1. INTRODUCTION

The long living Haraz tree (*Faidherbia albida)*isa key player in traditional agroforestry systems at theinterface between rainfed agriculture and pastoralismin the arid and semi-arid regions of Africa **(Depommier, 2003; Faye,*et. al.*, 2009).**The treeis widely spread in semi-arid tropical Africa intothe Middle East and Arabian countries, from 270 m below sealevel in Palestine up to 2500 m above sea level in JebelMarra in Sudan and it can live for 70-90 years with some individual trees being reported as old as 150 years **(Wickens, 2009; Joker, 2000).**

Haraz treeis particularly valued in agroforestryon account of its unusual habit of shedding its leavesduring the cropping season and regrowing them duringthe long dry season **(Payne, 2000; Ibrahim and Tibin, 2003).** It is therefore utilizedfor increasing soil fertility, water holding capacity anddrainage. This is crucial for plants since it resu1ts in nocompetition for water and nutrients between trees andcrops during the rainy season **(Gassama-Dia,*et. al.*,2003).**

The tree hastwo major functions on a farm, i.e., the provision oftree products such as fodder, fruits, pods and medicineand the tree services like shade, wind breaking and mulching**(Bonkoungou, 2001; Elsiddig, 2003; Leakey,*et. al.*, 2005).**

Therefore, Haraz tree *(F. albida)* is widely used and is welldocumented for increasing the yields ofcrops grown beneath it. The gum thatspontaneously exudes from the trunk issometimes collected like gum arabic, but itdoes not have the same properties. Thetimber, although straight-grained, denseand weighty, is soft and fibrous. It is usedfor building animal enclosures, huts anddug-out canoes, as well as for makingmany household objects and tools. InNigeria, the bark is pounded and used

as apacking material for goods carried on packanimals. The wood ash is used in soapmakingand as a tanning agent for hides (**Bernard, 2002)**.Also, the bark, fruits,leaves and root decoctions of *F. albida,*alone or mixed with other substances, are frequentingredients of African traditional medicinal preparations for external or internal application**(Tijani,*et. al.*, 2008).**

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

Objectives

This research programme has been designed to achieve the followingobjectives:

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

2. LITREATURE REVIEW

2.1 Haraz Tree (*Faidherbiaalbida)*

2.1.1 Botanical classification and nomenclature

Botanically, Haraz tree is named as *Faidherbia albida* (Delile) A. Chev.and belongs to a largefamily of floweringplants*Fabaceae* which is commonly known as legume or bean family(*Leguminosae*) as reported by **(Tutu, 2002;Mokgoldi,2011).**Moreover, the tree is belong to the genus *Faidherbia* in *Mimosoideae* sub-family of the family *Fabaceae* and kingdom *Plantae***(African Plant Database, 2013).**

In fact, the family *Fabaceae* contains 236 generaand over 3777 species with three subfamilies: *Caesalpinioideae, Faboideae* and *Mimosoideae*(**USDA, 2010)**.Synonymsfor *F. albida* incorporate *Acacia gyrocarpa* Hochst.ex A. Rich., *Acacia saccharata* Benth. and *Acacia albida*Del. **(Joker, 2000).**Also, the tree has different names in the different languages and countries; In Arabic it is known as "Haraz" or "Khoraim", while in English it is known as “Apple ring Acacia”, “Ana tree”, “Winter thorn” and “White thorn”, but in French it is known as “Arbre blane” **(Tutu, 2002; Moser, 2006**and**Gibreel, 2008).**

2.1.2 Description

In Sudan, the tree is a large thorny tree (4 - 30 meter high) with one main stem or sometimes it is shrub–like buttressed. The crown is ranging between rounded to irregularly spreading branches in the open areas. The trank usually single with diameters often up to 2 m. The Bark is dark brown or dull grey, rough, deeply and scaly in mature trees, smooth in young trees and fissured when old. The young

branches are distinctive white in zigzag pattern, while the branchlets are light grey, spiny only at nodes, spines, straight and brown in colour with white base. The Leaves are shed at start of rainy season (Diagnostic feature) and bipinnate, (2 - 12 pairs of pinnae) with a single conspicuous gland on the rachis, gland on the rachis to oval, yellow or reddish – brown to black, while the leaflets are grey - green, oblong (up to 1 cm long), hairy and unequal at base **(Tutu, 2002, Oluwakany- Insola,*et. al*., 2010**and**Hyde and Wursten, 2010).**

The Inflorescence spicate produced singly between paired spines or in a leaf axil on current season's growth, spike (3 - 16 cm long), on peduncles (0.8 - 6.3 cm long), terete and olive – green **(Barnes and Fagg, 2003).** The flowers are arranged in slender, creamy white spikes(4 - 14 cm long). Calyx (1 - 17 mm long)glabrous to pubescent with 5 sepals. Corolla (3 - 3.5 mm long) with 5 free petals. Fruit is an unusual pod, bright orange to reddish-brown, thick, indehiscent, characteristically and conspicuously curled and twisted; large, up to 25 × 5 cm. Each pod contain 10-29 dark brown, ovoid, with shiny seeds, each measuring 10 × 6.0 mm and separated by thin septum. The seed coat is tough, leathery and water proof. There are 7,000 - 20,000 seeds/kg, the seeds are smaller in West Africa than those from the East and South Africa **(Tutu, 2002).** Thewood is light; sapwood streaky grey whitewhile, the heartwood is yellow **(Barnes and Fagg, 2003)**.

2.1.3 Distribution

According to the literature, Haraz tree (*F. albida)* isoriginated in the Saharaprior to its desertification. Also, it has been mentioned that, the treewas originally a riverine tree of eastern and southernAfrica which was introduced into West Africa through pastoralismand agriculture **(Bernard, 2002**and **Moser, 2006).** *F. albida*is widely

spread in semi-arid tropical Africa intothe Middle East and Arabia, from 270 m below sealevel in Palestine up to 2500 m above sea level in JebelMarra, Sudan **(Joker, 2000).**

Haraz tree is widespread throughout tropical Africa, from Egypt, Senegal and Gambia south to the Transvaal and Natal, Syria, Palestine, India**,** Pakistan,Nepal and Peru**(Joker, 2000; Tijani *et al.*, 2008**and**Oluwakanyinsola,*et. al*., 2010).**In Sudan, Haraz tree is distributed through the different vegetation zones from Semi-desert region to the Savannah and mountainous area. Also, the species occur along the Nile River and its tributaries, Strom banks, Valleys and on hilly slopes on the Blue Nile State, South Kordofan, Northern State and Khartoum State **(Harrison and Jackson, 1958; El-Amin, 1990).**

2.1.4 Phenology

Haraz treeis an unusual tree in the African arborescent flora as it sheds its leaves at the start of the rainy season, while, the flowering of individual tree is often not uniform**(Tutu, 2002).**The mature*F. albida* usually spread its branches and a rough, darkbrown or greenish-grey bark that is often 1ight greyand smooth when young **(Oluwakanyinso1a,*et. al.*, 2010).**In contrast to all other native"acacias", *F. albida* has a pecu1iar inverse pheno1ogy, an unusua1 habit of retaining its 1eaves during thedry season and dropping them during the rains **(Tijani,*et. al*., 2008** and **Hyde and Wursten, 2010).**In addition to this reverse pheno1ogy, *F. albida* isdistinguished by its whitish twigs and paired straightthorns**(Tutu, 2002).**These reddish-brown with whitetip thorns are found at the base of the 1eaves and areabout 3 cm long and thickened at their base **(Palgrave, 2002).**

According to **Hyde and Wursten (2010)**, the flowering period of *F. albida* is between May and September, In Sudan, the flowering occurs from November to January and fruiting from December to April. However, not all *F. albida* trees flower every year but in certain areas the flowering may occur twice a year **(Joker, 2000).** The indehiscent pods of*F. albida* contain up to 30 dark brown seeds and are often curled and twisted in shape. The seeds are 10— 12 mm 1ong and can remain viab1e for many years **(Joker, 2000** and**Moser, 2006).** The 1eaves are bi-pinnate, blue-green with 3 to 12 pairs of pinnae, carrying 6 to 23 pairs of 1eaflets that are up to 12 mm long and 5 mm wide and part1y overlapping **(Moser, 2006; Tijani,*et. al.*, 2008; Oluwakanyinsola,*et. al.*, 2010).**

The seeds are often dispersed by animals after eating the pods. The tree has an inverted phenology thus, deciduous in the wet season and foliated in the dry season **(Tutu, 2002).**

2.1.5 Biophysical limits

F. albida grows in a wide range of ecological conditions in Africa, but, itprefers sites that associated with water such as besides rivers, at the edges of lakes and ponds with alluvia1 deep sandy soils **(Pa1grave, 2002; Moser, 2006).** The tree has strong and fast growing tap roots that can reach aquifers of up to 80 m below the surface to secure permanent water avai1ability **(Tijani,*et. al.*, 2008).**

The species can grow vigorously in altitude ranging from 270-2700 m with mean annual rainfalls between 250-1000 mm per year and mean temperatures degree between 18-30°C. The Soil type should be coarse-textured with well-drained alluvial soils. Moreover, the tree is tolerates seasonal water logging and salinity but cannot

withstand in heavy clayey soils **(Maydell, 2001).**Therefore, the occurrence of the tree isgenerally limited to watercourses where groundwater is present or to wadis where there is residual water in the alluvium following flooding and drying out **(Barnes and Fagg, 2003)**.

2.1.6 Harvesting

The pods are ripe when their colours are changed from green to yellow and they should be collected as soon as possible to avoid insect infestation. The harvesting is done by shaking the tree and catching the pods in a tarpaulin. The collection from the ground should be avoided **(Joker, 2000**and**Barnes and Fagg, 2003)**.

2.1.7 Processing and handling

After harvesting, the pods are left to dry in the sun before they are packed in bags. Seed extraction is best done with a flailing tresher, also, pistle and morter can be used. One kg of pods yields about 5.9 litre of seeds. After extraction the seed is dried in sun and then cleaned **(Joker, 2000**and**Barnes and Fagg, 2003)**.

2.1.8 Storage and viability

Seed infestation by insects is a great problem but, only a minor one if the seeds are packed with CO_2 and stored at low temperatures **(Joker, 2000, Barnes and Fagg, 2003**and**Omondi,*et. al*,2004)**.

2.1.9 Propagation and management

Propagation of this species bydirect seedling is notrecommended because of weed problems. However,sowingand in some times from root suckers can be done

(Marunda , 2002). The species produced about 8000 – 10000 seeds per Kilogram. The seeds require treatments pre-germination as natural regeneration is relatively slow in the dry areas **(Gibreel, 2008)**.

The seed has physical dormancy, therefore, the seed must be removed from the pods immediately since it could be invaded by larvae of Bruchid beetles. After long storage period prior to sowing, seeds should either be boiled for 7-15 minutes and then cooled slowly or should be soaked in boiling water for 24 hours. A solution of 66 % sulphuric acid can also be poured on the seeds, left for 4-5 minutes and then be rinsed off with water. These treatments give 40-60 % germination in 6-30 days. After germination, seedlings of *Faiherbia albida* will only survive if there is adequate moisture and if they are relatively free of competition **(Barnes and Fugg, 2003**and**Marunda , 2002).**When treated with insecticides and kept in simple closed containers, seeds can be stored for several years**(Omondi,*et. al*,2004).**

Mechanical scarification is reported to yield 95 % germination within 8 days of sowing. Promising new vegetative propagation methods include cuttings, grafting and multiplication by root fragments **(Marunda, 2002).**Regular lopping (once every 3-4 years) removing 0.4-0.5m^3 of foliage (or 35% of the total volume) at the start of the growing season is recommended. However, improper methods of lopping have been observed to cause wounds, predisposing the tree to attack by pathogens. The tree responds well to coppicing **(Mayde11,2001).**

2.1.10 Pests and diseases

Very few fungal pests have been reported on *Faidherbia albida* **(Barnes and Fugg, 2003).** *Ficusthoningii*, grows as an epiphyte and kills its host by strangulationand

Taphinanthus dodoneifolius are epiphytes that kill the plant through strangulation. Nematodes and insectsuch as *Meloidogyne javanica*and *M. icognita*. For example, bruchid beetles candestroy about 50% of *F. albida* seeds, *Kraussiana angulifera* and *Tylotropidius gracilipes* (Orthopetra), also they attack young plant, while, *Crypsotidia*, *C. mesonema* and *C. wollastoni* (Lepiodoptera) attack the leaves **(Maydell, 2001).** Caterpillars of the moth *Crypsotidia conifera* can defoliate mature trees by almost 50% **(Bernard, 2002).**

Also,the larger herbivores can do extensive damage to the trees, if the young tree is exposed to browsing from animals such as elephants, buffalo, impala, waterbuck, kudu and eland **(Barnes and Fagg, 2003).** Wood of mature trees is durable but sometimes is susceptible to attack by termites and borers **(Orwa, 2009)**.

2.1.11 Utilization of Haraz Tree

2.1.11.1 As Food

The seeds of *Faidherbia albida* are reported to be eatenas famine food by humans in Ghana, Nambia, Zambia and Zimbabwe **(Palmer and Pitman, 2002** and **Pardy, 2004).** The pods are crushed and the seeds will be separated from the chaff in winnowing baskets. After that, the seeds are boiled in water, drained and the seeds coat removed, boiled again for several hours with wood ash and washed with fresh water. This process is repeated several times and finally the seeds are boiled again without ash, salt may be added. The seeds can be also pounded and baked into cakes or mixed with maize meal. Furthermore, in the dry season or in times of famine, people eat the seeds and pods (cooked or raw). The pods may be also used

asflavouring agent or as condiment**(Marunda, 2002**and**Maundu and Tengnas , 2005).**

2.1.11.2 As fodders and apiculture

As mentioned by **Bernard (2002)**, the branches of Haraz tree (*F. albida*) are usually as fodder. In the aridand semi-arid regions of sub-Saharan West Africa,for instance, seasonal variations in the availability and quality of pastures affect livestock production**(Castillo-Caamal,*et. al.*, 2003).** Duringthe dry season, high quality supplementary feedsare often required to meet the nutritional requirements ofanimals. Unfortunately, most smallscale farmers areoften unable to afford the expensive supplementaryfeeds **(Matenga,*et. al.*, 2003; Hassan,*et. al.*, 2007).**Therefore, Haraz tree**(***F.albida)***is found as a valuable alternative and provides freenutritious fodder particularly during dry periods **(Gassama-Dia,*et. al.*, 2003).**

During periods of feedscarcity, *F. albida* provides abundant pods and greenfodder for nourishing animals **(Ibrahim and Tibin, 2003).**According to **Shiawoya and Adeyemi (2003)**, the protein content of *F. albida*is adequate tomeet the maintenance requirement of small ruminants(8.90%) and the average requirements (9.70%) fornursing cows. The branches are also prunedmore or less intensely by herdsmen for use as fodder**(Bernard, 2002).**

2.1.11.3 As fuel

The wood of Haraz tree(*Faidherbia albida)*suffers from being subject to insect and fungal attack. Pinhole borers and termites are mentioned among the most prevalent causes of damage and fungi cause discolouration as well as rot when the timber is green. However, the practice of soaking in water by submergence for several months

prior to use to remove the sap is an effective treatment for improving durability**.** The wood is said to be easily preserved and combustible with a calorific value of 4720 kcal kg-1 or 19740 kJ kg- 1 and easily carbonized with yields of 17%**. (Anon, 2000** and**Le Houérou, 2005).**

2.1.11.4 As traditional medicine

Anon(2000) and **Irvine (2003)** stated that, *F. albida* is used as a remedy forliver complaints, wounds, ulcers, psychological disorders, post-partum complications, opthalmia, ear-ache and deafness, colds and gripe**.** Also**,** it is used as a treatment for dysentery, inflamed eyes, skininfections,hemorrhage, rheumatism, pneumonia andvomiting **(Bernard, 2002; Moser, 2006; Kubmarawa,*et. al*., 2007; Tijani,*et. al*., 2009).**

As reported by **Irvine (2003)**, the root-bark of Haraz tree is used for leprosy and as a liniment for pneumonia, and a bark infusion is used as a febrifuge for coughs and to assist in difficult childbirth. In Ethiopia, the bark of*F. albida* is crushed, homogenized in water and takenorally to treat diarrhea **(Wondimu*, et. al*., 2007).**

Several studies have been carried out in order to determinethe basis for the use of *F. albida* in traditionalmedicine. The stem barkethanolic extracts was found to inhibitgrowth of Staphylococcus *aureus* and *Bacillus subtilis*bacteria **(Kubmarawa,*et. al*., 2007).**In Ivory Coast, the leaves of Haraz tree are mixed with salt and orally administered asa traditional veterinary medicine for anaemia (**Koné and Atindehou, 2008)**.

Bark, fruit, leaves and root decoctions of Haraz tree (*F. albida),*alone or mixed with other substances, are frequentingredients in African traditional medicinal

preparations for external or internal applications. The bark decoction is often used to cleanse new wounds whichhas an action parallel to that of potassium permanganatein the treatment of kidney pains and can also bemixed with other drugs for mental illness **(Tijani,*et. al.*, 2008).**

According to**Tijani,*et. al.*(2009)**, the hydro-alcoholicextract of the stem bark of *F. albida*treehas trypanostatic and anti-haemolytic etfects in albino ratsinfected with *Trypanosoma brucei***.** Bark and root preparations are also said to have antifebrile (anti-malarial) properties. They are used as an emetic for fever by the Masai, for cough and to assist in child birth and are used as poison to stupefy fish in Malawi**.** Furthermore, the bark isused in dental hygiene; strips are used as dental flossin Namibia while, the bark extract is applied in toothachetreatment **(Oluwakanyinsola,*et. al.*, 2010).**

2.1.11.5 As shade and reclamation

Faidherbia albida is maintained and protected on farms to shade coffee trees and to provide shade for livestock in the dry season **(Maundu and Tengnas, 2005)**.

2.1.11.6As improver or land fertility

Haraz tree(*F. albida)*was considerable a vital component of indigenousfarming systems due to its ability to improve soil fertilityand its conservation**.**Also, the tree was found to contributeto soil moisture preservationthrough the increament in soil organic matter, improving soil structure, enhancing soil microfauna populationsand minimizing excessive evapo-transpiration andsoil temperature **(Dangasuk *et al.*, 2001).**

According to**Maundu and Tengnas(2005),** Haraz tree increases water infiltration, has a beneficial effect on soil bulk density, structural stability and chemical and biochemical properties**.**Also, it was found to improve the nutrients status of the soils for the new seasons.

Moreover, due to the unusual phenology of *F. albida*,animals often gather and rest under it duringthe dry season and leave a lot of dung. Consequently,residues of cereal crops, pod and leaf fall, togetherwith the dung and urine of cattle that seek the shadeof these trees, improve the nutrient status and organiccontent of soil near established trees and therefore, the yieldsof agricultural crops are considerably increased **(Brouwer, 2008).**

2.1.11.7 As ornamental

Haraz tree (*Faidherbia albida)* is considerable as a useful ornamental tree for gardens and avenues. It uses as boundary, barrier, support and lopping of branches is common in many areas lopped for fencing compounds and livestock **(Maundu and Tengnas, 2005).**

2.1.11.8 Other uses

The tree bole is widely used for the construction of dugout canoes, boats and paddles and the sawn planks for furniture. While, the branches are used for huts, granaries and sheds **(Anon, 2000).**

Haraz gum thatspontaneously exudes from the trunk issometimes collected like gum arabic, but itdoes not have the same properties. Thetimber, although straight-grained, denseand weighty, is soft and fibrous. It is usedfor building animal

enclosures, huts anddug-out canoes, as well as for makingmany household objects and tools. InNigeria, the bark is pounded and used as apacking material for goods carried on packanimals (**Bernard, 2002)**.

F. albida flowers are used as nectar source for honeybees at the end of the rainy season when most plantsare not in flower. Haraz wood ash is also used to make soap **(Le Houerou, 2005).**

2.1.12Haraz fruits nutritional value

In fact, Legumes are known to contain anti-nutritional factor such as trypsin inhibitors, hemagglutins, goiterogenic factors, cyanogenic glucosides lathyric factors and compounds that cause favism and flatulence. The latter possibly caused by a gram positive anaerobic bacterium present in the intestinal tract **(Marunda, 2002).**

According to **Lawal and Kabiru (2007),** the dry matter, ash, crud protein, crude lipid, crude fiber and available carbohydrate in Haraz fruits were found to be 93.3 %, 6.7 %, 19.5 %, 3.3 %, 13.3 % and 50.5 %, respectively on dry basis. The estimated energy value was 1,363 KJ/100g pulp. Furthermore, the fruit was also found to be a good source of Calcium (55.0mg), Iron (8.8mg), Phosphorus (29.6mg), Potassium (88.8mg), Cupper (2.5mg), Zink (3.0mg), Magnesium (84.7mg) and Sodium (6.8 mg) per 100 g fruits pulp, respectively on dry basis. Also, the podseeds contain about 20.63% crude protein,13.3%crude lipid and 40.1% carbohydrates**(Hassan,*et. al.*, 2007).**

As indicated by **Wickens (2009),** the dry matter, ash, crude protein, crude lipid, and crude fiber of *Faidherbia albida* pulp in western Darfur in Sudan were 91.32%, 1.41% , 13.12%, 3.30%, and 13.30%, respectively (on dry basis). While, the

concentrations of calcium and phosphorus were found to be 4.0 and 2.12 mg per 100 g fruit pulp, respectively.

Ecoport (2009) reported the dry matter, crude protein, crude fiber, lignin and ash in Haraz pods as 92.11%, 11.01%, 26.48%, 8.86% and 4.19%, respectively (on dry basis). The energy value was estimated to be 1.763 kJ/100 g pulps. While, the concentrations of calcium, phosphorus, potassium, sodium, magnesium, manganese, zinc, copper and iron as mg per 100g fruit pulp were found to be 3.81, 1.60, 12.00, 0.11, 1.55, 22.00, 18.00, 5.00 and 4.10 mg / 100 g , respectively.

2.1.13 Haraz fruits processing

Abu-Elalla (2009)stated that, the extracted material from Haraz pods depend mainly on the fruit : water ratio, the extraction method used and the nature of the sample**.**

Atraditional Haraz drink has been prepared from the fruit by infusing the dried ground fruit pulp in hot water at a ratio of 1: 4 for 2 hrs. The extract was found to contain 10.61% total soluble solids (**Abdel-Rahman, 2011)**.

2.2 Concentrated fruitdrink 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 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 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 or pulp 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%. As the bottle is opened, partly used and then stored, it is necessary to add a preservative (800ppm 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 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 a sugar syrup, which can be filtered through a muslin cloth prior to mixing to

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

2.2.4 Pasteurization

All the fruit juice and drinks should be pasteurized at 80-95°C for 1-10 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°C. 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).**

2.3.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 away. 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 etc and wash thoroughlybefore 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 flavour.
- 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 flavour of the same kind of fruit from which it is made. The product's essential physical, chemical, organoleptical, and nutritional characteristics should be authenticated**(CODEX, 2005** and **SSMO, 2007).**

2.3.1Specification and legislation

Sugars with less than 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 purée. Subject to national legislation of the importing country, lemon juice or lime juice, or both, may be added to fruit juice up to 3 g/l anhydrous citric acid equivalent for acidification purposes to unsweetened juices. Also, for the purposes of product fortification, essential nutrients 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 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 salts of metals such as sodium, potassium, calcium etc.,when they are present, will also register a small but insignificant influence on the solids figure.

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 the most frequent figures beingbetween 3 and 4 pH. There are several chemical preservatives that can be added to fruit juices. Processors 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.

2.3.2 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 drinkis to minimize these undesirable reactions and to enhance the inherent quality of the starting fruit **(Bates, *et. al*., 2001).**

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)**.

3. MATERIALS AND METHODS

3.1 Materials

Haraz fruits *(Faidherbiaalbida)* were obtained from Elfashir market in North Darfur State at the harvesting season (March-2014). 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 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, 2003).**

Principle

The moisture content in a weighed sample is removed by heating the sample in an oven (under atmospheric pressure) at 105 ˚C. Then, the difference in weigh before and after drying is calculated as a percentage from the initial weight**.**

Five grams (5±1 mg) of ground and well mixed sample was weighted accurately in cleaned, dried Petri dishes using a sensitive balance (No. AR2140, OHAC,S CORO. USA). Then, the sample was placed in an oven (Carblite, sheffield, England) at 105˚C until a constant weight was obtained. Then, the moisture content (M.C) as per-cent was calculated as loss in weight after drying:

$$\text{Moisture content (\%)} = \frac{(W_1 - W_2) \times 100\%}{\text{Sample weight (g)}} \quad \textbf{eq. [1]}$$

3.2.1.2 Crude protein

The crude protein content in the sample was determined by the micro-Kjeldahl method following the method of the **AOAC (2003)**.

Principle:

Haraz fruit sample was digested with a strong acid (sulphuric acid) so that the sample releases its nitrogen content which can be determined by a suitable titration technique. The amount of protein present in the sample is then can be calculated from the nitrogen concentration of the sample. A conversion factor of 6.25 (equivalent to 16 g nitrogen per 100 grams of protein) was used in this study. The kjeldahl method is divided into three steps which can be summarized under the following:

A) Digestion

The Haraz fruit sample (0.2grams) was transferred into a digestion flask and then digested by heating the sample for 2-3 hours in (3.5N) sulphuric acid. The digestion process was catalyzed by a mixture 0.4 of 10 parts K_2SO_4 to one part of $CuSo_4$. The heating was continued till the black colour turned to pale blue and the fumes disappeared.

B) Distillation

After the digestion has been completed the digestion flask was cooled and transferred to a distillation unit using a minimum volume of water. The solution in the distillation unit was then turned alkaline by addition of 20 ml of sodium hydroxide (40%) to release the ammonia. The released ammonia was distilled into 20 ml of 2% boric acid in a conical flask, adding to it 2 to 3 drops of Bromochresol Methyl red as indicator.

C) Titration

The nitrogen content in the sample was then estimated by titration of the ammonium borate formed with a standard hydrochloric acid (0.1N). The titrations continued till the colour of the solution turned to red-pink. The protein concentration as per-cent was determined by using the following equation:

$$\% \text{ Crude Protein} = \frac{TV \times N \times 14.00 \times F \times 100\%}{\text{Sample weight (g)} \times 1000}$$

eq. [2]

Where:

TV: actual volume of HCl used for sample titration (ml sample – ml blank).

N: normality of HCl.

F: protein conversion factor = 6.25

3.2.1.3 Fat content

The sample oil content was determined by using petroleum ether in a continuous extraction apparatus (Soxhlet type) as described by **Pearson(1970).**

About five grams (5±1 mg) of dried Haraz fruit sample were weighed and transferred to an extraction thimble covered with a piece of glass wool and then placed in Soxhlet apparatus. After that, the solvent (petrolum ether) was added into a dried weighted Soxhlet flask and the extraction process was continued for about six hours. Then, the oil sample in each Soxhelt flask was dried in an oven (Carblite, sheffield, England) for 30 minutes to eliminate any remaining amounts of the solvent and the flask was reweighted. The fat per-cent was calculated by using the following equation:

$$\% \text{ Crude fat} = \frac{(W_2 - W_1) \times 100\%}{}$$

Sample weight (g)

eq. [3]

Where**:**

W1=weight of empty Soxhlet flask (g).

W2=weight of Soxhlet flask with oil content (g).

3.2.1.4 Determination of 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 100% as described by **West, *et. al*. (1988)**.

3.2.1.5Crude fiber

The crude fiber of the fruit pulp or flesh was determined following the standard method described by the Association of Official Analytical Chemists (**AOAC, 2003).**

Principle

The crude fiber is determined gravimetrically after the sample is chemically digested in chemical solutions. The weight of the residue after ignition is then corrected for ash content and is considered as crude fiber.

A sample of grams 2.0 gram was weighted and two hundred (200) ml of sulphuric acid (0.26N) were added, boiled for 30 minutes and then filtered. The residue was washed three times by using hot water and after that 200 ml of NaOH (0.26N) was added, boiled again for 30 minutes and filtered. Then, the residue was carefully washed three times with hot water until it was free from alkali. After that,

the sample was dried in an oven (Carblite, sheffield, England) at 105°C (overnight) and reweighted. The residue was ached in a muffle furnace (LEF- 103S, serial No. 07033002, Korea) at 550°C for three hours till a light grey ash was formed and a constant weight was obtained. Then, the total crude fiber per-cent was calculated using the following equation:

$$\text{Crude fiber \%} = \frac{(W_1 - W_2) \times 100\%}{\text{Sample weight(g)}} \quad \textbf{eq. [4]}$$

Where:

W_1 = weight of the sample before ignition (g).

W_2 = weight of sample after ignition (g).

3.2.1.6 Determination of available carbohydrates

The available carbohydrates were calculated by subtracting the total sum of moisture, fat, crude protein, crude fiber and ash as percentages from 100% as it was described by **West, *et. al*. (1988)**.

3.2.1.7 Total sugars, reducing sugars and non-reducing sugars

The total sugars, reducing and non-reducing sugars were determined according to Lane and Eynon titrometric method as described by the Association of Official Analytical Chemists (**AOAC, 1984)**.

Principle

Reducing sugars in pure solution in plant materials after suitable pre-treatment (to remove interference substances) may be estimated by using copper sulphate as oxidizing agent in a standard Fehling's solution.

Sample preparation:

(A)Reducing sugars

A sample of 10 g ± 1 mg was weighted and transferred to 250 ml volumetric flask. 100 ml of distilled water was carefully added and then neutralized with 1.0 N NaOH to a pH 7.5 – 8.0. Then, about 2 ml of standard lead acetate (NO. 23500, BDH, England) was added and the flask was shaked and left to stand for 10 min. After that, 2 grams of sodium oxalate was added to remove the excess amount of lead acetate and the solution was made up to volume with distilled water (250 ml) and filtered.

(B)Total sugars

From the previous clear sample solution, 50 ml was pipetted into a 250 ml conical flask and 5g citric acid and 50 ml distilled water were added slowly. Then, the mixture was gently boiled for 10 min to complete the inversion of sucrose and left to cool at room temperature. After that, the solution was transferred to 250 ml volumetric flask, neutralized with 20% NaOH solution in the presence of few drops of phenolphthalein (NO. 6606 J. T Baker, Holland) until the colour of the mixture disappeared and the sample was made up to volume before titration.

Procedure:

A volume of 10 ml from the mixture of Fehling's (A) and (B) solutions was pipetted into 250 ml conical flask. Then, sufficient amount of the clarified sugars solution was added from a burette to reduce Fehling's solution in the conical flask. After that, the solution was boiled until a faint blue colour is obtained. Then, few drops of methylene blue indicator (S-d-FINE-CHEM LIMITED) were added to Fehling's solution and titrated under boiling with sugars solution until brick-red colour of precipitate cuprous

oxide was observed. Finally, the titer volume was recorded and the amount of inverted sugars was obtained from Lane and Eynon Table and the total sugars, reducing and non-reducing sugars were calculated on dry basis by using the following formulas:

Calculation

$$\text{Total sugars \{\% DM\}} = \frac{\text{invert sugar (mg) x dilution factor} \times 100\%}{\text{Titre x sample weight (g) x (100\% - moisture \%) x 1000}}$$

$$\text{Reducing sugars \{\% DM\}} = \frac{\text{invert sugar (mg) x dilution factor} \times 100\%}{\text{Titre x sample weight (g) x (100\% - moisture \%) x 1000}}$$

Non-reducing sugars {% DM} ={Total sugars (%) – reducing sugars (%)}

eq. [5]

3.2.1.8 Determination of tannin content

Quantitative estimation of tannin was carried out using the modified vanillin-HCL method according to **Price, *et. al*. (1978).**

Tannin standard curve

Catechin was used to prepare the standard curve. This was done by adding 600 mg of D (+) Catechin to 100 mls of 1% HCL / methanol. From this stock solution various dilutions were prepared. Five ml of vanillin HCL reagent (0.5%) were added to 1 ml of each dilution. The absorbance was read using a Spectrophotometer (JENWAY 6305 UV/V) at 500 nm after 20 min. Then, the absorbance was plotted against catechin concentration.

Procedure:

A weight of 0.2g of the sample was placed in a test tube, then 10 ml of 1% HCL / methanol was added .The test tub was capped, continuously shaken for 20 min. and then centrifuged at 2500 rpm for 5min. One ml of the supernant was pippeted into each of the tubes and proceeding as described previously during the preparation of the standard curve.

For zero setting, 1ml blank solution was mixed with 5ml (1%) HCL / methanol and 5ml vanillin incubated for 20 min. at 30°C. Absorbance was read at 500 nm and the concentration of condensed tannins was determined the standard curve. Tannin concentration was expressed as % as follows:

$$CE\ \% = \frac{C \times V \times 100}{\text{Sample weight (mg)}}$$

eq. [6]

Where:

CE = Catechin equivalent.
C = Concentration corresponding to the optical density.
V = Volume of extract (ml).

3.2.1.9 Determination of ash content

The ash content of the sample was determined according to the **AOAC (2003).**

Procedure:

The empty crucibles were accurately weighed and then two grams of ground Haraz fruit flesh were transferred to each crucible by using a sensitive balance. Then, the crucibles and their content were placed in a muffle furnace (LEF- 103S, watts:

2KW10A serial No. 07033002, Korea) at 550° to 700° C for more than 6 hours until white to grey ash was obtained. After that, the crucibles were transferred from the furnace to a desiccators to cool to room temperature and re-weighed. The ash content was calculated by using the following equation:

$$\text{Ash content (\%)} = \frac{(Wt_1 - Wt_2) \times 100\%}{\text{Sample weight (g)}}$$

eq. [7]

Where:

Wt1 = weight of crucible with the remaining ashed sample (g).

Wt2 = weight of empty crucible (g).

3.2.1.10Determination 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).**

3.2.1.11 Titrable acidity

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

Procedure

50g ± 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 phenolphthalein solution (1%) as an indicator. The titrable acidity was calculated as percent citric acid according to the following equation:

Titrable acidity (%) =

$$\frac{\text{Titre} \times \text{N (NaOH)} \times \text{volme made up} \times \text{equivelent wt.of acid} \times 100\%}{\text{sample volume (ml)} \times \text{initial wt.of sample(g)} \times 1000} \quad \textbf{eq. [8]}$$

3.2.2 Physical and physico-chemical methods

3.2.2.1 Size of Haraz fruit

The different Haraz fruit dimensions(thickness and diameter) used in this study were measured by using Vernier Caplier (Vernier, 1.00 – 150 mm, Mituroyo, Japan).

3.2.2.2 Weight of Haraz fruit

The weight of each fruit capsule was recorded by using a sensitive balance (No. AR2140, OHAC S CORO, USA).

3.2.2.3 Colour

The colour intensity of Haraz fruits concentrated drink was recorded using a lovibond Tinto-meter as units of red, yellow and blue according to the **AOAC(2000).**

Sample of Haraz fruits concentrated drink was filtered through a filter paper and filled in the Tinto-meter cells. The instrument was switched on and the yellow colour was adjusted to 25. After that, the slides were adjusted to match the sample colour by a combination of red and blue colours. The values obtained by matching were recorded as degrees of red, yellow and blue colours.

3.2.2.4 Hydrogen ions concentration

The hydrogen ions concentration (pH)was measured following the method of the **AOAC (1990).**

Principle

The sample is measured potentiometrically with a pH-meter. After standardization of the meter electrodes with two 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 of 4.00 and 7.00), the electrode of the pH-meter was rinsed with distilled water, immersed in the sample solution (20 $^{\circ}$C) and left to stand until a staple reading was achieved. All the readings were expressed as pH to the nearest 0.00 pH units.

3.2.2.5 Total soluble solids

The total soluble solids (T.S.S %) of Haraz 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 (1984).**

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

3.2.3 Experimental processing methods

3.2.3.1 Haraz extraction methods

For determination of the optimum extraction conditions for production of Haraz fruits extract, two different extraction methods were used:

(A) Cold extraction method

In this method, two replicates from the crushed Haraz sample (100g) were soaked overnight (16hrs) at room temperature (27˚C) in distilled water at different fruit: water ratios (1:4, 1:6, 1:8, 1:10, 1:12). After that, the mixtures were stirred bya magnetic stirrer (Gallenkamp P 2375, England) for 5 min., immediately filtered with coarse silk sieve and weighed. Then, the weight of each Haraz fruit extract was recorded and checked 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:

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

eq. [9]

(**B) Hot extraction method**

In this method, two replicates from the crushed Haraz sample (100g) were soaked in hot distilled water (100 ˚C) but for only two hours (2hrs) with the same fruits: water ratio that used in the previous method. After that, the mixtures were blended for 5 min. by using a magnetic stirrer, immediately filtered, weighed and checked for its hydrogen ions concentration (pH), volume (ml),weight (g), total soluble solids (T.S.S.%) and yield (%).

3.2.3.2 Haraz concentrated drink processing method

After determination of the suitable extraction method and conditions for production of Haraz fruit pulp extract, Haraz fruits were crushed, ground and weighed (4 kg). Then, the fruits juice was extracted by diffusion in hot tap water (32.0 L / 100˚C) for two hours, filtrated, placed in stainless kettle and heated (100˚C) for 15min. After that, sugar (17 kg), citric acid (37g) was immediately added and the mixture was boiled for 5 min. Finally,Sodium benzoate as a preservative (10.65 g) was added and Haraz fruits concentrated drink was filled in a cleaned, sterilized plastic containers, tightly closed, cooled and stored at (4˚C) until needed for the different investigations. The recipe and the processing methodused in this study for production of Haraz fruits concentrated drink are shown in Table (1) and Fig. (1), respectively.

3.2.4 Organoleptic evaluation method

Haraz fruits 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, 20trained panelists from the Food Science and Technology Department, College of Agricultural Studies, Sudan University of Science and Technology, were asked to

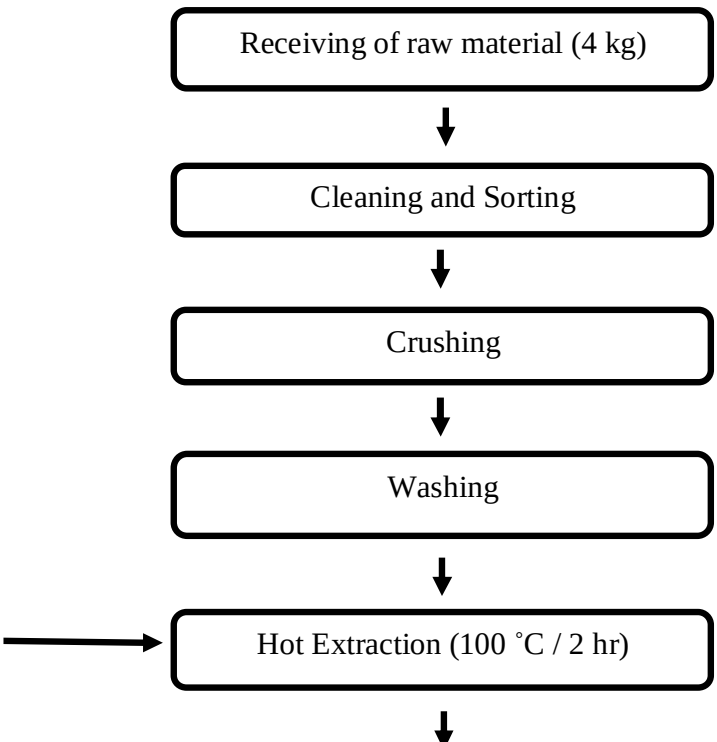
evaluate the product with respect to its colour, flavour, taste, appearance and over-all quality by using the following Scale: 1 = excellent, 2 = very good, 3 = good, 4= acceptable, 5= unacceptable. After that, the results obtained were statistically evaluated.

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 thesignificances according to Duncan's Multiple Range Test (DMRT) as described by (**Mead and Gurnow, 1983).**

Table (1): Haraz fruits concentrated drink processing recipe

Ingredients	Quantity
Haraz fruits	04.00 kg
Added water	32.00 L
Haraz fruit extract	18.50 kg
Haraz extract total soluble solids (T.S.S.)	04.00 %
Sugar	17.00 kg
Citric acid	37.00 g
Sodium benzoate	10.65 g



Boiled water

Figure (1): Flow processing diagram for production of haraz fruits concentrated drink

4. RESULTS AND DISSCUSSION

4.1 Physical characteristics of Haraz fruits

The physical characteristics of Haraz fruits during the harvesting season (March-2014) are presented in table (2). In general, the fruits are found with a bright – orange colour, curled and twisted, with an average fruit weight, length and diameter 7.47 g, 6.59 mm and 1.96 mm, respectively.**Barnes and Fagg (2003)** reported that, Haraz fruit is an unusual pod, bright orange to redish-brown, thick and conspicuously curled and twisted.

4.2 Nutritional value of Haraz fruits

4.2.1 Chemical composition

Table (3) shows the chemical composition of Haraz fruits pulp on wet and dry basis. The dry matter, total carbohydrates, crude fiber, total sugars and ash contents were found to be 92.59 %, 86.36 %, 32.48 %, 16.41 % and 4.37 %, respectively on dry weight basis. Among the total sugars, the reducing and non-reducing sugars constitute about 5.72 % and 10.69 %, respectively. Also, the fruits were moderately rich in protein (7.16 %), but with very low levels of fat (2.11 %) and tannins (0.52 %), on dry basis. The results obtained in this study are well agree with those reported by **Lawal** and **Kabiru (2007),Ecoport (2009)**and disagree with those reported by **Wicknes (2009)** especially for Haraz fruit protein, crude fiber and ash contents.

4.2.2 Minerals content

Table (4) indicates the minerals content of Haraz fruits pulp on wet and dry basis

Table (2): Physical characteristic of Haraz fruits

Characteristic	Mean Value [n = 10 ± SD]
Weight (g)	7.47 ± 0.16
Length (mm)	6.59 ± 0.10
Diameter (mm)	1.96 ± 0.15
Colour	Bright orange

SD ≡ Standard deviation.

n ≡ Number of independent determinations.

Table (3): Chemical composition of Haraz fruits pulp

Chemical composition	% On wet basis	% On dry basis
	[n = 3 ± SD]	
Moisture (or) dry matter	07.41 ± 0.80	92.59 ± 0.15
Protein	06.63 ± 0.30	07.16 ± 0.50
Fat	01.95 ± 0.00	02.11 ± 0.00
Total carbohydrates	79.96 ±0.30	86.36 ±0.30
Crude fiber	30.07 ± 0.60	32.48 ± 0.70
Available carbohydrates	49.89 ± 0.70	53.88 ± 0.60
Total sugars	15.20 ± 0.60	16.41 ± 0.20
Reducing sugars	05.30 ± 0.10	05.72 ± 0.20
Non-reducing sugars	09.90 ± 0.90	10.69 ± 0.20
Tannins	00.49 ± 0.00	00.52 ± 0.00
Ash	04.05 ± 0.20	04.37 ± 0.20

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

Table (4): Minerals content of Haraz fruits pulp

Minerals	On wet basis	On dry basis
	[(n=3 ± SD) , mg/100g]	
Sodium [Na]	063.71± 0.00	068.81 ± 0.00
Potassium [K]	032.52 ± 0.00	035.12 ± 0.00
Calcium [Ca]	147.45 ± 0.00	159.25 ± 0.00
Magnesium [Mg]	036.91 ± 0.00	039.86 ± 0.00
Phosphorus [P]	034.66 ± 0.00	037.43 ± 0.10
Iron [Fe]	017.80 ± 0.30	019.22 ± 0.05
Manganese [Mn]	001.26 ± 0.00	001.36 ± 0.02
Cupper [Cu]	000.49± 0.05	000.53 ± 0.01

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

as mg/100g fruit pulp. The fruit pulp was found with high levels of calcium (159.25 mg), sodium (68.81 mg), magnesium (39.86 mg), phosphorous (37.43 mg), potassium (35.12 mg)and iron (19.22 mg), on dry weight basis. On the other hand, the fruit contained very low levels of manganese (1.36 mg) and cupper (0.53 mg) per 100g fruit pulp. The results in this study are in good agreement with those reported by **lawal** and **kabiru, (2007),** but are disagree with those mentioned by **Wicknes (2009)** and **Ecoport (2009).**

4.3 Production of Haraz fruits concentrated drink

4.3.1 Extraction of Haraz fruits juice

For determination of optimum extraction method and conditions that should be used for preparation of Haraz fruits concentrate, two different extraction methods were separately used in this study:

(A) Cold extraction method

Table (5) shows the results of Cold extraction of Haraz fruits pulp, the volume, weight and yield (%) of Haraz fruits extract were significantly ($p \leq 0.05\%$) increased with the increasing of fruit: water ratio. In contrast, the total soluble solids percent(T.S.S %) of Haraz fruits extract was significantly ($p \leq 0.05\%$) decreased with the increasing of fruit: water ratio. However, among the different fruit: water ratios used in this experiment, the ratio of (1:8) was found more suitable for preparation of Haraz fruits extract with suitable volume (302.5 ml), PH (5.09), T.S.S % (4.35 %) and yield (24.02 %).

Table (5): Cold extraction of Haraz fruits pulp

Parameters	Fruit: water ratio					$Lsd_{0.05}$	SE±
	1:4	1:6	1:8	1:10	1:12		
	[n=2 ± SD]						
Haraz fruit 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}	0.4753^{IS}	0.0017
Extract weight (g)	52.00 ± 0.27^{e}	159.9 ± 0.44^{d}	300.3 ± 0.51^{c}	432.8 ± 0.73^{b}	529.1 ± 0.68^{a}	48.7425**	5.4216
Extract volume (ml)	58.00 ± 0.35^{e}	165.0 ± 0.47^{d}	302.5 ± 0.56^{c}	432.5 ± 0.74^{b}	530.0 ± 0.71^{a}	41.6324**	10.8931
Total soluble solids (T.S.S %)	09.00± 0.12^{a}	06.00±0.09^{b}	04.00±0.08^{c}	02.00±0.06^{d}	02.00±0.06^{d}	01.8621*	0.0981
Hydrogen ion concentration (pH)	05.20 ± 0.06^{a}	05.10 ±0.03^{b}	05.09±0.01^{b}	05.19±0.04^{ab}	05.23±0.08^{a}	00.0198*	0.0537
Yield % [on wet basis]	09.36 ± 0.14^{e}	19.19 ± 0.16^{c}	24.02 ± 0.19^{a}	17.31 ± 0.12^{d}	21.16 ± 0.18^{b}	01.9756*	0.0615

SD ≡ Standard deviation.
n ≡ Number of independent determinations.
Mean ± S.D value(s) bearing different superscript letter(s) in each row are significantly different (P≤0.05).
* ≡ Significant at (P≤0.05).
** ≡ Highly significant at (P≤0.05).
I.S ≡ insignificant.
$Lsd_{0.05}$ ≡ Least significant difference at (P≤0.05).
SE± ≡ Overall experimental error.

(B) Hot extraction method

Table (6) indicate the results of Hot extraction of Haraz fruits pulp, the volume (ml), weight (g) and yield (%) of Haraz fruits extract were also found to increase significantly ($p \leq 0.05\%$) with the increasing of the fruit: water ratio. While, the total soluble solids percent(T.S.S %) of Haraz fruits extract were significantly ($p \leq 0.05$ %) decreased with the increasingof fruits: water ratio. However, among the different fruit: water ratios used in this experiment, the ratio of (1:8) was also found more suitable for production of Haraz fruits extract with reasonable volume (285.0ml), T.S.S. (5.0%), PH (4.87) and yield (28.85%).

When comparing the results obtained during the cold and the hot extraction methods of Haraz fruits as indicated in Table (7), the hot extraction method at an extraction ratio of 1:8 was found more suitable for preparation of Haraz fruits extract. In fact, Haraz fruits extract that prepared by the hot extraction method at a ratio of (1:8) had the higher total soluble solids (5.0 %) and yield (28.85 %).

4.3.2 Processing of Haraz fruits concentrated drink

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

4.4 Quality evaluations of the end product

After production of Haraz fruits concentrated drink the product was evaluation for its chemical, physico-chemical, minerals and organoleptic properties.

Table (6): Hot extraction of Haraz fruits

Parameters	Fruit: water ratio					$Lsd_{0.05}$	SE±
	1:4	1:6	1:8	1:10	1:12		
	[n=2 ± SD]						
Haraz fruit 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}	0.7109^{IS}	0.0015
Extract weight (g)	29.50 ± 0.13^{e}	122.0 ± 0.47^{d}	288.5 ± 0.52^{c}	398.0 ± 0.62^{b}	527.2 ± 0.69^{a}	34.8546^{**}	5.8236
Extract volume (ml)	52.50 ± 0.24^{e}	131.5 ± 0.28^{d}	285.0 ± 0.49^{c}	392.5 ± 0.53^{b}	544.5 ± 0.75^{a}	37.7435^{**}	9.7465
Total soluble solids (T.S.S %)	10.00 ± 0.26^{a}	07.00 ± 0.23^{b}	05.00 ± 0.20^{c}	03.00 ± 0.18^{d}	02.00 ± 0.13^{e}	00.9732^{*}	0.0985
Hydrogen ions concentration(pH)	04.91 ± 0.17^{a}	04.90 ± 0.15^{a}	04.87 ± 0.11^{ab}	04.86 ± 0.09^{ab}	04.84 ± 0.06^{b}	00.0184^{*}	0.0536
Yield % [on wet basis]	05.09 ± 0.20^{e}	17.08 ± 0.70^{d}	28.85 ± 1.80^{a}	23.89 ± 0.90^{b}	21.08 ± 1.00^{c}	01.7564^{*}	0.0611

SD≡ Standard deviation.
n ≡ Number of independent determinations.
Mean ± S.D value(s) bearing different superscript letter(s) in each row are significantly different (P≤0.05).
* ≡ Significant at (P≤0.05).
** ≡ Highly significant at (P≤0.05).
I.S≡ insignificant.
$Lsd_{0.05}$ ≡ Least significant difference at (P≤0.05)

Table (7): Comparison between cold and hot extraction methods of haraz fruits extract

Parameters	Extraction method	Haraz fruits : water ratio				
		1 : 4	1 : 6	1 : 8	1: 10	
Haraz fruits weight (g)	Cold	50.0±0.00^{a}	50.00±0.00^{a}	50.00±0.00^{a}	50.00±0.00^{a}	5
	Hot	50.0±0.00^{a}	50.00±0.00^{a}	50.00±0.00^{a}	50.00±0.00^{a}	5
Hydrogen ion concentration (pH)	Cold	05.2±0.06^{a}	05.10±0.03^{b}	05.09±0.01^{b}	05.19±0.04^{a}	0
	Hot	4.91±0.17^{c}	004.9±0.15^{c}	04.87±0.11^{cd}	4.86±0.09^{cd}	0
Volume of fruit extract (ml)	Cold	58.0±0.35^{i}	165.0±0.47^{g}	302.5±0.56^{e}	432.5±0.74^{c}	5
	Hot	52.5±0.24^{j}	131.5±0.48^{h}	285.0±0.49^{f}	392.5±0.53^{d}	5
Weight of fruit extract (g)	Cold	52.0±0.27^{i}	159.9±0.44^{g}	300.3±0.51^{e}	432.8±0.73^{c}	5
	Hot	29.5±0.13^{j}	122.0±0.47^{h}	288.5±0.51^{f}	398.3±0.62^{d}	5
Total soluble solids(T.S.S %)	Cold	09.0±0.12^{b}	006.0±0.09^{d}	004.0±0.08^{f}	002.0±0.06^{h}	0
	Hot	10.0±0.26^{a}	007.0±0.23^{c}	005.0±0.20^{e}	003.0±0.18^{g}	0
Yield % [on wet basis]	Cold	9.36±0.14^{g}	19.19±0.16^{e}	24.02±0.19^{b}	17.31±0.12^{f}	2
	Hot	05.9±0.22^{h}	17.08±0.34^{f}	28.85±0.61^{a}	23.89±0.57^{c}	2

SD≡ Standard deviation.

n ≡ Number of independent determinations.

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

* ≡ Significant at (P≤0.05).

** ≡ Highly significant at (P≤0.05).

I.S ≡ insignificant.

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

4.4.1 Chemical and physico-chemical characteristics of Haraz fruits Concentrated drink

Table (8) shows the chemical and physico-chemical characteristics of Haraz fruits concentrate (with and without flavour). From the results, the titrable acidity as % citric acid, total soluble solids (T.S.S. %), hydrogen ions concentration (pH) and colour were found to be 0.60 %, 55.0 %, 4.04 and 0.54˚, respectively. The results obtained in this study are agree wellwith those reported by **SSMO (2007).**
As stated by **Anwar, *et.al*. (2010)**, fruit concentrated drinks have a low pH because they are rich in organic acids. Their overall range of pH is ranged between 2.0 to 5.0.

4.4.2 Minerals content of Haraz fruits concentrated drink

The minerals content of Haraz fruits concentrated drink is presented in Table (9). The product was found to provide appreciable amount of calcium(774.41 ppm), sodium (390.40 ppm), magnesium (234.40 ppm), phosphorous (217.50 ppm), potassium (159.52 ppm) and iron (58.26 ppm) per 100 ml.

4.4.3 Organoleptic evaluation

Asensory evaluation for Haraz fruits 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. Haraz fruits drinks with and without pineapple 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 (10). In general, Haraz fruits drinks with or without flavour were greatly accepted by the

Table (8): Chemical and physico-chemical characteristics of Haraz fruits Concentrated drink

Sample	Titrable acidity (%)	Total soluble solids % (T.S.S%)	Hydrogen ions concentration (pH)	Colour
	(n = 3 ± SD)			
A	0.60 ± 0.04[a]	55.0 ± 0.25[a]	4.04 ± 0.11[a]	0.54° R.y.b± 0.26[a]
B	0.60 ± 0.01[a]	55.0 ± 0.27[a]	4.01 ± 0.08 [a]	0.54°R,y.b ± 0.26[a]
$Lsd_{0.05}$	00.0437	01.4285	00.5247	00.6183
SE±	00.0081	00.0976	00.0508	00.0632

n = number of independent determinations.

SD = standard deviation.

A = Haraz concentrated drink with pineapple flavour

B = Haraz concentrated drink without pineappleflavor

R.y.b = Red, yellow, blue

Table (9): Minerals content of Haraz fruits concentrated drink

Minerals	Samples		$Lsd_{0.05}$	SE±
	A	B		
	[ppm]			
Potassium [K]	159.52 ± 0.07[a]	149.10 ± 0.03[b]	0.6401*	0.0423
Phosphorous [P]	217.50 ± 0.02[b]	202.36 ± 0.01[a]	0.0056*	0.0471
Sodium [Na]	390.40 ± 0.04[a]	370.87 ± 0.06[b]	0.0017*	0.0389
Calcium [Ca]	774.41 ± 0.05[a]	762.68 ± 0.07[b]	0.1809*	0.0016
Magnesium [Mg]	234.40 ± 0.03[a]	220.86 ± 0.09[b]	0.0721*	0.0274
Iron [Fe]	058.26 ± 0.07 [a]	049.79 ± 0.01[b]	0.1647*	0.0358
Manganese [Mn]	01.837 ± 0.03[b]	00.940 ± 0.04[a]	0.1185*	0.0419
Cupper [Cu]	01.798 ± 0.04[b]	01.518 ± 0.01[a]	0.0623*	0.0492

ppm = part per millon

A = Haraz concentrated drink with pineapple flavour

B = Haraz concentrated drink without pineapple flavour

Table (10): Organoleptic evaluation of Haraz fruit drinks

Sample	Quality attributes				
	Colour	**Taste**	**Flavour**	**Appearance**	**Overall quality**
	[Score, n = 20 ± SD]				
A	2.15 ± 0.87^{a}	2.35 ± 1.14^{b}	2.55 ± 0.94^{a}	2.05 ± 0.82^{b}	2.20 ± 0.83^{b}
B	2.05 ± 1.19^{b}	2.60 ± 1.14^{a}	2.40 ± 0.88^{b}	2.30 ± 0.86^{a}	2.35 ± 1.18^{a}
$Lsd_{0.05}$	00.0852^{*}	00.2463^{*}	00.1379^{*}	00.2166^{*}	000.1287^{*}
SE±	00.0412	00.0614	00.0369	00.0975	000.0618

n = number of independent determinations.

SD = standard deviation.

A = Haraz concentrated drink with pineapple flavour

B = Haraz concentrated drink without pineapple flavour

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

panelists. But, Haraz fruits drink with pineapple flavour had the better taste (2.35), appearance (2.05) and overall quality (2.20).

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the results obtained in this study it can be concluded that, Haraz fruits *(Faidherbia albida)* could be easly extracted in boiled water (100 ºC) for two (2) hours. The concentrated drink that made out of Haraz fruits 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 fruits concentrated drink.

5.2Recommendations

1. A comprehensive survey should be conducted with respect to haraz fruits distribution, production and productivity in Sudan.
2. Efforts should be directed towards the industrial food utilization of Haraz fruits in Sudan for production of Haraz fruits concentrated drink which can be used as functional food or as a treatment or traditional medicine for different diseases.
3. Additional studies are definitely needed to ensure safety, storage conditions,shelf-life, economic feasibility and the market demands for the product.
4. The anti-microbial activities of Haraz fruits should be also investigated.

REFERENCES

Abbo, Emmanue. S, Taiwo, I., Olurin,O. and Odeymi,G. (2006). Studies on the storage stability of soursop (*Annuna muricata* L.) juice. *African Journal of Biotechnology*, Vol. 5 (19), pp.1808-1812.

Abdel-Rahman, N. A. A. (2011). A Study of Some Sudanese Edible Forest Fruits and their Nectar. Ph. D. Thesis in Food Sciences and Technology, Sudan Academy of Sciences, Khartoum, Sudan, pp.239.

Abu-Elalla, F. (2009). Antioxidant and anticancer activities of Doum fruit extract (*Hyphaene thebaica*), *African Journal of Pure andApplied Chemistry*, Vol 3(10) p.p.197-201.

African Plants Database (2013). Conservatoire et Jardin botaniques de la Ville de Genève and South African National Biodiversity Institute, Pretoria,South Africa.

Anon (2000). Shurbs Monograph on *Acacia albida* In: Fich monographique – bilan: *Acacia albida* Del. Troisieme Comite Recherche Forestiere, Institut de Recherche en Biologie et Ecologie Tropicale, Ouagadougou, Republique del Laute Volta, 9 pp.

Anwar, F.; Tasnim, J.; Hossain, M.; Kamal, M.; Hossain, D.; Lopa andFormuzul, K.; Haque, M. (2010). Quality Assessment of Industrially Processed Fruit Juices Available in Dhaka City. Bangladesh Council of Scientific and Industrial Research, Dhanmondi, Dhaka, Bangladesh, 1205, pp 431-438.

A.O.A.C (1984). Association of Official Analytical Chemists. Official Methods of Analysis. 14th ed., Published by the AOAC Inc., North Nineteenth Street, Suite 210 Arlington. Virginia 22209. USA.

A.O.A.C. (1990). Association of Official Analytical Chemists. Official Methods of Analysis, Washington DC., USA.

A.O.A.C. (2000). Association of Official Analytical Chemists. Official Methods of Analysis. 17th ed., Gaithersburg, MD, USA.

A.O.A.C. (2003). Association of Official Analytical Chemists. Official Methods of Analysis. 17th ed. Arlington, Virginia, USA.

Ashurst, P. R. (2005). Chemistry and Technology of Soft Drinks and Fruit Juices. Seconond Edn., Blackwell Publishing Ltd, London, UK.

Azam, A. (2008). Fruit Juice Processing. The Schumacher Center for Technology and Development, Bourton-on-Dunsmore Rugby, Warwickshire, CV23 9QZ, UK.

Barnes, R. D. and Fagg, C.W. (2003). *Faidherbia albida* Monograph and Annotated Bibliography. Tropical Forestry Papers No. 41. Oxford Forestry Institute, UK, 267pp.

Bates, R. P. Morris, J. R. and Candall, P. G. (2001). Principle and practices of small and medium scale fruit juice processing. Technical Report, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

Bernard, C. (2002). *Faidherbia albida* (Delile) A. Chev. Plant Resources of Tropical Africa/Ressources vegetales de l Afrique tropicale (PROTA),Wageningen,The Netherlands.

Bonkoungou, E. G. (2001). Network on Agroforestry and Soil Conservation. Secretariat of the Convention to Combat Desertification. Lome, Togo.

Brouwer, J. (2008). The importance of within-field soil and crop growth variability to improving food production in a changing Sahel. http://cmsdata.iucn.org/downloads/cem.

Castillo-Caamal, J. B.; Jimenez-Osomio, J. J.; Lopez-Perez, A.; Aguilar-Cordero, W.and Castillo-Caamal, A. M. (2003). Feeding Mucuna beans to small ruminants of Mayan farmers in the Yucatan Peninsula, Mexico. *Trop Subtrop Agroecosyst*, 1: 113-117.

Chapman, H. D. and Parratt, F. P. (1961). "Ammoniumvandate" Mmolybdate method for determination of phosphorous method of analysis for soils, plant. Puplic Division of Agri. Science, University of California, USA, pp 169-176.

CODEX (2005). Codex General Standard for Fruit Juice and Nectars. CODEX STAN. France. (247), P 19.

Dangasuk, O. G. Gudu, S. Okalebo, J. R. (2001). Early growth performance of sixteen populations of *Faidherbia albida* in semi arid baringo district of Kenya. The 10th International Soil Conservation Organization Meeting, Purdue University and the USDA-ARS National Soil Erosion Laboratory, (24-29) May, 1999.

Depommier, D. (2003). The tree behind the forest: ecological and economical importance of traditional agroforestly systems and multiple uses of trees in india. *Trop Ecol*, 44:63-71.

Ecoport (2009). Ecoport database. Feedibedia, Animal Feed Resources Information Systemhttp://www.ecoport.org**.**

EIsiddig, E. A. (2003). The Importance of Trees and Forests forLocal Communities in Dry Lands of Sub-Saharan Africa.VITRIlETFRN/IUFRO-SIDO Workshop, Finland, (30June-4July, 2003).

El-amin, H. M. (1990). Trees and Shrubs of the Sudan. Published by Ithaca Press, England, p110.

Faye, A.; Krasova-Wade, T.; Thiao, M. ; Thioulouse, J. ; Neyra, M. ; Prin, Y.; Galiana, A.; Ndoye, I.; Dreyfus, B. and Duponnois, R. (2009). Controlled ectomycorrhization of an exotic legume tree species *Acacia holosericea* affects the structure of root nodule bacteria community and their symbiotic effectiveness on *Faidherbia albida*, a native Sahelian Acacia. *Soil Biol Biochem*, 41: 1245─1252.

Gassama- Dia, y. K. ; Sana, D. N. and Doye, M. (2003). Reproductive biology of *Faidherbia albida* (Del.) A. Chev. *Silva Fenn*, 37:429-436.

Gibreel, H. H. (2008). A Taxonomic Study on Trees Shrubs of El-Nour Natural Forest Reserve, Blue Nile State. M.Sc. Thesis in Forestry, University of Khartoum, Sudan, pp 50- 58.

Harrison, M.N. and Jackson,J.K. (1958). Ecological Classification of the Sudan. Forest Department, Forest Bulletin No. 2. Ministry of Agriculture and NaturalResources, Khartoum, Sudan.

Hassan, L. G. Umar, K. J. Yuguda, H. (2007) . Nutritional evaluation of *Faidherbia albida* seeds and pulp as source of feeds for Iivestock. AJFAND, 7. http://www.ajfand.netlIssue 161PDFs/ Hassan_183 5. Pdf.

Hyde, M. A. and Wursten, B. (2010). Flora of Zimbabwe: Species Information: *Faidherbia albida*. http://www.zimbabweflora.

Ibrahim, A. and Tibin, I. M. (2003). Feeding potential of *Faidherbia albida*ripe pods for Sudan deseret goats. Khartoum University, Faculty of Animal Production, Khartoum, North, Shambat , Sudan. *Scienfic Journal of King Faisal University* (basic and applied science) 4 (1):1424.

Irvine, F.R. (2003). *Acacia albida*. In: Woody plants of Ghana with special reference to their uses. Oxford University Press.London, UK.

Joker, D. (2000). *Faidherbia albida* (Del.) A. Chev. Seed Leaflet No.28. DANIDA Forest Seed Centre. Denmark.

Kone, W. M. Atindehou, K. K. (2008). Ethnobotanical inventory of medicinal plants used in traditional veterinary medicine in Northern Cote d'lvoire (West Africa). *S Afr J Bot*, 74: 76-84.

Kubmarawa, D. Ajoku, G. A. Enwerem, N. M. Okorie, D. A. (2007). Preliminary Phytochemical and antimicrobial screening of 50 medicinal plants from Nigeria. *Afr J Biotechnol*, 6: 1690-1696.

Lawal, G. and Kabiru, J. (2007). Nutritional evaluation of *Faidherbia albida*seedsandpulpassourceoffeedsfor livestock.*African Journal of Food, Agriculture, Nutrition, and Development.*vol. (7).

Le Houerou, H. (2005). *Faidherbia albida* Del. A. Chev. http:// www.fao. org/ag/ AGP/ AGPC/doc/Gbase/DATA/PfU00095. htm. Accessed 17 Aug 2010.

Leakey,R. ; Tchoundjeu, Z. ; Schreckenberg, K. ; Shackleton, S. and Shackleton, C. (2005). Agroforestry tree products (AFTPs):Targeting poverty reduction and enhanced Iivelihoods. *Int J Agric Sustain*, 3: 1-23.

Marunda, C. (2002). Use of *Faidherbia albida* (syn. Acacia albida) for Human Consumption during Famine Periods in the Gokwe Communal Lands of Zimbabwe. Proceedings of a workshop Held at Glen Helen, Northern Territory, Australia 7 – 10th August 2002.

Matenga, V. R. ; Ngongoni, N. T. ; Titterton, M. and Maasdorp, B. V. (2003). Mucuna seed as a feed ingredient for small ruminants and effect of ensiling on its nutritive value. *Trop Sub trop Agroecosyst*, 1: 97─105.

Maundu, P. and Bo Tengnas. (2005). Useful trees and shrubs for Kenya, World Agroforestry Centre, Kenya.

Maydell, II.J.V. (2001). Tree and Shurbs of the central Sudan. In: A land between two Niles. Edited by William, M. A. J and Adamson, A.A. Baxema Roberdam, Nether Land.

Mead, B. and Gurnow, R. W. C. (1983). Statistical Analysis Methods in Agricultural Experimental Biology. Published by Champan and Hall, London, New York.

Mokgolodi, Neo C., Moffat P. Setshogo, Shi Ling-ling, Liu Yu-jun., Ma Chao. (2011). Achieving food and nutritional security through agroforestry: a caseof *Faidherbia albida*in sub-Saharan Africa. *Forestry Studies in China*, Vol.13:123-131.

Moser, P. M. (2006). Regeneration and utilization of *Faidherbia albida* and *Acacia erioloba* along ephemeral rivers of *Namib*. Ecology and Development series. No. (42), Cuvillier verlag Gottingen,Germany.

Oluwakanyinsola, S. A. ; Adeniyi, T. Y. ; Akingbasote, J. A. and Oga, E. (2010). Acute and sub acute toxicity study of ethanolic extract of the stem bark of *Faidherbia albida* (Del.) A. chev (Mimosoidae) in rats. *Afr J Biotechnol,* 9: 1218─1224.

Omondi, W; Maua, J. O. and Gadathi, F. N. (2004). Tree Seeds Handbook of Kenya. 2nd Edition, Kenya Forestry Institute. Nairobi, Kenya, pp 257-284.

Orwa, C.; Mutua, A.; Kindt, R. ; Jamnadass, R. and Anthony, S. (2009). Agro-forest trees data base. In: A Tree reference and selection version 4.0 (http//www.worldagroforesty.org/sites/treedbs/treedatabases.asp).

Palgrave, C. K. (2002). Trees of Southern Africa. 3rd edn, Struik Cape Town, South Africa.

Palmer, E. Pitman, N. (2002). Trees of Southern Africa. A.A. Balkema, Cape Town, South Africa,(2) 741-743.

Pardy, A.A. (2004). Notes on indigenous trees and shurbs of Southern Rhodesia: *Acacia albida* (Del.) *Mimosaceae Rhoesian Agricultural Journal*, Vol.(50), 324-326.

Payne, W. A. (2000). Optimizing crop water use in sparse standsof Pearl Millet. *Agron J*, 92: 808-814.

Pearson, D. (1970). Chemical Analysis of Food. 7th ed, Published by Churchill living Stone, London, England.

Perkin-Elmer, C. (1994). Trace Metal Determination in Fruit Juice and Juice Products Using an Axially Viewed Plasma. Karen W. Barnes, 761 Main Avenue, Norwalk, CT 06859-0219, USA.

Price, M. L.; Van Scoyok, S. and Butler, L. G. (1978). A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. *Journal of Agricultural and Food Chemistry*, 26(5): 1214.

Ranganna, S. (1979). Manual of Analysis of Fruits and Vegetables Products. Tata Mc-Graw Hill Publishing Company Limited, New Delhi, India.

Ranganna, S. (2001). Handbook of Analysis and Quality Control for Fruits and Vegetables Products. 2nd ed., Tata. Mc-Grow Hill Published Company Limited, New Delhi, India.

Shiawoya, E. L. and Adeyemi, A. A. (2003). Nutrient composition of mixed forages growing on Bosso Campus of the Federal University of Technology (FUT) Minna, Niger State, Nigeria. *J Pure Apple Sci*, 6:213-218.

SSMO (2007). Standards Specification of Juices, Natural and Artifical Drinks.Sudanese Standardization and Metrology Organization, Khartoum , Sudan.

Tijani, A. ; Uguru, M. O. ; Salawu, O. A. ; Abubakar, A. ; Onyekwelu, N. O. and Akingbasote, J. A. (2009). Effect of Faidherbia albida on some biochemical parameters of rats infected with Trypanosoma brucei brucei. *Afr J Pharm Pharmacol*, 3: 26-30.

Tijani, A. Y. ; ; Uguru, M. O. and Salawu, O. A. (2008). Anti-pyretic, anti-inflammatory and anti-diarrhoeal properties of *Faidherbia albida* in rats. *African Journal of Biotechnology*, Vol. 7 (6), pp. 696-700.

Tutu, S.O. (2002). Trees and Shurbs of Shambat Area. In: Taxonomy, Growth, Natural regeneration and Uses. M.Sc Thesis, Faculty of Agriculture, University of Khartoum, Sudan ,pp 302 – 305.

USDA. (2010). National Genetic Resources Program. Germplasm Resources lnformation Network (GRIN), Beltsville, USA.

West, C.E. Repping, F. and Temalilwa, C.R. (1988). The Composition of Food Commonly Eaten in East Africa. Published by Wageningen, Nether Lands, Vol. 290.

Wickens, G. E. (2009). Role of Acacia Species in the Rural Economy of Dry Africa and the Near East. FAO,Conservation Guide (32), Rome.Italy.

Wondimu, T. Asfaw, Z. Kelbessa, E. (2007). Ethnobotanical study of medicinal plants around ‘ Dheeraa' town, Arsi Zone, Ethiopia. J Ethnopharmacol, 112: 152-161.