1. INTRODUCTION

1.1 Laloub fruits

Laloub tree (*Balanites aegyptiaca*) is wildly distributed as adesert plant in Africa, Middle East and South Asia **(Chapagain and Wiesmen, 2005)**.

In Sudan, the tree is widely spread in Kordofan, Darfur, Blue Nile and Kassala states. It is considered as a multipurpose plant for its wide utilization as traditional food, traditional medicine, folkloric, fire wood, forage hedges and afforestration **(Abdoun, 2005).** Also, in Sudan Laloub fruit pulp is usually used in sudan as traditional food or as a remedy for many diseases, due to its high contents of sugars (glucose, fructose and sucrose), protein and many active chemical compounds such as diosgnin and yamogenin , both of which are used in the partial synthesis of the steroid drugs **(Von-Maydell, 1986).**

The diosgnin compound in Laloub fruits has been found to have a positive effect on the activity of the female reproductive tract **(El-Sheikh, 1994).** In addition to that, Laloub saponin compounds were also found to be toxic for the Schistsoma mansoni miracidia, Cercaria and worms **(Cheeke, 1997).** Besides the fruit pulp is found to contain laxative and anthelemintic materials and it is commonly used as a source of steroidal drugs, and for prevention of cancer cells growth and viability, cholesterol reduction, anti-oxidant, and immunological support **(Malinow, 1997).**

Therefore, the utilization of laloub fruits pulp in production of juice concentrated could certainly improve the traditional utilization of the fruits as food or as a remedy for different diseases such as stomach complaint or disorder (as laxative or worms repulsive) cholesterol induced diseases diabetes, cancer (as anti-oxidant). The development of Laloub concentrated drink will add economic value

to the raw material and facilitate their consumption and their different industrial utilization in Sudan.

1.2 Objectives

The main objectives of this research could be summarized under the following:

1. To study the nutritional value of Laloub fruits pulp.
2. To study the suitability of Laloub fruits for production concentrated of Laloub drink.
3. To evaluate the end product for its chemical, physico-chemical and organoleptic characteristics.

2. LITERATURE REVIEW

2.1 Laloub fruits

2.1.1 Botanical classification

Laloub tree is scientifically classified under the subfamly *Tribuloide* which belongs to the family *zygophyllaceae* The genus of the tree is *Balanites* ,and the recognized binominal name is *Balanites aegyptiaca* s(L) Delile **(Wikipedia,2010).**

Laloub tree has many synonyms:the most famous names are *Ximenia aegyptiaca* L. (*Balanites roxburghii* Planch); *Agialida senegalensis* van Tiegh., *Agialida barteri* van Tiegh., *Agialida tombuctensis* van Tiegh., *Balanites ziziphoides* Milbr. Et Schlechter, *Balanites latifolia* **(Joker, 2000).**

2.1.2 Botanical description

Laloub tree is an ever green tree with a small to medium-size and a height of about 6-1m,with a fluted bole and a stem diameter of 30-50cm.The tree crown is spherical or irregular, while the bark is smooth and green in color with young branches brown to grey. The leaflets has 2-5 cm long and with 1.0 to 2.5cm width The flowers in small clusters with yellow –green color and 1-3 cm in diameter . The fruit of the tree are green at first and then turning to yellow or brown with 3-4 cm long, with a yellow brown sticky edible flesh and containing a large hard pointed stone .The ripe fruit has a space between the epicarp and the sticky fleshy mesocarp so that the last one is readily and easily removed **(Joker, 2000 ; Gebauer, *et al*, 2002; Abdoun, 2005; Guar, *et. al*, 2008).**

Laloub fruit is mainly composed of four layers; the first one is the epicarp which represents the outer layer and it is leathery smooth or wrinkled .The second

one is the mesocarp which is the middle part and it looks yellow brown , sticky fleshy , oily ,and gummy with bitter sweet taste **(Abdoun, 2005).**

2.1.3 Distribution

Laloub tree (*Balanites aegyptiaca)* is perhaps one of the most wide-spread woody plants of the African continent. It is distributed throughout Africa from costal Mauritania and Senegal to Somalia and Egypt, southwards to Zambia and Zimbabwe, as well as in the Middle East from Yemen to Jordan and Israel. Benin, Burkina Faso, Cameroon, Chad, Djibouti, Ethiopia, Gambia, Ghana, Guinea, Bissau, Guinea, Ivory Coast, Kenya, Mali, Mauritania, Nigeria, Niger, Senegal, Sudan, Somalia, Tanzania, Togo, Uganda, Zaire, and Zambia are the primary African countries where *Balanites* are grown. Algeria, Angola, Burundi, Central African Republic, Libya, Morocco, and Rwanda are the other African countries where *Balanites* are found. *Balanites* are not only grown throughout the African continent but also in the Middle East, the Arabian Peninsula, and Southern Asia. Israel, Jordan, Saudi Arabia, North and South Yemen, India, and Myanmar are the countries beyond Africa where *Balanites* naturally grow. In Israel, *Balanites* are found in the Arava Valley (near the Jordanian border), Eilat (near Red Sea coast), Ein-Gedi oasis (near the Dead Sea), and Bet-Shean Valley (near the Sea of Galilee) **(Chapagain and Wiesman, 2005).**

The growth range of Balanites was found to extend across more than 50º of latitude: from 35º N (Bet-Shean Valley, Israel) to about 19º S (Budi district, Zimbawe). However, it is mainly distributed in semiarid and arid zones in tropical Africa **.**

The tree is called as *Lalob* in Arabic, *Aduwa* in Hausa, Hingota in Hindi, and Zaqum mitzri in Hebrew **(Bishnu, 2006).**

In the Indian subcontinent, so far *B. aegyptiaca* and its subspecies are reported to be found only in India and neighboring Burma (Union of Myanmar) . In India, *Balanites* are widely grown in Rajasthan and neighboring states, whereas, in Burma this plant is recorded so far only from the Irrawady Valley and one of two adjacent areas between Yeu (*ca.* 22º 50' N) in the north and Prome (*ca.* 18º 15' N) in the south. The Burmese species is better known as *B. triflora*. The Indian species of *Balanites* is known *Balanites roxburghii*. Although some taxonomists have indicated the differences between these two species of *Balanities*, until they are precisely examined, the relationships between *triflora* and *roxburghii* remain uncertain **(Bishnu, 2006).**

2.1.4 Biophysical limits

Altitude: 0-2 000 m, Mean annual temperature: 20 -30 deg. C, Mean annual rainfall: 250-1200 mm

Soil type: The soils in its range tend to be deep sands, sandy clay loams, sandy loams or clays**(NRC,2008).**

2.1.5 Nutritional value

The chemical composition of *Balanites aegyptiaca* fruits pulp was investigated by **Dougal, *et.al*.(1964), Abu-Alfutuh (1983), Becker, (1983)** and **Nour, *et.al*.(1985)**.The results of the prevlous and authors were summarized by **El-Saed (2015)** in Table (1). Also, the minerals and vitamins were investigated by **El-Saed (2011)** and **Frigoun (2015)** as indicated in Table (2).

Balanites aegyptiaca fruit pulp contains high amounts of sugars, protein, lipid, minerals and vitamins **(NRC, 2008).** The total sugars of Laloub fruits pulp ranges from 40-70 % and it contains about 5 % proteins and 0.1 % fat.

The concentrations of calcium, magnesium, phosphorus, sodium, sulpher and iron were found to be 24.4, 6.33, 1.58, 0.542, 1.81 and 1.23 as g/kg on dry basis (DM), respectively. While, the concentrations of manganese, copper, zinc and selenium as trace elements were 22.5, 33.7, 32.5 and 48.0 as mg/kg on dry basis (DM), respectively **(Abd-Alrazak**, ***et .al***, **2010).**

2.1.6 Utilization

2.1.6.1 Food utilization

The desert dates or the *Balanties aegyptiaca* are very rich in saturated fatty acids that can be used as cooking oil **(Ndoye**, ***et al***, **2004).** In kordofan and Darfur, the green leaves, young sprouted leaves and green thorns are eaten fresh as vegetable salad or may be cooked, besides, the laloub yellowish edible oil is released by extended boiling of the fruit kernel **(Abdoun, 2005).**

Many parts of the plant were used as famine foods in Africa; the leaves are usually eaten raw or cooked, the oily seed is boiled to make it less bitter and eaten mixed with sorghum, and the flowers can be eaten. The tree is considered valuable in arid regions because it produces fruit even in dry times. The fruit can be fermented for production alcoholic beverages, the seeds cake remaining after oil is extraction is commonly used as animal fodder in Africa. **(Wikipedia, 2015).**

2.1.6.2 Medicinal utilization

Desert dates contains steroids such as (saponins and sapogcnins and diosgcnins) which are normally used as raw materials for industrial production of contraceptive pills , corticoids , anabolisants and other sexual hormones. **(Ndoye, *et.al*, 2004).**

Table (1): Chemical composition of *Balanites aegyptiaca* fruits pulp

Chemical Composition(%)	Dougal, *et al*. (1964)	Abu-Afutuh (1983)	Becker (1983)	Nour,*etal*. (1985)
	On dry basis%	On fresh basis		
Dry matter or moisture content	-	75.4-82.1	78.90	88.70-89.5
Protein	08.50	03.2-06.60	04.90	01.20-01.50
Fat	06.60	00.1-00.70	00.10	00.10-00.40
Carbohydrates	39.00	64.00-74.00	69.90	-
Fiber	40.80	00.90-04.40	03.50	-
Total sugars	-	56.70	-	34.90-37.10
Reducing sugars	-	56.10	-	28.50-33.80
Non reduceing sugars	-	00.60	-	-
Ash	05.10	04.90-06.90	-	02.40-02.90

(El-saed, 2011)

Table (2): Minerals and vitamins content of *Balanites aegyptiaca* fruits pulp

Mineral and Vitamin	Weight basis(mg/100g)
Phosphorus (P)	058.00
Calcium (Ca)	147.00
Iron (Fe)	004.00
Vitamins (B1)	000.27
Vitamins (B2)	000.07
Vitamins (B6)	001.74
Vitamins (C)	046.00

(El-saed, 2011 and Frigoun, 2015)

Desert date fruit is add to porridge and eaten by nursing mothers to improve lactation. Oil from the fruit is used for headach and to dress Bark extracts to destroy freshwater snails and copepods organisms that act as intermediary hosts host the parasites Schistosoma, including Bilharzia, and guinea worm, respectively. Existing worm infections, liver and spleen disorders are also treated with desert dates. Moreover, a docation of the bark are used as an abortifacient and an antidote for arrow-poison in West African traditional medicine. The seed contains 30-48% fixed (non-volatile) oil, like the leaves, fruit pulp, bark and roots, and contains the sapogenins diosgenin and yamogenin. Saponins likewise occur in the roots, bark wood and fruit. Diosgenin can be used to produce hormones such as those in combined oral contraceptive pills and corticoids **(Wikipedia, 2015).**

An emulsion made from the fruit or bark is lethal to the freshwater snails that are the host of miracidia and cercaria stages of bilharzia and to a water flea that acts as a host to the guinea worm. A fish poison can be obtained from the fruit, root and the bark. The active agent of the poison is saponin. The compound is toxic to fish but does not affect mammals and rapidly becomes inert, so that fish retrieved are edible. However, in the Fada region of Cote d'Ivoire, the poison is reported to damage the sight of fishermen after they have used it for 5-6 years. **(Orwa *et. al*, 2009).**

2.1.6.3 Fodder

The fresh and dried leaves, fruit and sprouts are all eaten by livestock. As shown in an experiment in Burkina Faso, *B. aegyptiaca* contributed up to 38% of the dry-matter intake of goats in the dry season. Kernel meal, the residue remaining after oil extraction, is widely used in Senegal, Sudan and Uganda as a stock feed. The tree is lopped for fodder in India and Tamil Nadu **(Orwa *et. al*, 2009)**.

2.1.6.4 Hedges and forestation

The thorny branches of the tree are massed together to form lives hedging and boundaries. Also, the cut branches are used to make live stock enclosures. (**Orwa *et. al*, 2009**)

2.1.6.5 Folkloric utilization

Desert date(*Balanites aegyptiaca*)wood is a very good fire wood and produces good quality charcoal. The wood is resistance to the insects so it is used for making tool handles, gun stocks and furniture ,In Sudan, people use the seeds for making Sibha or for playing Siga, while, the wood of the tree is used to make wooden spoons, stools and combs (**Abdoun, 2005**).

2.1.6.6 Others

A greenish-yellow to orange-red resin is produced from the stems. It is sucked and chewed when fresh. It is used as a glue for sticking feathers to arrow shafts ,spearheads and in the repair of handle cracks and arrows. **(Orwa *et. al*, 2009).**

2.2 Fruit juice

Fruit juice is defined as the aqueous liquid expressed or extracted from one or more fruits or vegetables, purees of the edible portions of one or more fruits or vegetables, or their concentrates. The word Juice also refers both to beverages that are composed exclusively of an aqueous liquid orliquids extracted from one or more fruits or vegetables and those beverages that contain other ingredients in addition to juice. And also Codex Alimentarius defines juice as “unfermented but fermentable juice, intended for direct consumption, obtained by the mechanical process from sound, ripe fruits, preserved exclusively by physical means. The juice

may be turbid or clear. The juicemay have been concentrated and later reconstituted with water suitable for the purpose of maintaining the essential composition and quality factors of the juice. The addition of sugars or acids can be permitted but must be endorsed in the individual standard **(Hassan, 2009).**

2.2.1 Concentrated fruit juice

Concentrated fruit juice is the product that complies with the fruit juice definitions except that water has been physically removed in an amount sufficient to increase the Brix level to a value at least 50% greater than the Brix value established for reconstituted juice from the same fruit, as indicated in the Annex. In the production of juice that is to be concentrated, suitable processes are used and may be combined with simultaneous diffusion of the pulp cells or fruit pulp by water provided that the water extracted soluble fruit solids are added in-line to the primary juice, before the concentration procedure **(CODEX, 2005).**

2.3 Processing of concentrated fruits juice

The goal of processing is to minimize these undesirable reactions while still maintaining and in some cases enhancing, the inherent quality of the starting Fruit **(Bates and Crandall, 2001).**

There is an industry need for new technologies to process fruit juices that further conserve the nutritive value and freshness, and other sensory properties of juices without compromising food safety **(Wikipedia, 2007).**

2.3.1 Processing steps

2.3.1.1 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 by the **CODEX (2005) and SSMO (2007).**

2.3.1.2 Filteration

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 pectin enzymes to break down the pectin so as to have a clear juice. Pectin enzymes may be difficult to find and expensive and therefore should only be used if it is really necessary and readily available **(Azam, 2008).**

2.3.1.3 Formulation

When the fruit juice or pulp is extracted, it is necessary to prepare according to especial recipe. Fruit squashes would normally contain about 25% fruit material mixed with sugar syrup to give a final sugar concentration of about 40%. As the bottle is opened, partly used and then stored, it is necessary to add 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. Also, 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 sweet product. The amount of sugar added in practice is usually decided by what the 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. Sugar should be added to the fruit juice as syrup, which can be filtered through a muslin cloth prior to mixing to

remove particles of dirt which are alwaya present. This gives a clearer product with high quality **(Azam, 2008).**

2.3.1.4 Pasteurization

A given amount of the syrup is mixed with fruit juice in stainless steel pan to increase the temperature of the mixture to 60-70°C. Then the mixture is quickly heated to the pasteurizing temperature {80-95°C /1-10 min} **(Al-baloal, 2013).**

2.3.1.5 Filling and bottling

The fruit juices and drink products should be hot filled into clean and sterilized bottles .After that ,the bottles are capped and laid on their sides to cool prior to labeling(**AL-baloal, 2013).**

2.3.1.6 Labeling

The name of the product shall bear the name of the fruit used in production of concentrated juice or juice concentrate **(SSMO, 2007).** The sealed jars are mechanically conveyed to a labeling machine. These labels must list truthful and specific information about the product. The jars are then packed into cartons for marketing **(Ashurst, 2005).**

2.3.1.7 Quality control

As reported by **Azam (2008),** the juice should be stored in a refrigerator or in a cool place and away from the direct sunlight. It should be collected into a clean, sterile container and covered to keep out dirt, dust and insects. For the best quality product it is essential to work quickly between the extraction of the juice and the bottling stage. The longer the juice is out of the bottles, the more chance there is of contamination. The quality of the concentrated drink daily should be monitored and controlled to ensure that every bottle of from the product has the

correct keeping and drinking qualities. Therefore, the following points should be considered as mentioned by the aforementioned author:

- Only fresh, fully ripe fruit should be used; mouldy or insect damaged fruit should be thrown away. All unwanted parts (dirt, skins, stones etc) should be removed.
- All equipment, surfaces and floors should be thoroughly cleaned after each day's production.
- Water quality is critical. If in doubt use boiled water or add one tablespoon of bleach to 5 litres of water to sterilise it. If water is cloudy, a water filter should be used.
- Pay particular attention to the quality of re-usable bottles, check for cracks, chips etc and wash thoroughly before using. Always use new caps or lids.
- The concentration of preservative should be carefully controlled for correct preservation of squashes and cordials, and may be subject to local laws. Check first and use accurate scales to measure the preservative.
- The temperature and time of heating are critical for achieving both the correct shelf life of the drink and retaining a good colour and flavour. A thermometer and clock are therefore needed.
- The correct weight should be filled into the bottles each time.

2.3.1.8 Specifications and legislations

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 or, concentrated fruit puree. lemon juice or lime juice, or both , may be also added to fruit juice up to 3g /L anhydrous

citric acid equivalent for acidification purposes to unsweetened juices. Moreover essential nutrients such as vitamins and minerals could be added **(Ashurst, 2005).**

As reported by the **CODEX (2005),** for production of fruit should juice that requires reconstitution of concentrated juices, the juice must be in accordance with the minimum brix level in the fruit. Total soluble solids (T.S.S%) contents are related directly to both fruit sugars and acids. Pectins, glycosidic materials and the salts of metals such as sodium, potassium, calcium etc., when they are present, will also register a small but insignificant influence on the solids content.

According to the **SSMO (2007),** a good quality concentrated fruit drink should has total soluble solids, pH and Titrable acidity , between 50-55%, 2.0 -5.0 and 0.5-0.8%, respectively.

Fruit concentrated drinks have a low PH because they are comparatively rich in organic acid . The overall range of PH is 2 to 5 for common fruits with most frequent figures being between 3 and 4 PH . There are several chemical preservatives standards agencies to find the maximum permitted levels **(Tasnim, *et.al* , 2010).**

2.3.1.9 Storage stability

Most mechanical juicers use centrifugal force to separate the juice and residue (pulp) automatically. During the process, contamination from raw materials, equipment or food handlers could be easily transferred to the final product. If pathogens such as *Salmonella* were present in freshly squeezed juices, individuals may be exposed to health hazards **(Bates, *et.al*, 2010).**

The preservation of the juice was carried out using sugar, benzoic acid, citric and a combination of citric and benzoic acid under room temperature. The result revealed that the juice maintained its colour, aroma and taste for at least one month

when 30% benzoic acid was used as preservative. This happens to be the best among all. The juice under other preservation like 4% sugar went bad after three days, while that of 4% citric acid maintained its qualities for one week and some days, but after that the aroma started to fade **(Tasnim, *et.al*, 2005)**.

The combination of 3% benzoic acid and 4% citric acid maintained the qualities of the juice fairly between two to three weeks, also altered the pH so that it is impossible for pathogens to exist at such a low pH environment **(Azam, 2008).**

The most frequent reason for quality deterioration of a food product is the result of the microbial activity such as food moulding , fermenting and changing in acidity (**Abbo, *et.al*, 2006).** Therefore, there is an industry need for new technologies to process fruit juices that further conserve the nutritive value and freshness, and other sensory properties of juices without compromising food safety **(Tasnim *et.al* , 2007).**

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 reaction and to enhance the inherent quality of the starting fruit **(Bates, *et.al*,2010**).

3. MATERIALS AND METHODS

3.1 Materials

Laloub fruits (*Balanites aegyptica)* were obtained from Al-obied market, Kordofan State in March, 2016. The sample was tightly kept in polyethylene bags and stored at room temperature until needed for the different investigations.

3.2 Methods

3.2.1 Chemical methods

3.2.1.1 Moisture content

The moisture content of the fruit pulp or flesh was determined following the standard method described by the Association of Official Analytical Chemists **(AOAC, 2008).**

Principle: The moisture content in a weighed sample is removed by heating the sample in an oven (under atmospheric pressure) at 105 $^{\circ}$C. Then, the difference in weight before and after drying is calculated as a percentage from the initial weight.

Procedure: A sample of 5 gm ±1 mg of finely ground and well mixed sample was weighted accurately in cleaned and dried Petri dishes using a sensitive(No.AR2140, OHAC,s CORO.USA).Then, the sample was placed in an oven (Carblite, Sheffield, England) at 105 $^{\circ}$C until a constant weight was obtained .Then, the moisture content (M.C) as Per-cent was calculated as loss in weight after drying .

Calculation:

$$\text{Moisture content (\%)} = \frac{(W1 - W_2)}{\text{Sample weight (g)}} \times 100\%$$

[eq.1]

Where:

W1 = weight of sample before drying.

W_2 = weight of sample after drying.

3.2.1.2 Crude protein content

The protein content was determined in all samples by micro-Kjeldahl method using a copper sulphate-sodium sulphate catalyst according to the official method of the **AOAC (2003).**

Principle: The method consists of sample oxidation and conversion of its nitrogen to ammonia which reacts with the excess amount of sulphuric acid forming ammonium sulphate. After that, the solution was made alkaline and the ammonia was distilled into a standard solution of boric acid (2%) to form the ammonia-boric acid complex which is titrated against a standard solution of HC1 (0.1N). The protein content is calculated by multiplying the total N % by 6.25 as a conversion factor for protein.

Procedure: A sample of two grams was accurately weighed and transferred together with 4g $NaSo_4$ of Kjeldahl catalysts (No. 0665, Scharlauchemie, Spain) and 25 m1 of concentrated sulphuric acid (No.0548111, HDWIC, India) into a Kjeldahl digestion flask. After that, the flask was placed into a Kjeldahl digestion unit (No.4071477, type KI 26, Gerhardt, Germany) for about 2 hours until a colourless digest was obtained and the flask was left to cool to room temperature.

The distillation of ammonia was carried out into 25m1 boric acid (2%) by using 20 ml sodium hydroxide solution (45%). Finally, the distillate was titrated

with standard solution of HC1 (0.1N) in the presence of 2-3 drops of bromocreasol green and methyl red as an indicator until a brown reddish colour was observed.

Calculation:

$$\text{Crude Protein (\%)} = \frac{(\text{ml HCl sample} - \text{ml HCl blank}) \times N \times 14.00 \times F}{\text{Sample weight (gm)} \times 1000} \times 100\%$$

[eq.2]

Where:

N: normality of HCl.

F: protein conversion factor = 6.25

3.2.1.3 Fat content

Fat content was determined according to the official method of AOAC (2008). Five grams were weighed into an extraction thimble and covered with cotton that previously extracted with hexane (No.9-1.6-24/25-29-51, LOBA Cheme, India). Then, the sample and a pre-dried and weighed extraction flask containing about 100 ml hexane were attached to the extraction unit (Electrothermal, England) and the extraction process was conducted for 16 hr. At the end of the extraction period, the flask was disconnected from the unit and the solvent was redistilled. Later, the flask with the remaining crude ether extract was put in an oven at 105 °C. for 3 hr, cooled to room temperature in a desiccator, reweighed and the dried extract was registered as fat content according to the following formula;

Calculation:

$$\text{Fat content (\%)} = \frac{(W_2 - W_1)}{W_3} \times 100\ \%$$

[eq.3]

Where:

W_2 =Weight of the flask and ether extract

W_1 =Weight of the empty flask.

W_3=initial weight of the sample.

3.2.1.4 Total carbohydrates

The total carbohydrates content of the sample was calculated by subtracting the total sum of moisture, fat, crude protein and ash as Per-cent from difference 100% as described by **West, *et. al*. (1988).**

%Total carbohydrates = 100% - (Moisture% + Protein% + Fat% + Ash%).

[eq.4]

3.2.1.5 Crude fibre content

The crude fibre content in the different sample was determined according to the offitial method of the **AOAC (2008).** Two grams of a defatted sample was placed into a conical flask containing 20m1 of H2SO4 (0.26 N). The flask was then fitted to a condenser and allowed to boil for 30 minutes. At the end of the digestion period, the flask was removed and the digest was filtered (under vacuum) through a porcelain filter crucible (No.3). After that, the precipitate was repeatedly rinsed with distilled boiled water followed by boiling in 20 ml NaOH (0.23 N) solution for 30 min under reflux condenser and the precipitate was filtered, rinsed with hot distilled water, 20m1 ethyl alcohol (96%) and 20 ml diethyl ether.

Finally, the crucible was dried at 105 °C (over night) to a constant weight, cooled (in a desiccator), weighed, ashed in a Muffle .furnace (No.20. 301870, Carbolite, England) at 550-600 °C until a constant weight was obtained and the difference in weight was considered as crude fiber.

Calculation:

$$\text{Crude fiber (\%)} = \frac{(W_1 - W_2)}{\text{Sample weight (gm)}} \times 100\%$$

[eq.5]

Where:

W_1 = weight of sample before ignition (gm).

W_2 = weight of sample after ignition (gm).

3.2.1.6 Ash content

The ash content was determined according to the method described by the **AOAC (2008).**

Principle: The inorganic materials which are varying in concentration and composition are customary determined as a residue after being ignited at a specified heat degree.

Procedure: A sample of 5g ±1 mg was weighed into a pre-heated, cooled, weighed and tarred porcelain crucible and placed into a Muffle furnace (No.20. 301870, Carbolite, England) at 600 $^{\circ}$C until a white gray ash was obtained. The crucible was transferred to a desiccator, allowed to cool to room temperature and weighed. After that, the ash content was calculated as a percentage based on the initial weight of the sample.

Calculation:

$$\text{Ash content (\%)} = \frac{[(W1) - (W2)]}{\text{sample weight(g)}} \times 100\ \%$$

[eq.6]

Where ;

W1 = weight of crucible with the remaining ashed sample (g).

W2 = weight of empty crucible (g).

3.2.1.7 Minerals content

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 diluted to 100 ml in a volumetric flask and filtered. 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 parratt (1961).**

3.2.2 Physico-chemical methods

3.2.2.1 Total soluble solids

The total soluble solids as percent (T.S.S %) in the different samples were measured as described by **Ranganna (2001)**.

Principle: The index of refraction of a substance 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 the sample solution.

Procedure: After the adjustment of the Hand-Refractometer (No.002603, BS-eclipse, UK) with distilled water, the sample was placed on the surface of the refractometer prism, the prism was closed and the reading was recorded to the nearest 0.01 as T.S.S %.

3.2.2.2 Hydrogen ions concentration

The Hydrogen ions concentration (pH) of the different samples was determined as described by **Ranganna (2001).**

Principle: The pH value of the different samples was measured with a pH-meter. After standardization of the pH-meter electrodes with buffer solutions, the reading of the sample is recorded as pH value.

Procedure: After standardization of the pH-meter (N0.478530, Hanna, India) with buffer solutions (pH 4.01 and 7.01), the electrode of the pH-meter was rinsed with distilled water, immersed in the sample and left to stand until a staple reading was achieved. All the readings were expressed as pH to the nearest 0.01-pH units.

3.2.2.3 Titrable acidity

The titrable acidity of laloub sample was determined according to **Ranganna(1979).**

procedure

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

Titrable acidity % =

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

[eq.7]

3.2.3 Experimental processing methods

3.2.3.1 Laloub juice extraction method

The laloub fruits pulp was extracted as described by **Al-saed (2011).** In this method, a sample of cleaned laloub fruits (100 gm) was soaked overnight (16 hours) at room temperature in distilled water at different fruit: water ratio (1:1, 1:2, 1:3, 1:4, 1:5). Then, the mixtures were stirred by using a magnetic stirrer (No.505010E, Gallen hamp, England) for 5 min, immediately filtered with a coarse silk sieve, and weighed. After that, the filtrates were checked for their pH, total soluble solids (T.S.S), volume, weight and the yield (%) of each extract was calculated, as follows:

Calculation:

$$\text{Yield [\%]} = \frac{[\text{Weight of extract (gm)} \times \text{T.S.S \%}]}{\text{Initial weight of sample (gm)}} \times 100\%$$

[eq.8]

3.2.3.2 Processing of laloub fruits concentrated drink

After cleaning and washing of decorticated laloub fruits (3 Kg), the fruits were soaked in tap water (12 L) overnight (16 hr). After that, the mixture was blended for 5 min with an electric mixer and filtred. Then the pH and the total soluble solids of laloub extract were detected and the required amounts of citric acid, sodium benzoate and sugar were calculated according to the methods adopted by **Al- Saed (2011).** After that, laloub extract (9 kg) with the proper amount of sugar (6.5 kg) were placed in an open kettle and, the mixture was pre-cooked until the total soluble solids reached (45 Brix°). Then, citric acid (31 gm) and sodium benzoate (5gm) as solutions were immediately added with continuous stirring. Finally, laloub fruit concentrated drink was hot filled in dried plastic jars, tightly closed, cooled at room temperature and stored until needed for chemical, physico-

chemical and organoleptic evaluations. Laloub concentrated drink recipe and its processing method are shown in Table (3) Fig (1).

3.2.4 Sensory evaluation method

Laloub juice products were sensory evaluated as described by **Ranganna (2001).** In this method, 20 trained panelists from the Food Science and Technology Dept, College of Agricultural Studies, Sudan University of Science and Technology, were asked to evaluate the products with regard to their colour, flavour, taste, consistency and overall quality using the following quality scales :

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

3.2.5 Statistical analysis method

The results were subjected to Statistical Analysis System (SAS) by using One-Factor Analysis of Variance (ANOVA). The Mean values were also tested and separated by using Duncan's Multiple Range Test (DMRT) as described by **Steel, *et. a1*. (1997).**

Table (3): Recipe of laloub fruits concentrated drink

Ingredients	Kg
Weight of raw material	03.00
Water Volume	12.00
Weight of Laloub extract	09.00
Sugar	06.50
Citric acid	0.031
Sodium benzoate	0 .005

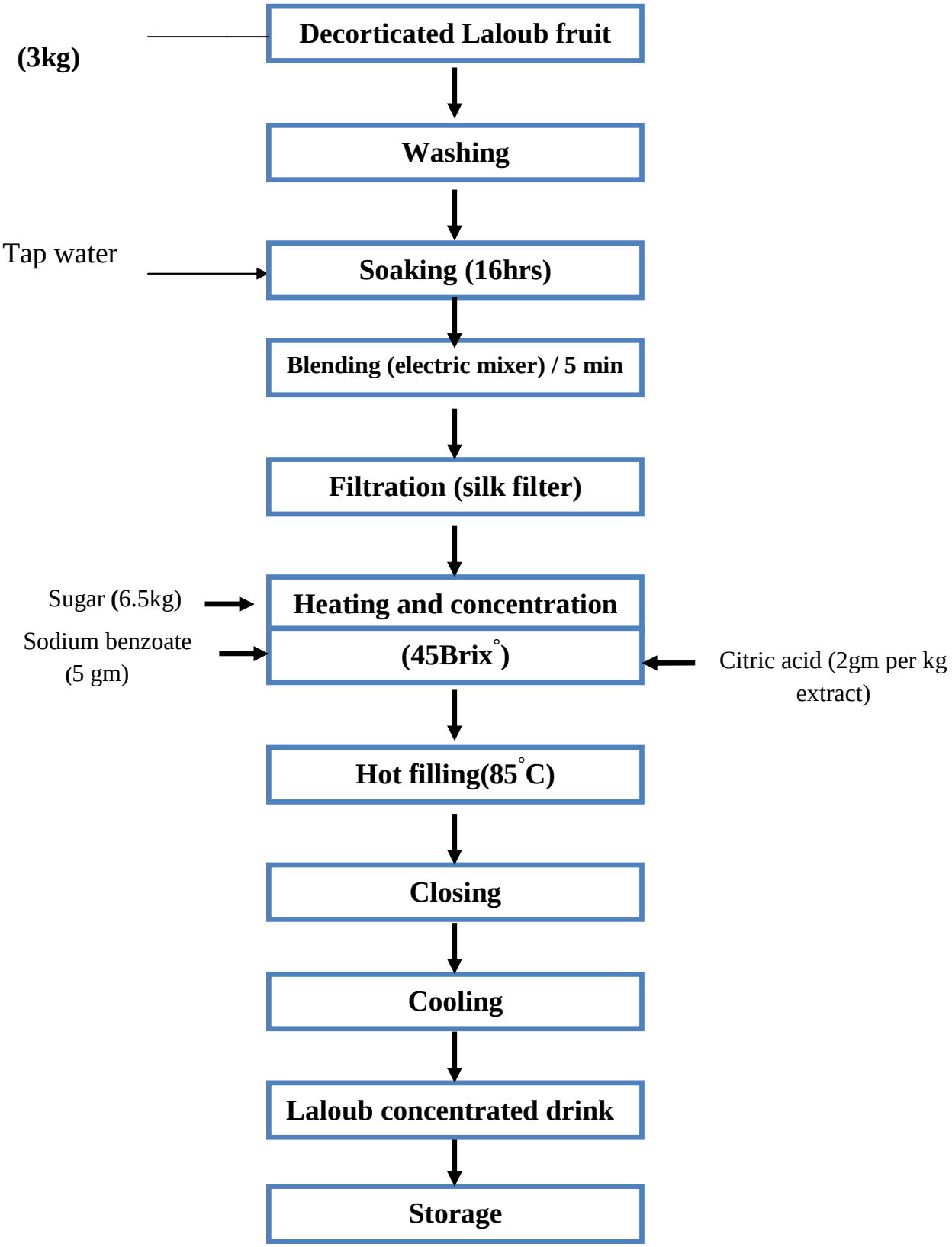

Fig. (1): Processing method of laloub concentrated drink

4. RESULTS AND DISCUSSION

4.1 Nutritional value of Laloub fruits

4.1.1 Chemical composition

The chemical composition of Laloub fruits pulp on wet basis is shown Table (4). The fruits pulp was found to more high percentages of total carbohydrates (63.82%), available carbohydrates (60.38%) and moisture (27.72%), with low percentages of crude protein (5.66%), crude fiber (3.44%), ash (1.65%), and fat (1.15%), on wet basis. The results obtained in this study are well agree with those reported by **Booth and Wickes (1988**) and **NRC (2008).**

4.1.2 Minerals content

Table (5) shows the minerals content of Laloub fruits pulp on wet basis as mg/100g. From the results, the fruits pulp was found to contain high levels of sodium (146.27 mg), calcium (88.04mg) magnesium (49.26mg), iron (7.53 mg), The results obtained in this study are in a good agreement with those reported earlier by **Booth and Wickes (1988**), **Abdulrazak (2010) and El- Saed (2011).**

4.2 Processing of Laloub fruits concentrated drink

Laloub fruits extract was prepared according to the method of **El-Saed(2011).** In this method the cleaned Laloub fruits (3 kg) were soaked in tap water (12 L) for (16 hr) at room temperature. After that, the mixture was blended for 5 min and filtered. The recipe and the processing method used for production of laloub concentrated drinks are shown in Table (3) and fig (1), respectively.

Table (4): Chemical composition (%) of Laloub fruits pulp

Chemical composition	% On wet basis
	[n = 3 ± SD]
Moisture	27.72 ± 1.10
Protein	05.66 ± 0.24
Fat	01.15 ± 0.24
Total carbohydrates	63.82 ± 0.18
Crude fiber	03.44 ± 0.17
Available carbohydrates	60.38 ± 0.14
Ash	01.65 ± 0.17

SD ≡ Standard deviation.
n ≡ Number of independent determinations.

Table (5): Minerals content of Laloub fruits pulp

Minerals content		**On wet basis (mg/100g)**
		[n= 3± SD]
Sodium	[Na]	146.27 ± 0.00
Calcium	[Ca]	88.04 ± 0.00
Magnesium	[Mg]	49.26 ± 0.00
Iron	[Fe]	07.26 ± 0.00
Zink	[Zn]	04.09 ± 0.20

SD ≡ Standard deviation.

n ≡ Number of independent determinations.

While, Table (6) presents the physico-chemical characteristics of Laloub fruit extract that used for production of Laloub concentrated drink.

4.3 Quality evaluation of Laloub concentrated drink

4.3.1 Physico-chemical characteristics of the end product

The physic - chemical characteristics of Laloub Juice are indicated in Table (7). From the results obtained in this study, the product was found to meet the recommended levels of total soluble solids (49%), hydrogen ions concentration (3.70) and titrable acidity (7.2 %) as reported by the **CODEX (2005) and SSMO (2007)**.

4.3.2 Organoleptic evaluation

The organoleptic evaluation of Laloub concentrated drink is diluted Juice was carried out by using trained panelists from the Food Science and Technology Dept., College of Agricultural Studies, Sudan University of Science and Technology. Laloub Juice products with or without flavour were sensory evaluated as described by **Ranganna (2001).**

Table (8) shows the recorded scores by the panelists for the different Laloub Juice samples with respect to their colour, taste, flavour, consistency and overall quality. In general, both Laloub Juices that produced with or without flavour were highly accepted by the panelists. But, significan differences were found between the two products with respect to their colour, consistency and overall quality. However, Laloub Juice that produced with pineapple flavour was highly preferred by the panelists in comparison with that produced without any flavour.

Table (6): Physico-chemical characteristics of Laloub fruits extract

Parameter	Laloub fruits extract
Total soluble solids (T.S.S %)	05.00 %
Hydrogen ions concentration (pH)	04.71%
Titreable acidity	0.32%

Table (7): Physico-chemical properties of concentrated Laloub drink

Properties	On wet basis [n = 3 ± SD]
Total soluble solids (T.S.S %)	49.00 ± 2.67
Hydrogen Ion concentration (pH)	03.70 ± 0.15
Titreable acidity (%)	0.47± 0.08

SD ≡ Standard deviation.

n ≡ Number of independent determinations

Table (8): Organoleptic evaluation of Laloub Juice products

Quality Characteristics	Quality characteristics			
	Colour	**Taste**	**Flavour**	**Overall quality**
	(n = 20 ± SD)			
A	2.67 [a] ± 1 .02	3.09 [a] ± 1.22	2.91 [a] ± 0.83	2.62 [a] ± 1.02
B	2.52 [a] ± 0.93	2.43 [b] ± 0.98	2.14 [b] ± 0.79	2.3 8 [a] ± 1.02
$Lsd_{0.05}$	0.163 [ns]	0.759**	0.482*	0.271[ns]
SE±	0.054	0.253	0.161	0.093

Scale: 1 = excellent, 2 = very good, 3 = good, 4 = acceptable, 5 = unacceptable
A ≡ Laloub Juice without flavour.
B ≡ Laloub Juice with pineapple flavour .
SD ≡ Standard deviation.
Mean ± S.D value (s) bearing different superscript letter(s) within columns are significantly different (P≤0.05).
* ≡ Significant at (P≤0.05).
n.s ≡ Not significant.
$Lsd_{0.05}$ ≡ Least significant difference at (P≤0.05).
SE± ≡ Overall experimental error.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the results obtained in this study it can be concluded that Laloub fruits are found with high nutritional value and suitable for production of concentrated drink and with acceptable organoleptic characteristics.

5.2 Recommendations

1. The industrial utilization of Laloub fruits in production of concentrated drink in Sudan should be encouraged.
2. Utilization of Laloub fruit in Juice production will make the product very cheap and affordable especially for low income groups in Sudan.
3. The product could be used for reducing the high incidences of minerals deficiency and energy- malnutrition among pre-school children and pregnant womens specially in the rural areas, in Sudan.
4. Comprehensive survey for the different Laloub fruits production zones should be conducted to estimated the actual total production and productivity of the fruits in Sudan.
5. Additional studies are definitely needed to ensure safety, storage stability, economic feasibility and market demands for the product.

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Plate (1): Laloub fruits with peels

Plate (2): Laloub fruits without peels

Plate (3): Laloub fruit concentrated drink

Plate (4): Laloub fruits juice