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ABSTRACT

The main goal of this research was to study the suitability of red beet (*Beta vulgaris*) for production of ready-to-use concentrated drink, with high nutritional value, functional and organoleptic properties so as to encourage and to improve for the industrial utilization of plant beets in Sudan. The physical and chemical characteristics of red beet before and after processing were investigated.

The results revealed that, red beets have a high percentage of Na (7.700 ppm) and contain estimated amounts of Ca (1.600 ppm), Mg (0.230 ppm), phosphorus (0.380 ppm), potassium(0.305 ppm) and iron(0.090 ppm) per 100 g of dry matter.

In addition to that, the fruits were easily extracted with reasonable total soluble solids (1.80%), hydrogen ion concentration (7.11), and yield percent (11.84%), when the fruits were boiled for only 30 minutes in hot water (100 °C) at a ratio of (1: 6).

After the preparation of red beet extract, the recipe and processing method used in this study were found to produce a satisfactory ready-to-use red beet concentrated drink with reasonable total soluble solids (52%), titrable acidity (0.70%) and hydrogen concentration (2.96). Also, the product was found to contain reasonable amounts of sodium (8.000 ppm), potassium (4.760 ppm), magnesium (4.600 ppm), calcium (0.726 ppm) and iron (0.262 ppm).

Finally, the results of the acceptability test that carried out for Red beet concentrate as diluted drinks (13%) clearly revealed the good quality and acceptability of the products (with and without flavour). But Red beet drink sample that made with strawberry flavour had the better taste, appearance and overall quality.

ملخص الدراسة

الهدف الأساسي لهذا البحث هو دراسة مدى إمكانية استخدام البنجر لإنتاج شراب مركز جاهز للإستخدام ذو قيمة غذائية وخواص وظيفية وحسية عاليتان لتشجيع وتطوير الإستخدام الصناعي للبنجر في السودان. لذلك تتم دراسة الخواص الفيزيائية والكيمائية للبنجر قبل وبعد التصنيع. ولقد أظهرت النتائج إن البنجر يحتوي على كميات مقدرة من الصوديوم (7.700جزء من المليون)، والبوتاسيوم (350.00 جزء من المليون) والماغنسيوم (0.03جزء من المليون) والكالسيوم (1.600جزء من المليون) والحديد(0.09جزء من المليون) لكل 100جم من المادة الجافة .

بالإضافة الى ذلك لقد تم إستخلاص البنجر بسهولة ولقد أحتوى المستخلص على نسبة معقولة من المواد الصلبة الذائبة (% 1.80) وتركيز أيون الهيدروجين (7.11) ونسبة عائد الأستخلاص (%11.84) وذلك عندما تم سلق البنجر لمدة 30 دقيقة فقط في ماء (100°م) بنسبة (1:6).

وبعد تحضير مستخلص البنجر وجد أن نسب المكونات وطريقة التصنيع التى أستخدمت في هذه الدراسة أدت للإنتاج ناتج مقبول من مركز البنجر الجاهز للإستخدام ويحتوي على تركيزات معقولة من المواد الصلبة الذائبة (%52) والحموضة النقطية (%0.70) وتركيز أيون الهيدروجين (2.96). كما أحتوى المنتج أيضا على كميات معقولة من الصوديوم (8.000 جزء من المليون)، والبوتاسيوم (4.760 جزء من المليون) والماغنسيوم (4.600جزء من المليون) والكالسيوم (0.726 جزء من المليون) والحديد(262.o جزء من المليون).

وأخيرا أظهرت بوضوح نتائج التقييم الحسي التى أجريت على مركز البنجر كمشروب مخفف (%13) جودة وقبول المنتج (بنكهة أو بدون نكهة) إلا أن عينات مشروب البنجر التى أضيفت لها نكهة الفراولة كانت هي الأفضل من حيث الطعم والمظهر والجودة الكلية.

1. INTRODUCTION

The beet root is taproot portion of the beet plant (oxford, 2009), is part of the Chenopodiaceae family contains 102 genera and 1400 species, and was first cultivated by the Romans. Beta vulgaris is known by several common names like red beet as reported by **Romeiras, *et. al.,* (2016)**. The plant is grown throughout the Americas, Europe and Asia (U.S. **Department of Agriculture, 2013).** It can also be grown in temperate climates such as Egypt. Beet cultivation is good for all types of land and preferably good drainage such as northern Sudan and the valley Nile and has been cultivated in Al Jazeera Cold weather with long daytime, leading to good flowering, Seeds are grown in mid-august until February and march and the most appropriate date is from September to November **(Ministry of transport Extension and Agriculture, 2017).**

Early Greeks and Romans used the root for its medicinal properties and the leaves as vegetables. Beets contain betaines ehomocysteine. High circulating levels of homocysteine may be harmful to blood vessels and thus contribute to the development of cardiovascular disease **(Pajares, Perez 2006).** This hypothesis is controversial as it has not yet been established whether homocysteine itself is harmful or is just an indicator of increased risk for cardiovascular disease **(Potter *et*. *al*., 2008).**

Beets have long been known for its amazing health benefits for almost every part of the body. Effect on mechanisms of cardiovascular disease **(Hobbs, *et. al.,* 2012).**

Tentative evidence has found that dietary nitrate supplementation such as from beets and other vegetables results in a small to moderate improvement in endurance exercise performance **(McMahon, *et. al.*, 2016).**

Accordingly, efforts should be directed towards the industrial utilization of red beet in Sudan are considered very rich in carbohydrates, crud fiber, crude protein and minerals. Production of red beet ready-to-drink juices concentrated drink or dry mixes products will add economic value, facilitate the consumption and the industrial utilization of the raw materials.

Objectives

This research programme has been designed to achieve the following objectives:

1- To study the nutritional value of red beet.
2- To study the suitability of red beet for production of ready –to- use concentrated drinks.
3- To evaluate the end product for its chemical, physico-chemical and organoleptic characteristics.

2. LITERATURE REVIEW

2.1 Beet root (*Beta vulgaris* L.)

2.1.1 Botanical classification and nomenclature

Botanical, beet root is named as *Beta vulgaris L* which is belong to Betoideae subfamily and the family italics or goosefoot of the large order italics **(Romeiras, *et. al.*, 2016**) which belong to the class italics and kingdom italics **(Schick, Y. k., Horizons, H. 2008).**

In fact family Chenopodiaceae contains 102 genera and 1400 species, and it has several cultivar groups. All cultivars fall into the subspecies italics. The wild ancestor of the cultivated beets is the sea beet (Beta *vulgaris* subsp. maritima) as reported by: **Romeiras, *et. al.*, 2016).** However, *Beta vulgaris* is known by several common names like beet, sugar beet, chard, spinach beet, sea beet, white beet, red beet and Chukander (in Hindi) **(U.S Department of Agriculture, 2013).**

2.1.2 Botanical Description:

The beet is a root vegetable with purple-green variegated leaves. It either a round tap root with minimal secondary roots, plant high 6 to 22 in, spread 4 to 8 in, and the root depth to 2 ft, some reaching down to 5 ft **(Decoteaus, 2000 and Ashworth, 2002).**

Beta vulgaris is an herbaceous biennial or rarely perennial plant up to 120 cm (rarely 200 cm) height, cultivated forms are mostly biennial. The roots of cultivated forms are dark red, white, yellow and moderately or strongly swollen and fleshy (subsp.vulgaris) or brown, fibrous, sometimes swollen and woody in the wild subspecies. The stems grow erect or in wild forms, often procumbent they are simple or branched in the upper part. The basal leaves have a long petiole which may be thickened and red, white or yellow in some cultivars the sample leaf bade is oblanceolated to heart-shaped, dark green to dark red, slightly fleshy, usually with a prominent midrib, with entire or undulated margin, 5-20 cm long on wild plants. The upper leaves are smaller their blades are rhombic to narrowly lanceolat. The flowers are produced in dense spike-like, basally interrupted inflorescences. Very small flowers sit in one-to three- (rarely eight) flowered glomeruli's in the axils of short bracts or in the upper half of the inflorescence without bracts. The hermaphrodite flowers are green or tinged reddish, and consist of five basally connate perianth segments (trpals), 3 – 5 × 2-3 mm, 5 stamens, and a semi-inferior ovary with 2 – 3 stigmas **(Shultz, 2003).**

The perianths of neighboring flowers are often fused. Flowers are wind-pollinated. In fruit, the glomerulus of flowers forms connate hard clusters. The fruit, the (utricle) is enclosed by the leathery and incurved perianth, and is immersed in the swollen, hardened perianth base. The horizontal seed is lenticular, 2 – 3 mm, with a red-brown, shiny seed coat **(Zhu, *et. al.*, 2003 and Flores, *et. al.*, 2008).**

2.1.3 Distribution

According to the English and German sources show that beetroots are commonly cultivated in Medieval Europe **(Hill and Langer, 1991; Hopf, *et. al.*,2000).A**lso, the plant is grown throughout the Americas, Europe, and Asia (**U**.**S**. **Department of Agriculture, 2013).** It can also be grown in temperate climates such as Egypt.

Beet cultivation is good for all types of land and preferably good drainage such as northern Sudan and the Villy Nile and has been cultivated in Al Jazeera **(Ministry of transport Extension and Agriculture, 2017).**

2.1.4 Growth Requirements

As soon as the soil can be worked in early spring (approximately May 20). Beet seeds can be planted. They can be planted successional at two –week intervals until early July, for a continuous crop of beet greens and fresh beets .They enjoy a warm, open, sunny area. The soil temperature should be at least 45ºF for germination **(Coleman-Eliot, 1989)**. Also, the seeds will germinate in five to ten days in temperature from 55 °F- 80 °F **(Ashworth, 2002).**

2.1.5 Soil/Moisture Requirements

Beets grow well in a soil with a pH of 6.5- 7.5 with a boron moisture content a constant supplementation and the beets are seeded 0.5 in deep and in rows 12 to 18 in. The seedlings are often thinned to about 3 to 4 in, between plants. These thinned beets cab be used as greens **(Coleman-Eliot, 1989).**

However, beet root quality is reduced if the plants become stressed by lack of water or from water logging due to poor drainage. Frequent shallow cultivation is important in the growing of good-quality beets because beets are extremely shallow cultivations are the most effective methods of controlling weeds in a row **(Decoteaus, 2000).**

2.1.6 Harvesting and Handling

Beet roots are usually ready to harvest 8 to 9 weeks, under dry weather and soil conditions, beet store best at 32 ºF with 95% humidity for 10 to 15 days, topped beets store considerably longer**(Decoteaus, 2000).**

2.1.7 Pests and diseases

Damping off may occur in early sowings if conditions are cold and damp, the main pest likely to cause trouble is black fly **(Decoteaus, 2000).**

2.1.8 Utilization

2.1.8.1 As food

Young leaves of the garden beet are sometimes used for eating. The midribs of Swiss chard are eaten boiled while the whole leaf blades are eaten as spinach beet. In some parts of Africa, the whole leaf blades are usually prepared with the major as one dish **(Grubben, *et. al.*, 2004).**

Beet top may be cooked or served fresh as greens, the roots may be pickled for salads or cooked whole, sliced, or diced. Beets are also added to soups and beets are the primary ingredient of borscht. Beet juice is used for coloring in many different products (a Russian stock soup). Beet root juice is very potent, when diluted at least 4 times with other milder juices such as carrot, cucumber. Moreover, it has a better taste, a beautiful rich ruby red colour and it is known to help the blood. Beet root pigment is used commercially as a food dye. It changes its colour when heated so it can only be used in ice-cream, sweets and other confectionary. Also but is cheap and has no allergic side-effects. Beets are delightful for their color and flavor as well as for their beet nutrition. Their juice is wonderful mixed with carrot juice and can also be used as a dye. In some countries the beet juice, betanin, is processed commercially for coloration in various products **(NRCS, 2006).**

2.1.8.2 As medicine

Early Greeks and Romans used the root for its medicinal properties and the leaves as vegetables. In England, beet root juice or broth was recommended as an easily digested food for the aged, weak, or infirm. Even in mythology, Aphrodite is said to have eaten beets to retain her beauty. In folk magic, if a woman and man eat from the same beet, they will fall in love. In Africa, beets are used as an antidote cyanide poisoning **(Pajares and Perez, 2006).**

The root and leaves of beet have been used in traditional medicine to treat a wide variety of ailments. Ancient Romans used beet root as a treatment for fevers and constipation, amongst other ailments. Apices in De recoquinaria give recipes for soups to be given as a laxative, three of which feature the root of beet platina recommended taking beet root with garlic to nullify the effects of ' garlic-breath'. Beet greens and Swiss chard are both considered high oxalate foods which are implicated in the formation of kidney stones **(Grubben, *et. al.*, 2004).**

Beets contain betaines which may function to reduce the concentration of homocysteine. High circulating levels of homocysteine may be harmful to blood vessels and thus contribute to the development of cardiovascular disease **(Pajares Perez, 2006).** This hypothesis is controversial as it has not yet been established whether homocysteine itself is harmful or is just an indicator of increased risk for cardiovascular disease **(Potter, *et. al.*, 2008).**

Beets have long been known for its amazing health benefits for almost every part of the body. Start adding beets to your juicing diet to enjoy all its heavenly goodness in anemia, blood pressure, cancer, constipation, dandruff, detoxification, gastric ulcer, kidney ailments, liver toxicity or bile, skin disorders, tonic effects, lowers cholesterol, increases sex drive **(Grubben, *et. al.*, 2004 and Carmen-Socacin, 2008)**.

In preliminary research, beet roots juice reduced blood pressure in hypertensive animals **(Lundberg, *et. al.*, 2011)** and so may have an effect on mechanisms of cardiovascular disease **(Hobbs, *et. al.,* 2012).** Blood pressurelowering effects of beetroot juice and novel beetroot-eniched bread products in normotensive male subjects were studied "Inorganic Nitrate in beetroot juice was found to reduce blood pressure in adults **(Siervo, *et. al.*, 2013).** Tentative evidence has found that dietary nitrate supplementation such as from beets and other vegetables results in a small to moderate improvement in endurance exercise performance **(McMahon, *et. al.*, 2016).**

2.1.8.3 As food additive

During the middle of the 19th century wine often was coloured with beetroot **(Pajares Perez, 2006).** Betanin, obtained from the roots, is used industrially as red food colorant, to improve the color and flavor of tomato paste, sauces, desserts, jams and jellies, ice cream, sweets, breakfast cereals as reported by(**Grubben, *et. al.*, 2004).**

2.1.9 Nutritional value

Beets are low in calories and are a source of vitamin C, one medium sized beet has only 50 calories, with no grams of saturated fat and 2g of dietary fiber .This serving of beet also provides 4% of the RDA of vitamin C. Beet tops (greens) are a good source of vitamin A and a better source of most minerals and vitamins than the roots**. (Decoteaus, 2000).**

According to **USDA (2009),** the protein, fat, sugar and carbohydrate in beet root were found to be 1.68 %, 0.18 %, 7.96% and 9.96 % per 100 g. The estimated energy value was 180 kJ/100 g (43 kcal). The beets were also a good source of vitamin-A (2 µg), thiamine-B1 (0.031 mg), riboflavin-B2 (0.027 mg), niacin-B6 (0.331 mg), pantothenic acid-B5 (0.145 mg), folate-B9 (80 µg) and vitamin-C (3.6 mg). Also were a better source of most of calcium (1.600 ppm), iron (0.090 ppm), magnesium (0.230 ppm), manganese (0.030 ppm), phosphorus (0.380 ppm), potassium (0.305 ppm), sodium (7.700 ppm), zinc (0.035 ppm).

2.1.10 Red beet processing

The red beet was sliced and blended different in different water ratios .After that, the mixture were stirred by a magnetic stirrer for 5 min, immediately filtered with coarse silk sieve and weighted.

Then the juice was extracted by boiling in hot tap water (100°C) for 15-25minblending, filtrated, placed in stainless kettle and heated (100°C) for 15 min. After that, sugar, citric acid was immediately added and the mixture was boiled for 5 min.

2.2 Concentrated fruit drink processing steps

2.2.1 Juice extraction

For all fruits based beverages, the first processing step is the extraction of juice or pulp from mature and undamaged fruits. Any fruits that are mouldy or under-ripe should be sorted and removed. There are several mechanical methods for juice extraction depending on fruit types. The fruit juice may also be obtained by diffusion in water. The soluble solids content of the finished product should meet the minimum brix level for reconstituted juice specified in the Annex **(CODEX, 2005 and SSMO, 2007).**

2.2.2 Filtration

The extracted juice or pulp is filtered through a muslin cloth or a stainless steel filter or with a filter presses. Although juice is naturally cloudy, some consumers prefer a clear product. In this case, it is necessary to use pectic enzymes to break down the pectin so as to have a clear juice. Pectic enzymes may be difficult to find and expensive and therefore should only be used if it is really necessary and readily avail **(Azam, 2008).**

2.2.3 Formulation

When the juice has been extracted, it is necessary to prepare according to the recipe. Juices are sold either pure or sweetened. Fruit squashes would normally contain about 25% fruit material mixed with sugar syrup to give a final sugar concentration of about 40 %. It is a preservative (800 ppm sodium benzoate). The addition of sugar to the fruit pulp to achieve the recommended levels for preservation must take into account the amount of sugar already present in the juice. It is important to achieve the minimum level that will prevent the growth of bacteria. Once that level has been achieved, it is possible to add more if the consumers require a sweeter product. The amount of sugar added in practice is usually decided by what purchasers actually want. Pearson Square is a useful tool that should be used for batch formulation and calculation the amount of sugar to be added. **(Azam, 2008).**

2.2.4 Pasteurization

All the fruit juice and drinks should be pasteurized at 80-95ºC for 10-15 minutes prior the hot filling. A given amount of the syrup is then mixed with fruit juice in a small stainless steel pan and this increases the temperature to 60-70 ºC.

The juice/syrup mixture is then quickly heated to the pasteurizing temperature **(Azam, 2008).**

2.2.5 Filling and bottling

The fruit juices and drink products should be hot-filled into clean, sterilized bottles. After the hot filling, the bottles are capped and laid on their sides to cool prior to labeling **(Azam, 2008).**

2.2.6 Labeling

The name of the product shall bear the name of the fruit used "concentrated juice" or "juice concentrate" **(SSMO, 2007).**

2.2.7 Storage stability

Fresh natural juice is highly subjected to spoilage more than the whole fruit. The unheated juice is also subject to rapid microbial, enzymatic, chemical and physical deterioration. Thus, the goal of heat treatment during processing of fruit concentrated drink is to minimize these undesirable reactions and to enhance the inherent quality of starting fruit **(Bates, *et. al.,* 2001).**

The most frequent reason for quality deterioration of a food product is the result of the microbial activity during storage such as food moulding, fermenting and changing in acidity **(Abbo, *et. al.*, 2006).**

2.3. Concentrated fruit drink quality control

Azam (2008), stated that, for production of high quality product, it is essential to work quickly between juice extraction and the bottling stage. Therefore, the following points should be considered:

- Only fresh, fully ripe fruit should be used; mouldy or insect damaged fruit should be thrown a way. Also dirt, skins, stones should be removed.

- Only treated and filtered water should be used.
- The re-usable bottles should be checked for cracks; chips act and wash thoroughly before using. Always use new caps or lids.
- The preservative concentration should be carefully controlled according to the local laws.
- The heating temperature and time are critical for achieving both the correct shelf life of the drink and retaining a good colour and flavor.
- The correct weight should be filled into the bottles each time. These factors are important because a customer will stop buying the products if the quality varies with each purchase.

The fruit concentrate should have the characteristic colour, aroma and flavor of the same kind of fruit from which it is made. The products essential physical, chemical, organoleptical and nutritional characteristics should be authenticated **(CODEX, 2005 and SSMO, 2007)**

2.3.1 Specification and legislation

Sugar with less 2% moisture, sucrose, dextrose anhydrous, glucose, fructose, may be added to all fruit juices. Liquid sucrose, invert sugar solution, invert sugar syrup, fructose syrup, liquid cane sugar, glucose and high fructose syrup may be added only to fruit juice for production of concentrated fruit juice, concentrated fruit puree. Subject to national legislation of the importing country, lemon juice or lime juice, or both, may be added to fruit juice up 3 g/1 anhydrous citric acid equivalent for acidification purposes to unsweetened juices. Also, for the purposes of product fortification, essential nutrient such as vitamins and minerals may be added (**Ashurst, 2005**).

As reported by the **CODEX (2005),** the brix level of directly pressed fruit juices shall be the same brix as expressed in the fruit and also, the soluble solids content of the single strength juice shall not be modified. The preparation of the fruit juice that requires reconstitution of concentrated juices, the juice must be in accordance with the minimum brix level. Total soluble solids (T.S.S) contents are related directly to both fruit sugars and acids. Pectins, glycosidic materials and the solids figure.

Fruit concentrated drinks have a low pH because they are comparatively rich in organic aid. The overall range of pH is 2 to 5 for common fruit with the most frequent figures begin between 3 and 4. There are several chemical preservatives that can be added to fruit juices. Processes need to check with local authorities or standards agencies to find the maximum permitted levels **(Tasnim *et. al.,*2010).**

As reported by **SSMO** (**2007**), a good quality fruit concentrate should have Total soluble solids, pH and Titrable acidity, between 50- 55, 2.0 -5.0 and 0.5 – 0.8 %, respectively

3. MATERAIALS AND METHODS

3.1 Materials

Red beet (*Beta vulgarisl*) were obtained from Shambat central market at the harvesting season (June - 2017). The sample was tightly kept in polyethylene bags and stored at (-18°C) until needed for the different investigations.

3.2 Methods

3.2.1 Experimental processing method

3.2.1.1 Red beet cold extraction method

In this method, two replicates from the sliced red beet sample (50g) were blended different fruit: water ratios (1:2, 1:4, 1:6, 1: 8 and 1:10). After that, the mixture were stirred by a magnetic stirrer (Gallenkamp P 2375, England) for 5 min, immediately filtered with coarse silk sieve and weighted. Then, the weight of each Red beet extract was recorded and checked from for its hydrogen ions concentration (pH), volume (ml), weight (g), total soluble solids (T.S.S.%) and yield (%).The yield of each extract was calculated by using the following equation:

$$\text{Yield} = \frac{\text{T.S.S \% × weight of extract (g) \} × 100 \%}}{Iitinal\ weight\ of\ sample}$$

[eq. 1]

3.2.1.2 Red beet concentrated drink processing method

After determination the suitable extraction method and conditions for production of red beet extract, beet were peeling, cutting and weighted (2Kg). Then the juice was extracted by boiling in hot tap water (12 L /100°C) for 15-25min., blending, filtrated, placed in stainless kettle and heated (100°C) for 15 min. After that, sugar (10 Kg), citric acid (120 g) was immediately added and the mixture was boiled for 5 min. Finally, sodium benzoate as a preservative (6.6 g) was added and red beet concentrated drink was filled in a cleaned, sterilized plastic containers, tightly closed, cooled and stored at (4°C) until needed for the different investigations.

3.2.2 Chemical methods

3.2.2.1 Determination of minerals

Ten milliliters (10 ml) of HCL (2N) were added to the remaining ash sample and placed in a hot sand path for about 10 −15 min. After that, the sample was filtered and diluted to 100 ml in a volumetric flask. Then, the trace elements ferrous (Fe^{++}) and manganese (Mn^{++}) were determined according to **Perkin Elmer (1994**) by using Atomic Absorbance Spectroscopy (JENWAY 3110, UK). Sodium (Na) and potassium (K) were determined by using Flame Photometer (Model pep7 JENWAY). While, calcium (Ca), magnesium (Mg) and phosphorus (P) were determined as described by **Chapman and Pratt (1961).**

3.2.2.2 Titrable acidity

The Titrable acidity of red beet sample was determined according to **Ranganna, (1979).**

Procedure: 50 g + 1g sample was diluted to 100 ml of distilled water and filtered using filter paper (No>4).Then, 20 ml of clear filtrate was titrated against (0.1 N) sodium hydroxide using phenolphthalein solution (1%) as an indicator. The titrable acidity was calculated as percent citric acid according to the following equation:

Titrable acidity (%) =

$$\frac{\text{Titre} \times \text{N}(\text{NaOH} \times \text{volume made up} \times \text{equivalent wt. of acid} \times 100\ \%)}{\text{Sample volume (ml)} \times \text{initial wt. of sample(g)} \times 1000}$$

[eq. 2]

3.2.3 Physical and phsico-chemical methods

3.2.3.1 Total Soluble Solids

The total soluble solid (T.S.S %) of Red beet extracts and concentrated drink were measured using a Hand Refractometer {No. 002003 .BS Eclipse, UK (0 −50, 42−80 Brix)} and the results were expressed as (%) sucrose or degree Brix according to the **AOAC (2010).**

Principle: The index of refraction of a sample is a ratio of light velocity under vacuum to its velocity in the substance which is largely dependent on the composition, concentration and temperature of sample solution.

Procedure: After the adjustment of the Hand- Refractometer (0-50 Brix, Eclipse BS 002603, UK) with distilled water, the sample was placed on surface of

Refractometer prism. Then, the prism was closed and the reading was recorded to the nearest 0.00 as (T.S.S %)

3.2.3.2 Hydrogen ions concentration

The hydrogen ions concentration (pH) was measured following the method of the **AOAC (2010).**

Principle: The sample is measured potentiometrically with a pH-meter. After standardization of the meter electrodes with buffer solutions, the reading is taken when the equilibrium potential across the electrodes is achieved.

Procedure: After standardization of the pH-meter (JENWAY, 3510 pH meter, UK.) with two buffer solutions (pH : 4 and 7), the electrode of the PH-meter was rinsed with distilled water, immersed in the sample solution (20º C) and left to stand until a staple reading was achieved. All the readings were expressed as pH to the nearest 0.00 pH unit.

3.2.4 Organoleptic evaluation method

Red beet concentrated drink as a diluted juice (13% T.S.S.) was sensory evaluated by using the Scoring method that described by **Ranganna (2001).** In this method, 20 trained panelists from the Food Science and Technology Department, College of Agricultural Studies, Sudan University of Science and Technology, were asked to evaluate the product with respect to its colour, flavour, taste, appearance and over – all quality by using the following scale: 1 = excellent, 2 = very good, 3 = good, 4 = acceptable, 5 = unacceptable. After that, the results obtained were statistically evaluated.

3.2.5 Statistical analysis method

The data obtained in this study were subjected to statistical analysis by using the Statistical Package for Social Science (SPSS).The mean values were obtained by the Analysis of Variation (ANOVA). Probability of 5% was used to indicate the significant according to Duncan's Multiple Range Test (DMRT) as described by **(Mead and Gurnow, 1983).**

Table (1): Red beet concentrated drink processing recipe

Ingredients	Quantity

Red beet	02.00 Kg
Added water	12.00 L
Red beet extract	12.50 Kg
Red beet extract total soluble solids (T.S.S)%	0.800 %
Sugar	10.00 Kg
Citric acid	120.0 g
Sodium benzoate	6.600 g

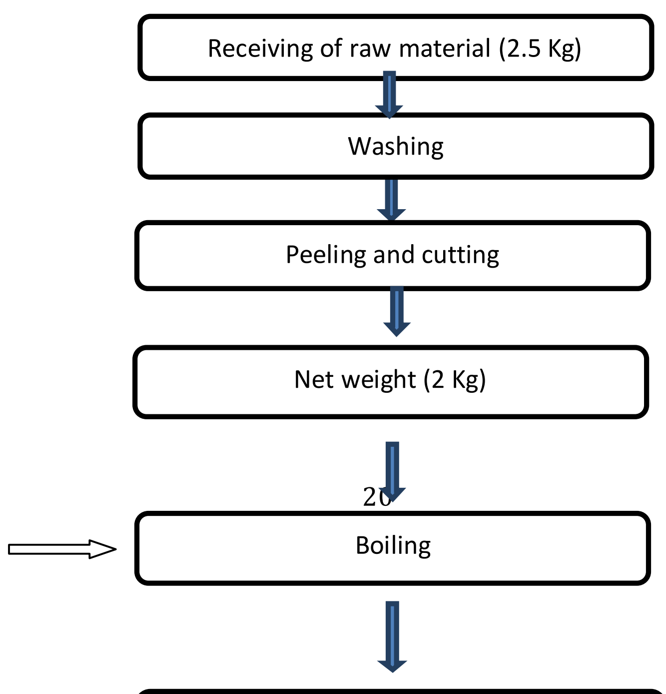

Figure (1): Flow processing diagram for production of Red beet concentrated drink.

4. RESULTS AND DISSCUSSION

4.1 Production of red beet concentrated drink

4.1.1 Extraction of red beet juice

(A)Cold extraction method

Table (2) shows the result of Cold extraction of red beet, the volume weight and yield (%) of red beet were significantly (p<0.o5%) increased with the increasing of fruit: water ratio. In contrast, the total soluble solids percent (T.S.S %) of red beet extract was significantly (p<0.05%) decreased with the increasing of fruit: Water ratio. However, among the different fruit: water ratios used in the experiment, the ratio of (1:6) was found more suitable for preparation of red beet extract with suitable volume (335 ml), pH (7.11), T.S.S% (1.80 %) and yield(11.48 %).

4.1.2Proceessing of red beet concentrated drink

After determination of the suitable extraction method and condition for production of the red beet extract, the processing method and recipe used in this study for production of red beet concentrate are indicated in Fig.(1) and Table (1), respectively.

4.2Quality evaluations of the end product

After production of red beet concentrated drink the product was evaluation for its chemical, phsico-chemical, minerals and organoleptic properties.

4.2.1 Chemical and physico-chemical characteristics of red beet concentrated drink

Table (3) shows the chemical and physico-chemical characteristics of red beet concentrate (with and without flavour). From the results, the titrable acidity as % citric acid, total soluble solids (T.S.S %) and hydrogen ions concentration (pH)

Table (2): Cold extraction of red beet

Parameters	Fruit: water ratio					$Lsd_{0.05}$	SE±
	1:2	1:4	1:6	1:8	1:10		
	n = 2 ± SD						
Red beet weight (g)	50.00±0.00[a]	50.00±0.00[a]	50.00±0.00[a]	50.00±0.00[a]	50.00±0.00[a]	-	-
Extract weight (g)	134.50±0.71[e]	234.00±1.41[d]	329.00±1.41[c]	428.00±1.41[b]	538.00±1.41[a]	85.16*	28.39
Extract volume (ml)	140.00±0.00[e]	237.00±2.83[d]	335.00±2.83[c]	437.50±0.71[b]	545.00±2.83[a]	74.32*	24.77
T.S.S (%)	2.40±0.00[a]	1.90±0.00[b]	1.80±0.00[b]	1.70±0.00[bc]	1.55±0.07[c]	0.147*	0.049
pH-value	7.19±0.04[a]	7.15±0.01[a]	7.11±0.00[a]	7.06±0.00[b]	6.65±0.05[b]	0.152*	0.051
Yield (%)	6.46±0.04[e]	8.89±0.06[d]	11.84±0.06[c]	14.56±0.05[b]	16.68±0.71[a]	1.934*	0.085

SD ≡ Standard deviation.

n ≡ Number of independent determinations.

Mean ±S.D value(s) bearing different superscript letter (s) in each row are significantly (P≤0.05).

* ≡ Significant at t (P≤0.05).

I.S ≡ In significant.

$Lsd_{0.05}$ ≡ Least significant difference at (P≤0.05).

SE± ≡ Overall experimental error.

Table (3): Chemical and physico-chemical characteristics of red beet Concentrated drink

Sample	Titrable acidity (%)	Total soluble solids % (T.S.S%)	Hydrogen ions concentrations (pH)
	(n = ±SD)		
B	0.7393[a] ±0.01	52.00[a] ± 0.00	2.9705[a] ± 0.01
A	0.7008[b] ±0.01	52.00[a] ± 0.00	2.9665[b] ± 0.01
$Lsd_{0.05}$	0.0285[*]	0.092[NS]	0.0039[*]
SE±	0.0046	0.00	0.0007

n = number of independent determinations.

SD = standard deviation.

B = Red beet concentrated drink without strawberry flavour.

A= Red beet concentrated drink with strawberry flavour.

were found to be 0.70 %, 52% and 2.96, respectively. The results obtained in this study with are agreed well with those reported by **SSMO (2007).**

4.2.2 Minerals content of red beet concentrated drink

The minerals content of red beet concentrated drink is presented in Table (3). The product was found to provide appreciable amount of calcium (0.542 ppm), sodium (8.000 ppm), magnesium (2.150 ppm), phosphorous (0.050 ppm), potassium (4.760 ppm), iron (0.262 ppm) and manganese (0.014 ppm) per 100 ml. The results obtained in this study with are approximately with those reported by **USDA (2009).**

4.2.3 Organoleptic evaluation

A sensory evaluation for red beet concentrate as diluted drink (13 Brix) was carried out by using trained panelists (20) from the Food Science and Technology Department, College of Agricultural Studies, Sudan University of Science and Technology. Red beet drinks with and without strawberry flavour were evaluated according to their colour, taste, flavour, appearance and over –all quality by using the acceptability method. The results are indicated in table (5).

In general, red beet drinks with or without flavour were greatly accepted by the panelists. Red beet drink with strawberry flavour had the better taste (2.10), appearance (2.40) and over-all quality (2.25).

Table (4) Minerals content of red beet concentrated drink

Minerals	Samples		$Lsd_{0.05}$	SE±
	B	A		
	[ppm]			
Potassium [K]	$4.760^{a} \pm 0.05$	$4.700^{b} \pm 0.03$	0.581^{*}	0.126
Phosphorous[P]	$0.050^{a} \pm 0.00$	$0.050^{a} \pm 0.00$	0.092^{NS}	0.00
Sodium[Na]	$8.000^{a} \pm 0.00$	$8.000^{a} \pm 0.00$	0.092^{NS}	0.00
Calcium[Ca]	$0.726^{a} \pm 0.01$	$0.542^{a} \pm 0.03$	0.0841^{*}	0.0325
Magnesium[Mg]	$4.600^{a} \pm 0.07$	$2.150^{a} \pm 0.04$	1.4509^{*}	0.7611
Iron[Fe]	$0.130^{a} \pm 0.01$	$0.262^{a} \pm 0.04$	0.0326^{*}	0.0128
Manganese[Mn]	$0.030^{a} \pm 0.01$	$0.014^{a} \pm 0.00$	0.0159^{*}	0.0075
Copper[Cu]	$0.013^{a} \pm 0.00$	$0.012^{a} \pm 0.00$	0.0234^{NS}	0.0097

ppm = Part per millon

B = Red beet concentrated drink without strawberry flavour.

A= Red beet concentrated drink with strawberry flavour.

Table (5): Organoleptic evaluation of red beet drinks

Sample	Quality attributes				
	Colour	Taste	Flavour	Appearance	Overall Quality
	[Score, n= 20± SD]				
B	2.70 ±0.98[b]	2.60±1.10[a]	2.90±1.25[a]	3.00± 1.12[a]	2.45±1.05[a]
A	2.80 ±0.95[a]	2.10± 1.17[b]	1.75±0.79[b]	2.40 ± 1.14[b]	2.25± 0.79[a]
$Lsd_{0.05}$	0.185[NS]	0.432[*]	0.156[*]	0.567[*]	0.252[*]
SE±	0.062	0.144	0.051	0.189	0.074

n = number of independent determinations.

SD = standard deviation.

B = Red beet concentrated drink without strawberry flavour.

A= Red beet concentrated drink with strawberry flavour.

Score: 1= excellent, 2 =very good, 3 = good, 4= acceptable, 5= unacceptable.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the results obtained in this study it can be concluded that, red beet (*Beta vulgaris*) could be easily extracted in hot (boiled) water 100Cº for 30 min. The concentrated drink that made out of red beet extract has been found with acceptable chemical, physico-chemical and organoleptic characteristics as a natural drink. Also, the product was found to provide appreciable amount of minerals and within the local and international specifications of fruit concentrated drink.

5.2 Recommendations

1- Efforts should be directed towards the industrial food utilization of red beet in Sudan for production of red beet concentrated drink which can be used as functional food or as a treatment or traditional for different diseases.

2- Additional studies are definitely needed to ensure safety, storage conditions-shelf-life, economic feasibility and the market demands for product.

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Plate1: Red beets

Plate 2: Red beet concentrated drinks

P = Red beet concentrated drink without strawberry flavour.

F= Red beet concentrated drink with strawberry flavour.

Plate 3: Red beet diluted drink.