, such information has been introduced as evidence in a court of law and played a rather important part in a damage suit arising from the storage of fruit juices at elevated temperatures. One study reported about the rate of inversion of sucrose in canned orange juice during storage at room temperature (80º to 100ºF). It was found that non-reducing sugars which amounted to 6.37% initially were reduced to 3.49% and 1.21%, respectively, by the end of 3 and 6 months of storage. No further change had occurred after 9 months of storage (Tressler and Joslyn, 1961).

2.11. Microbiology of fruit juices:

The quality of processed fruit juices is directly related to microbial activity. Certain bacteria, yeast and mold are considered indicators of sanitation and must be controlled during processing to avoid losses of product (Cook, 1983).

2.11.1. Bacteria:

During processing, some bacteria may develop in juice and juice concentrates, especially *Leuconosto mesenteroides* and *Lactobacillus plantarum*, and spoil the product because of the production of aceto. If the raw material has already been microbiologically spoiled, an increase in lactic acid, acetic acid, ethanol, glycerol will be found (Dauthy, 1995).

2.11.2. Yeasts:

The important property of the yeasts is that they carry out alcoholic fermentation, producing ethanol and carbon dioxide from sugars, most yeasts produce appreciable quantities of organic acids, especially acetic acid. Yeast get to the beverages manufacturing process by way of: (a) Raw material and container, such as sugar and sacks, (b) contaminated flavours and colouring material, (c) dust and other air-borne materials or dirt picked up during the manufacturing, (d) unsanitary plant operations, (e) contaminated equipment and pipe lines, (f) improperly or incompletely sterilized bottles or cans and (g) dusty crowns (Tressler and Joslyn, 1961).

2.11.3. Moulds:

A wide variety of mould fungi take part in the rotting of fruit, and are therefore likely to appear in juices (Luthi and Halter, 1961). Moulds of the *penicillium* group are the most common and most troublesome to the manufacturer of fruit and vegetable products. *P. glaucum,* or, more correctly, *p. expansum*, is the best known of the *penicillium* moulds and the one responsible for very great losses to fresh fruit shippers and fruit-products manufacturers. Another very, common group of moulds often seen on grapes and other fruits are the *Aspergillus* moulds. *Aspergillus niger* is the best known of these moulds (Cruess, 1958).

2.12. Quality control of fruit juices:

Quality might be defined as that for which the consumer is willing to pay more in proportion to its presence and less because of its absence. The purpose of quality control is to provide the information and organization necessary to achieve the production of quality control (Hall, 1947).

2.12.1. Steps of quality control:

2.12.1.1. Control of raw material:

Raw materials are the ingredients used in the formulation of a product, as well as all other materials needed for its production. A high – quality product cannot be produced from boor raw materials, but poor quality products can be made from high–quality raw materials (Bockelmann and Bockelmann, 1988). Quality control must begin with the fruits while it is still in the field. Fabian (1947) point out the influence of such factors as genetic composition, soil fertility, and control of harvesting time upon quality.

2.12.1.2. Control of preparation and processing procedures:

The quality control department must check each step in the preparation and processing procedures after the raw product enters the production line, on a time or batch basis, and a complete check be made at the beginning of the pack and at 2-hours intervals thereafter (Herschdoerfer, 1972).

2.12.1.3. Examination of finished product:

A sampling procedure which allows adequate checks on quality of all lots or batches of each product should be set up. Immediate examination then permits corrections to be made also allows the processor to isolate any lots which should not be put on the market. Their is some tests should be made on the finished materials , such as color, flavor, texture, pH, vitamin content and soluble solids (Nelson and Tresser, 1980).

2.12.1.4. Control of storage and distribution:

The responsibility of quality control does not end with the packing of the product but must continue as long as it is within the jurisdiction of the packer. Periodic inspection of the warehouse should be made for the purpose of detection of spoilage or the incidence of container damage. Temperature is very important and a record of warehouse temperatures should be obtained. The shelf-life of processed foods is largely affected by temperature of storage (Bockelmann and Bockelmann, 1988).

2.12.1.5. Laboratory examinations:

The laboratory should be equipped to perform the tests which are significant measures of the quality and stability of the products which are produced. Chemical analysis such as total soluble solids, acidity, sucrose, ascorbic acids, oil content, and tannin may be important in individual products. Bacteriological examinations may be made to insure freedom from spoilage hazards. Tests should be run to detect the presence of faulty or damaged containers which may affect the wholesomeness or shelf-life of the product (Tressler and Joslyn, 1961).

CHAPTER THREE

MATERIALS AND METHODS

3. Materials:

Three types of natural fruits drinks and their concentrates were supplied by a beverage factory located in Khartoum State. A sample batch of 63 drinks bottles for each type were taken directly from the processing line. First,9 bottles from the batch were analysed immediately for microbiological , chemical and physical attributes. The rest of the batch (54bottels) were stored in equal portions both at the house hold and market enviroment. Then samples of each 9 bottles were randomly withdrawn at time interval of 3,6 and 8 months and subjected to the above mentioned series of tests .The three fruit types concentrates were also analyzed, at once, for the microbiological, chemical and physical analysis.

3.1. Analysis of Methods:

3.1.1. Moisture content:

The moisture content of the samples was determined according to the chemical analysis of foods as stated by Egan *et al.* (1981).

Five grams of the samples were weighed on a crucible, placed in an air oven at 70ºC and left to dry for 24 hours. After drying the crucibles were accurately reweighed.

The percentage of moisture content was calculated using the following equation:

$$\text{Moisture content} = \frac{w_1 - w_2}{w_0} \times 100$$

Where:

w_1 = The weight of crucible plus sample before drying.

w_2 = The weight of crucible plus sample after drying.

w_0 = The weight of sample.

3.1.2. pH:

The pH of the samples were determined with a glass electrode pH-meter (KARL KOLB, D-6072 Dreieich) at room temperature.

3.1.3. Titratable acidity:

Ten grams of sample were diluted with (100 ml) distilled water and then filtered. Ten ml of the prepared sample were titrated against 0.1 N sodium hydroxide, using phenolphthalein as an indicator (Egan *et al.,* 1981).

Calculation:

Total acidity (mg/100g) expressed as citric acid =

$$\frac{(ml\ of\ NaOH) \times (N.NaOH) \times (Dil.\ factor) \times (Equ.wt.of acid) \times 100}{1000\,(wt.of\ sample\,(g)}$$

Dilution factor = $\frac{Total\ volume\ of\ sample}{Sample\ volume\ used\ in\ titration\ (10)}$

3.1.4. Total soluble solids (T.S.S):

T.S.S was determined using a hand refractometer, it was expressed as Brix degree.

3.1.5. Ascorbic acid:

Ascorbic acid was determined according to the method illustrated by Ruck (1963).

Thirty mls of the sample were blended with about 100 ml of 0.4% oxalic acid for 2 minutes in awaring blended. The blended mixture was made to 500 mls in a volumetric flash with 0.4% oxalic acid and filtered. The filtrate was titrated with standard 2, 6 dichlorophenol indophenol. The results were expressed in mg/100 g or ml.

3.1.6. Total sugar and reducing sugar:

Total sugars and reducing sugars were determined using the official lane-Eynon titrometric method (AOAC, 1984).

3.1.7. Sucrose:

Sucrose of sample was calculated using the following equation:

Sucrose (%) = Total sugar –Reducing sugar × 0.95

3.1.8. Viscosity measurements:

The flow time of the sample was determined using capillary viscometer (SHOTT GERATE Type 501 20/II). at room temperature.

The relative viscosity was calculated using the following formula:

$$\eta = \frac{d_1 t_1}{d_2 t_2}$$

where:

η = relative viscosity (centipoise).

d_1 = density of the sample.

d_2 = density of the reference solution.

t_1 = flow time of the sample in second

t_2 = flow time of the reference solution in second

*: water was used as reference solution.

3.2. Microbial examination:

3.2.1. Preparation of media:

3.2.1.1. Nutrient agar (NA)(oxoid):

It was used for enumeration of bacteria. It was obtained in a dehydrated form. The constituents of the medium were lab-lemco powder, yeast extract, peptone, sodium chloride and agar. It was prepared according to the directions of the manufactures by suspending 28 gm in 1 litre of distilled water. The medium was allowed to boil until it was completely dissolved. The pH of the medium was adjusted to 7.0 and then it was sterilized in an autoclave at 121ºC for 15 minutes under pressure of 15lb/inch.

3.2.1.2. Potato dextrose agar (PDA)(Oxoid):

This medium was used for enumeration of yeasts and moulds. It was obtained in a dehydrated form. The medium was composed of peeled and diced potatoes, dextrose and agar. It was prepared according to the manufacture's instructions by suspending 39 gm in one litre distilled water and boiling to dissolve completely. The pH of the medium was adjusted to 5.6 and then it was sterilized in an autoclave at 121ºC for 15 minuets under pressure of 15lb/inch.

3.2.1.3. MacConkey's broth (MB)(oxoid):

It was used for the detection of coliform bacteria by the multiple tube technique. It was obtained in dehydrated form. The medium was composed of peptone, lactose, bile salts sodium chloride, bromo-cresol purple. It was prepared according to the manufacturer's instructions by suspending 40 gm in one litre distilled water, distributed in 5 ml amount in 50×16 mm test tube with inverted durham tubes. The pH of the medium was adjusted to pH 7 and then sterilized in an autoclave at 121ºC for 15 minutes under pressure of 15lb/inch.

3.3. Methods:

Juice samples were shaken and duplicate samples of 10 ml each, were taken by peptide in flat bottomed flasks containing 90 ml distilled water and shaken for 10 min. serial decimal dilutions up to 10^{-6} were prepared, 0.1 cm^3 aliquot of each dilution was pour-plated in duplicates into NA and surface plated into dry surface plates of PDA.

The NA plates were incubated at 37ºC for 24 and 48 hrs. While the PDA plates were incubated at 28ºC for 48 hrs. one cm^3 of each of the 3 first dilutions 10^{-1}, 10^{-2} and 10^{-3} was incubated in triplicate in tubes of MB and incubated at 37ºC for 48 hrs. The most-probable numbers (MPN) were recorded.

3.4. Statistical analysis:

Data were statistically analysed using statistical analysis system (SPSS). The analysis of variance was performed to examine the significant effect in all parameters measured by using by using completely randomized design. Least significant different (LSD) was used to separate the means

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1. Physico-chemical and microbiological properties of natural fruit drinks (orange/carrot, mango and apple):

Three natural fruit drinks (orange, carrot, mango and apple) produced by one of the beverage factories in Khartoum State were systematically evaluated and stored under two different conditions (Room and market), to identify their quality and stability for storage.

The data in tables (1 and 2) show some physico-chemical and microbiological properties for orange/carrot, mango and apple natural fruit drinks. There were observed differences in moisture content between the three types of fruit drinks, which were 86.64%, 85.33% and 83.70% for natural orange/carrot drink, natural mango drink and natural apple drink, respectively. Orange/carrot drink had recorded the highest percent of moisture content, while apple drink had the lowest percent of moisture content. Shrestha and Bhatia (1982) has reported that the moisture content of apple juice ranged between (83.25 – 84.5%).

The pH value, for natural orange/carrot drink, natural mango drink and natural apple drink vary between 2.50, 3.59 and 1.86 respectively. These results disagree with the reported range of (3.52-3.88) for orange juice (Nagy and Smoot, 1993), and (3.43 – 4.25) for apple juice (Lee and Wrolsted, 1988). While, the pH value for natural mango drink was in full agreement with Sead (1974) who reviewed that the pH value for mango nectar ranged between (3.0-4.4).

Table (2): Number of total viable bacteria yeasts and moulds and coliform bacteria for the three types of drinks and their concentrates.

Microbial types	Number of microbes (cfu/ml)			Concentrates
	Orange/carrot drink	Mango drink	Apple drink	
Total viable bacterial count	6.5×10^2	5.9×10^2	None	None
Coliform bacteria	None	None	None	None
Yeasts and moulds	None	None	None	None

Analysis of the amount of titrable acidity of the three types of the natural fruit drinks were found to range between 1.65%, 0.37% and 0.26% for natural orange/carrot drink, natural mango drink and natural apple drink, respectively. Egan *et al.* (1981) summarized that the titrable acidity for orange juice and apple juice ranged between (0.4-3.5%) and (0.22-0.80%), respectively. These results agree with the present results. On the other hand, Mattick and Moyer (1983), listed that the titrable acidity for apple juice was in the range between (0.15-0.91%). While Sead (1974) reported that the titrable acidity for mango nectar vary between (0.17-0.47%). When the results of titrable acidity of natural orange/carrot drink was compared with Kuwaiti Standard (FAO, WHO, 1992) for orange beverage, which ranged between (0.8-1.5%), it can be observed that the natural orange/carrot drink disagree with the recommended range.

Natural orange/carrot drink and natural mango drink had recorded the highest ascorbic acid content (72.99, 72.5mg/100ml) respectively. While, the content of ascorbic acid for natural apple drink was 66.98mg/100ml. The content of ascorbic acid for natural orange/carrot drink was in agreement with the reported range of 20-80 mg/100ml (Egan *et al.*, 1981), but the result of ascorbic acid content for natural mango drink disagree with Sead (1974) who reviewed that the ascorbic acid content for mango nectar ranged between (1.7- 29.8mg/100ml).

As for viscosity content, natural mango recorded the highest value (2.30centi poise) and this is in full agreement with Sead (1974) who reported that the viscosity for mango nectar ranged between (3.1-4.7c.p).

On the other hand, Tressler and Joslyn (1961) recorded that the flow rate through the capillary viscometer for measuring viscosity of fruit nectar and other fruit juice products at 75ºF. must be not less than 30 seconds. While, the viscosity for natural orange/carrot drink and natural apple drink were 1.62 and 1.47 centipoise, respectively.

The contents of the total soluble solids showed values of 12.86, 14.42 and 13.42 ºBrix for natural orange/carrot drink, natural mango drink and natural apple drink, respectively. The value of total soluble solids for natural orange/carrot drink disagree with the findings Egan (1981) who reported that the total soluble solids for orange juice ranged between 10.0 and 12.0 ºBrix. (FAO/WHO, 1992), it was recommended that the total soluble solids for orange juice (exclusive of added sugars) shall be not less than 10.0% as determined by refractometer, uncorrected for acidity and read as ºBrix on the international sucrose scales.

Where the juice had been obtained using concentrated juice with the addition of water, the soluble orange juice solids content shall not be less than 11.0% as determined by refractometer, uncorrected for acidity and read as ºBrix on the international sucrose scales. Also for apple juice, the Saudi Arabian Standards, Kuwaiti Standards (FAO/WHO, 1992) and Sudanese Standards (2002), had recommended that the total soluble solids for apple juice shall be not less than 10.0% as determined by refractometer, uncorrected for acidity and read as ºBrix in the international sucrose scales. While, for liquid pulps mango products the recommended value for the total soluble solids for these products shall be not more than 20.0%, as determined by refractometer, uncorrected for acidity and read as ºBrix in the international sucrose scales (FAO/WHO, 1992). As a result, the found values of total soluble solids for the three types of natural fruit drinks were in full agreement with the recommended values of total soluble solids.

Moreover, it has been observed that natural apple drink recorded the highest value of total sugar (14.47%), while natural orange/carrot drink gave the lowest total sugar (11.68%), where total sugar for natural mango drink was (12.3%). The results of total sugar content for natural apple drink was agreed with the reported range between 5.91-15.3% (Lee and Wrolsted, 1988). FAO/WHO (1992) recommended that the total quantities of added sugars for orange juice shall not exceed 50g/kg. While, the general standard for fruit juices (FAO/WHO, 1992) recommended that the total quantities of added sugars shall not exceed 100g/kg except for very acid fruits, where 200g/kg is permitted.

Natural orange/carrot drink, natural mango drink and natural apple drink had recorded the following values of reducing sugars 3.79, 3.66 and 6.72% respectively. From the results it can be observed that the natural apple drink scored the highest value of reducing sugar. Shrestha Bhatia (1982) reported that the range of reducing sugar for apple juice was between (7.9 – 10.6%).

On the other hand, sucrose contents were 7.77, 7.49 and 7.33% for natural orange/carrot drink, natural mango drink and natural apple drink, respectively.

Beside the physico-chemical properties there are microbiologi-cal properties which also influence the quality of fruit juices and their products. Table (2) show the count of microbes isolated from orange\carrot, mango and apple drinks and their concentrates at zero time. The coliform bacteria showed zero numbers growth for orange\carrot, mango and apple drinks and their concentrates. The total viable bacterial count were 6.5×10^2, 5.9×10^2 and zero number cfu\ml for orange\carrot, mango and apple drinks, respectively, while the concentrates for the three types of drinks showed zero numbers growth. The yeasts and moulds count show zero numbers growth for orange\carrot, mango, apple drinks and their concentrates. FAO/WHO (1992) for general fruit juice, apple juice, orange juice and liquid pulps mango product, was recommended that the product: (a) shall be free from microorganisms capable of development under normal conditions of storage; and (b) shall not contain any substances originating from microorganisms in amounts which may represent a hazard to health. The presented results (table 2) were in full agreement with the recommended standards for natural fruit drinks.

4.2. Effect of storage on some physico-chemical properties of natural fruit drinks (orange/carrot, mango and apple):

4.2.1. Moisture content:

Table (3) shows the effect of storage on moisture content for three types of natural fruit drinks (orange/carrot, mango and apple). Results indicated significant changes in moisture content of the three types of natural fruit drinks (orange/carrot, mango and apple) under storage conditions (both at room and market conditions). At zero time the moisture content values were 86.64%, 85.33% and 83.70% for natural orange/carrot drink, natural mango drink and natural apple drink, respectively.

Three months storage period at room temperature had significantly decreased the original moisture content to values of 85.52%, 84.75 and 83.28% for natural orange/carrot drink, natural mango drink and natural apple drink, respectively. Also at market conditions the moisture contents were significantly reduced, at the same period, to values of 85.54%, 84.67% and 83.18 for natural orange/carrot drink, natural mango drink and natural apple drink, respectively. A significant decrease in moisture content values for the three types of natural fruit drinks were also observed for the 6^{th} and 8^{th} month storage conditions (room and market).

The decrease in moisture content could probably be due to hydrolysis of sucrose into reducing sugars. Khurdiya and Anand, 1981) had revealed that there is a continuous hydrolysis for sucrose into reducing sugar during storage of fruit beverage.

4.2.2. pH value:

Table (4) shows the effect of storage (room and market) on pH value for the three types of natural fruit drinks (orange/carrot, mango and apple). The results of pH value indicated significant changes during storage (room and market conditions).

The pH values for the three types of natural fruit drinks were 2.50, 3.59 and 1.86 for natural orange/carrot drink, natural mango drink and natural apple drink, respectively at zero time. Three months storage period at room temperature significantly increased the pH of the three types of natural fruit drinks to values of 2.83, 3.66 and 2.89 for natural orange/carrot drink, natural mango drink and natural apple drink, respectively. The same period on market condition also indicated a significant increase in the pH value for the three types of natural fruit drinks, the founded values were 2.83, 3.68 and 2.81 for natural orange/carrot drink, natural mango drink and natural apple drink, respectively. Six months storage period at room temperature and on market condition, had recorded a significant increase for the three types of natural fruit drinks. While, eight months storage period (room temperature and market condition) has recorded a decrease in pH for natural orange/carrot drink and natural mango drink.

The pH value for natural apple drink had showed an increase after eight months storage. The increase in pH value had agreed with Shresth Bhatia (1982) who reported that there was an increase on pH values for apple juice during storage at room temperature and at 37ºC from 3.70 (the original value) to 3.75, 3.80, respectively. The increase in pH value may be due to decrease in titrable acidity (Shresth and Bhatia, 1982).

4.2.3. Titrable acidity:

Table (5) shows the effect of storage on titrable acidity for the three types of natural fruits drinks. Titrable acidity contents had obtained a significant difference for the three types of natural fruit drinks (orange/carrot, mango and apple) after storage period (room temperature and market condition). The titrable acidity contents at zero time were 1.65%, 0.37% and 0.26% for natural orange/carrot drink, natural mango drink and natural apple drink, respectively. These results show a significant decrease in titrable acidity content after three months of storage as compared to their original content to values of 0.40%, 0.26% and 0.19% for natural orange/carrot drink, natural mango drink and natural apple drink, respectively at room temperature. While the results of titrable acidity during storage on market condition indicated the same significant decrease to values of 0.42%, 0.27% and 0.19% for natural orange/carrot drink, natural mango drink and natural apple drink, respectively. Six months storage period caused a significant increase in acidity of natural orange/carrot