أستهلال

﴿الَّذِي جَعَلَ لَكُمُ الْأَرْضَ فِرَاشًا وَالسَّمَاءَ بِنَاءً وَأَنْزَلَ مِنَ السَّمَاءِ مَاءً فَأَخْرَجَ بِهِ مِنَ الثَّمَرَاتِ رِزْقًا لَكُمْ فَلَا تَجْعَلُوا لِلَّهِ أَنْدَادًا وَأَنْتُمْ تَعْلَمُونَ ﴾

صدق الله العظيم

سورة البقرة الاية رقم " 22"

Dedication

This work is dedicated to

my beloved parents,

brother ,sisters

and uncleHabib .

Acknowledgements

First of all my greater thanks and gratitude to Almighty Allah for giving me health and strength to complete this work.

I would like to express my gratitude and appreciation to my supervisor Dr.Mohammed Suleiman for his valuable advice, encouragement and help throughout this work.

My thanks and appreciations would extend to the staff of the chemistry Department, Sudan University of Science and Technology.

Abstract

The aim of this study was the isolation andcharacterizationof tamarind oil from its seeds. Tamarind samples were obtained from Ali Ibrahim shop for tamarind juice. Ash moisture and protein contents were measured for the seeds. Mineral contents ofseeds were measured by ICP instrument. Tamarind oil was extracted by n-hexane using soxhlet apparatus. The chemical composition of tamarind oil was investigated by GC/MS spectroscopy. Some physical and chemical properties of the extracted oil were also measured. They include density, acid value, peroxide value, saponification value and ester value.

The obtained results showed the percentage ash content fortamarind seedwas2.47%. The percentage moisture content of tamarind seeds was 8.38% and protein as 20.78%.The inductively coupled plasma analysis showed that, tamarind seeds wererich in some minerals of macro and micro levelincludingpotassium(K),calcium(Ca),magnesium(Mg), phosphorous(P), copper(Cu), manganese(Mn) and zinc(Zn).The hazardous elements showed very low concentrations in tamarind seeds. Aluminium and silicon as undesired elements showed considerable concentrations in tamarind seeds. Titanium (Ti) ,strontium(Sr) and lead(Pb) showed notable concentrations in tamarind seeds. The Tamarind fruit showedhighcontent of vitamin(C).

The GC-MS analysis of tamarind oil gave considerable constituents of essential fatty acids including linoleic acid (44.956%), Oleic acid (23.98%), palmatic acid (11.984|%), stearic acid (4.476%) and arachidicacid(3.032%.

The antimicrobial activity of n-hexane extract of the seeds was evaluated against five gram-positive and gram-negative and it as showed activity against bacteria Escherichia coliand fungi Candida ablicans.

المستخلص

الهدف من هذه الدراسة هو استخلاص زيت العرديب وتوصيف الخواص الفيزوكيميائية لثمرة،بذور وزيت العرديب .جمعت عينات العرديب من مركز علي ابراهيم للعرديب (المحطة الوسطى). تم تقدير محتوى الرطوبة والرماد والبروتين لبذور العرديب، وقدر المحتوى المعدني لبذور العرديب باستخدام تقنية مطيافية الانبعاث الضوئي بالحث البلازميالمزدوج(ICP). قدرفايتمين(C) في ثمرة العرديب. استخلصالزيت بواسطة الهكسانكمذيب باستخدام جهازSoxhlet.تم تحديد التركيب الكيميائي لزيت العرديبباستخدام تقنية كروماتوغرافيا الغاز ومطيافية الكتلةGC–MSقدرت بعض الخواص الفيزيائية والكيميائيةللزيت شملت الكثافة، رقم االحموضة،رقم البيروكسيد،رقمالتصبن ورقم الاستر.

أظهرت الدراسة ان نسبة الزيت لبذور العرديب (3.53%)وان محتوى الرماد لبدرة بذور العرديب (2.47%) وانمحتوي الرطوبةلبذورالعرديب(8.38%) وان محتوي البروتين (20.78%) ومحتوي الألياف(2.04%).

تم قياس تراكيز المغذيات المعدنية الكبري والصغري باستخدام تقنية ال(ICP) حيث تم تقدير البوتاسيوم (K)، الكالسيوم(Ca) ، الماغنيزيوم(Mg) ، الحديد(Fe) ، النحاس(Cu) ، المنجنيز(Mn) والزنك . (Zn)

العناصر غير المرغوب فيها أظهرت تراكيز منخفضة جدا في بذور العرديب.كانت تراكيز كل من الالمونيوم(Al) والسيليكون(Si)عالية نسبيا كعناصر غير مرغوب فيها. تمت ملاحظة تراكيز مقدرة لكل من التيتانيوم(Ti) الاسترانشيوم(Sr) و الرصاص(Pb). وقد كان محتوى فايتمين (C)في ثمرة العرديب عاليا.

اظهر التحليل بكروماتوغرافيا الغاز ومطيافية الكتلة احتواء زيت العرديب على نسب مقدرة من الأحماضالأمينية الأساسية شملت حمض اللينوليك 44.956% حمضالأوليك23.98% حمض البالمتيك 11.984%حمض الستريك 4.746% ، ميثايلارشسيت 3.032% .

تمت دراسة فعالية المستخلص الهكسيني من بذور نبات العرديب علي اربعة انواع من البكتريا ونوع واحد من الفطريات ووجد انها جمعيها لها تأثير ضعيف علي نشاط البكتريا والفطريات

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1.1 History of Tamarind Culture

1.1.1 Origin

Tamarindusindic a member of the family leguinosaefabacea is native to dry savannas of the tropical Africa (Bhattacharya et.al.,1994). In ancient times the tree was introduced to Asia by Arab traders (Duke et al., 1981 ,Morton, 1987) and with its pleasant and acidic tasting fruit, the name of tamarind driven from the Arabic name Tamar-al-hind which means date of India also known as tamarindo(Spanish and Portuguese) and tamarin, tamarinier, tamarindier(French). The origin of species is still subject to debate some authorities tracing the origin to Indian sub-continent but most evidences placing its origin within Africa, either central Africa or Ethiopia) Gunassena and Hughes, 2000) and Nigeria across ecological zones (Keay and Onochie, 1964).

Tamarind is an important woody perennial fruity species. It is found throughout the tropics for its beauty, ornamental adaptability to variable climatic and Delphic conditions and fruit production) ELSiddig et. al, 1999). The international survey of unexploited tropical and sub-tropical b-perennials revealed that tamarind is cultivated on an orchard basis in Caribbean, central America, South Americacentral Asia and South East Asia) Sedgely and Gardner,1989).

1.1.2 Description of the tree

The tamarind tree is a medium sized, semi evergreen with short strong trunk with grey scaly bark. The leaves are alternate pinnately compound 7-15cm long with pulvinus at the base of petioles. There are 10-20 pairs of small leaflet, arranged opposite, entire almost sessile, oblong. The inflorescence is small terminal drooping raceme 5-1ocm long. The flower is small, scented and attractive with yellow and red colour. The pods are usually carved flattened and very considerably in size and shape, they are constricted, in dehiscent 1-10 seeded. When ripe the fruit are stiff and brittle. The seeds are obovate, flattened, brown, about 1-5mm long and joined to each other with tough fiber running through brown sticky pulp. Tamarind is long lived and attains a large size but the rate of growth after the seedling stage is slow. The tree begins to bear fruits at the age of 13-14 year and continues to yield abundant crops for more than 6o years (TWI, 1976).

Fig (1.1) tamarind tree

1.1.3 The species and family: (plant classification)

Kingdom:Plantae

Clade:Angiosperms

Clade:Eudicots

Clade:Rosids

Order:Fabales

Family:Fabaceae

Subfamily:Detarioideae

Genus:***TamarindusL.***

Species: *T. indica*

Binomial name

*Tamarindusindica*L. 1753

1.1.4 Distribution of TamarindusIndica in Africa:

Tamarind is found in Angola, Benin, Burundi, Cameroon, Central Africa Republic, Ivory Coast, Djibouti, Eritrea, Ethiopia, Ghana, Kenya, South Africa, Sudan, Tanzania, Malawi, Nigeria, Senegal, Somalia, Zambia and Zimbabwe (Fries, 1992). It worth mentioning that Africa does not produce tamarind on large scale through local people uses it widely.

1.1.5 Distribution in Sudan:

Tamarindusindica is a Sudanese tree which spreads into sahelo-sudanian zone. It is sometimes planted on account of it is dense shade and fruit quality. A number of plant species (e.g., coriander ,lupin, roselle, watermelon, okra and tamarind) grown in Sudan could be classified as a neglected and or underutilized crop. These species, although important for people, receive little or no attention as for as research and development is convened. However , some of the crops including tamarind play important role in the economy of Sudan and contribute considerable share in the national and international trade (Hamid, 2006) in Sudan the tamarind is cited with baobab on sandy soils and Khors (water source) in short grasses Savannas in KordofansDarfur, Blue Nile, Bahr ElGhazal (El Amin, 1990).

1.1.6 Uses of tamarind tree:

Tamarind tree is valuable timber species widely used of tool handles, furniture, charcoal, oil mills, rice ponders and fuel wood. The leaves are an important source of food and herbal medicine. The most valuable part of the tamarind tree is the fruit which contains the pulp, the shell, fiber and seed. The pulp constitutes (30-50%) of the ripe fruit (Purseglove, 1987;Shankarachya,1998). The shell and the fiber account for 11-30%and the seed about 25-40% of the fruit (Chapan, 1948;Shankarachya,1998). The edible pulp of ripe fruits is used as flavoring agent in cooking, soup, jams chutneys, sauces, juices and the preparation of beverages (Siddhuraju et. al., 1995). The pulp is the richest natural source of tartaric acid (8-18%) and is the main acidulate used in the preparation of food in India and many other Asian countries. Other industrial product of tamarind is tamarind juice, tamarind

pickles and paste (Shankarachya, 1998). Tamarind has an exceedingly wide range of domestic and industrial uses, yet this is important tree remains under exploite.

1.1.7 Uses of Tamarind seed:

Till 1943, tamarind seed did not find any major food or non -food application. Only during the famine periods, the tribes in India mixed the roasted and de-husked tamarind seed powder with the flour of the other food grains and used it as a famine food and also as a feed for animals (Mohamedain,1991). During the Second World War, to meet the scarcity of starch (an edible product) for the Indian textile industry, research was carried out at the forest Research Institute (FRI) at Dehra Dun (Indian) to find a substitute for starch for sizing cotton yarn and couth. As a result, Tamarind Kernel Powder (TKP) was found to be a reasonable substitute for starch as sizing material for cotton and jute. This effort created a worldwide utilization of tamarind seed which is the major by-product in the tamarind industry. The seed contains of 30%testa and 70%endosperm, the testa coloring matter. The presence of tannins and other coloring matter in the testa make the whole seed unsuitable for human consumption. Therefore, the testa has to be separated from the kernels by boiling or roasting. Otherwise, such side effects as depression, constipation and gastro-intestinal disorders may result (Anon, 1976).the tamarind endosperm oar kernels are grounded to give a cream or a buff colored powder which yield a water soluble poly-saccharide that is known in the literature by various name such as Tamarind seed polysaccharide,(TSP), as reported by Srivastava and Singh, (1973), tamarind pectin, tamarind polyose, tikernose, tamarind gum, tamarind amyliod (because of it is starch-like response to iodine).

The seed is also used in the vegetable and processing industries, tamarind xyloglucan “tamarind gum” is commercially available as food additive for improving the viscosity and texture of processed foods (SoneandSota, 1994). Seeds couid be used as a cheaper source of protein to alleviate protein malnutrition which is widespread in many developing countries (Siddhuraja et. al 1995).

Seed teats are the residual product in preparation of kernel powder used as dye to the presence of Leuceanthocyamins and also as a plywood adhesive. The testae contain cured fiber found21.6%, ash 7.4%and the tannins 20-24%. It can be used as a low source of antioxidant in lipid containing food.

1.1.8 The most common applications of tamarind in African traditional medicine:

1.1.8.1. Laxative

With few exceptions, all laxative medicine is prepared from the fruit or fruit pulp. The use of the fruit as a laxative, due to the high amounts of malic and tartaric acids and potassium acid tartrate (Irvine, 1961), is universally recognised and can even be found in the pharmacopoeias of industrialised countries like France, Britain and the United States (Irvine, 1961; Morton, 1987). In Africa, this use is consistently found across the Sahel and Soudan zones from Senegal to Sudan, but also in Madagascar. Some older sources (Dalziel, 1937; Kerharo and Bouquet, 1950a) emphasize the common use of the fruits as a laxative. The laxative can be taken in form of a sweetmeat, called bengal by the Wolof of Senegal, prepared from the unripe fruit and sometimes mixed with lime juice or honey (Dalziel, 1937, p. 200).

Kerharoand Adam (1974, p. 307) state that in most cases in Senegal, the fruits are peeled, deseeded and then mashed in a mortar. This fruit mass is then diluted with water or sanglé, a beverage based on milk and millet flour, and drunk with or without salt. The Dogon people of Central Mali macerate the fruit with the leaves of Combretummicranthumin water, until the drink develops a sour taste (Keita and Coppo, 1993, p. 84).

In Bamako, Mali, drinks prepared from the pulp are used (Diarra, 1977, p. 45) and in Burkina Faso fruits are crushed and soaked for half a day in water with a little salt before consumption (Kerharo and Bouquet, 1950a, p. 114). Soaked fruit are also eaten by rural Fulani in Nigeria, to relieve constipation (Lockett et al., 2000,p. 201). In northern Benin, the fruit pulp is mixed into a water-based drink and sweetened to taste with sugar (Fandohan, 2007, p. 36). In eastern Sudan, people prepare an infusion or decoction (El-Kamali and El-Khalifa, 1999, p. 496), as they do in Togo (Adjanohoun et al., 1986cited inAnonymous, 1993). Children in Madagascar are given whole tamarind fruits for breakfast to overcome constipation but an anal wash based on tamarind may also be used (Boiteau, 1986 cited inAnonymous, 1993).

Strikingly, there are no clear records of tamarind fruits used as a laxative in East Africa.Mpande and Mpofu (1995)have found tamarind used in the treatment of gastro-intestinal disorders in Zimbabwe, but the plant part is not specified. While almost all accounts of tamarind use as a laxative refer to the use of its fruit, a macerate of its leaves with potash has been reported in northern Nigeria (Bhat et al., 1990) and the pastoral Maasai of Kenya use a decoction of the bark for calves (Ole-Miaron, 2003). In Benin, the fresh bark of young stems is macerated for 24 h and taken orally as a purgative or for abdominal pain (Fandohan, 2007).

1.1.8.2 Wound healing

Tamarind is often cited in literature concerning the treatment of cuts, wounds and abscesses. In general, wound healing is an important application of plant based traditional medicine in developing countries (e.g.Tignokpa et al., 1986). In Mali, over 80% of wounds are treated using traditional medicine compared to pharmaceuticals (Diallo et al., 1996cited inInngjerdingen et al., 2004).

Wounds are first washed with a decoction of a plant, followed by the application of dried powder of the species (Diallo et al., 2002; Inngjerdingen et al., 2004). As for tamarind, bark or leaves are most commonly used (Mali:Diallo et al., 2002; Benin:Fandohan, 2007; Mali:Inngjerdingen et al., 2004; Senegal:Kerharo and Adam, 1974), applied externally on the spot, either as a decoction or as a powder or poultice, alone or in combination with other species. A decoction of the leaves may be used to wash wounds and ulcers (Irvine, 1961; Kerharo and Adam, 1974), lesions or sores in the mouth (Tapsoba and Deschamps, 2006). Applying leaf powder to a wound is rather common (e.g.Inngjerdingen et al., 2004) and may be carried out to dry up open sores (Irvine, 1961). Fresh (Irvine, 1961) or boiled (Dalziel, 1937) leaf pulp can be applied as a poultice.

Some studies mention the use of the leaves alone (Nigeria:Fabiyi et al., 1993; Burkina Faso: Kerharo and Bouquet, 1950a; Kenya: Simitu and Oginosako, 2005, p. 19). In the medicinal plant market in Dakar, tamarind bark was mostly sold for wound healing purposes (Tignokpa et al., 1986). Occasionally other tamarind plant parts are found in wound healing medicine, like the fruit (Tapsoba and Deschamps, 2006), the pod husks (Kerharo and Adam, 1974)or the gum (Inngjerdingen et al., 2004). At the beginning of the century, leaves

were used as a dressing around circumcision cuts in Dagariland, Burkina Faso (Dalziel, 1937). Recently, the use of a leaf decoction to wash circumcision wounds was found in nearby Benin (Fandohan, 2007, p. 35).

The fact that tamarind leaves and bark are often mentioned in connection to wound healing does not automatically prove it is the most appreciated species for this purpose. In the Bamako region of Mali, for instance, tamarind was not among the 15 most important species used for wound healing (Diallo et al., 2002). In Dogonland, on the other hand, tamarind was the second most important ingredient in wound healing medicine. It was found in wound healing in 6 out of 22 villages, only to be supassedbyGuierasenegalensisthat was found in a total of nine villages (Inngjerdingen et al., 2004). In Bauchi state, Nigeria, a decoction of tamarind leaves was one of the most important agents to clean wounds caused by Guinea worm infections (Fabiyi et al., 1993).

The perceived medicinal effects of tamarind leaves (Fabiyi et al., 1993), bark (Kerharo and Adam, 1974; Tignokpa et al., 1986) and pod husks (Fl Congo Belgique iii438 cited inIrvine, 1961) relate to its anti-inflammatory activity and scarification or cicatrisation (the formation of scar tissue).

1.1.8.3 Abdominal pain

Abdominal pain is not a specific disorder but a complaint, indexed by Cook (1995), which refers to a painful abdomen and which may have a wide variety

of causes, including constipation or diarrhoea. Depending on the underlying cause, abdominal pain may be treated with various parts of Tamarindusindica. When a plant is recorded in the literature as a remedy to alleviate a painful or distended abdomen, this often implies that the actual problem was not stated. Knowing which plant parts of tamarind are used for which abdominal complaints without knowing their cause, we could turn the argument around and start probing for the disorder that has caused the abdominal pain based on the part of the tamarind used in the treatment. When fruit is used (Etkin and Ross, 1982; Ichikawa, 1987,p.34;Norscia and Borgognini-Tarli, 2006), constipation may have been the cause, assuming the fruit is given as a laxative. Bark treatments for abdominal pain in Nigeria (Doughari, 2006) could well refer to diarrhoea. When leaves are used, it is more difficult to assess what may have caused the abdominal pain. In East Africa this could be diarrhoea (Haerdi, 1964; Fleuret, 1986; Chhabra et al., 1987) whereas in West Africa, although atypical, leaves have been recorded as a laxative (Bhat et al., 1990) and macerated fresh bark of the young twigs was used both as a purgative and to relieve abdominal pain (Fandohan, 2007). Roots are repeatedly found in the treatment of stomach ache or painful abdomen, mainly in East Africa, prepared as an extract (Chhabra et al., 1987; Ichikawa, 1987; Geissler et al., 2002), but also in Burkina Faso (Kristensen and Balslev, 2003).

1.1.8.4Diarrhoea and dysentery

Other important disorders treated by tamarind include diarrhoea and dysentery. Dysentery is a kind of diarrhoea containing mucus or blood, usually caused by an infection of the intestine.

When diarrhoea is not treated accurately, the patient risks dehydration and death. In tropical countries, diarrhoea is one of the major health problems and frequently occurs during rainy weather (Heinrich, 1998cited in Gutiérrez et al., 2008). There appears to be a striking dissimilarity between West and East Africa in the treatment of diarrhoea. For West Africa, literature only mentions the use of the bark. It can be applied as a decoction (Dalziel, 1937; Kerharo and Bouquet, 1950a; Traoré, 1983; Keita and Coppo, 1993), pulped with lemon (Kerharo and Bouquet, 1950a) or macerated in milk (Keita and Coppo, 1993). In East Africa, it is not the bark but the leaf that is used (Fig. 3), made into a juice or beverage (Haerdi, 1964; Chhabra et al., 1987) or prepared in a concoction withSterculiaAfricana (Kokwaro, 1976). In Kenya the use of ground seeds

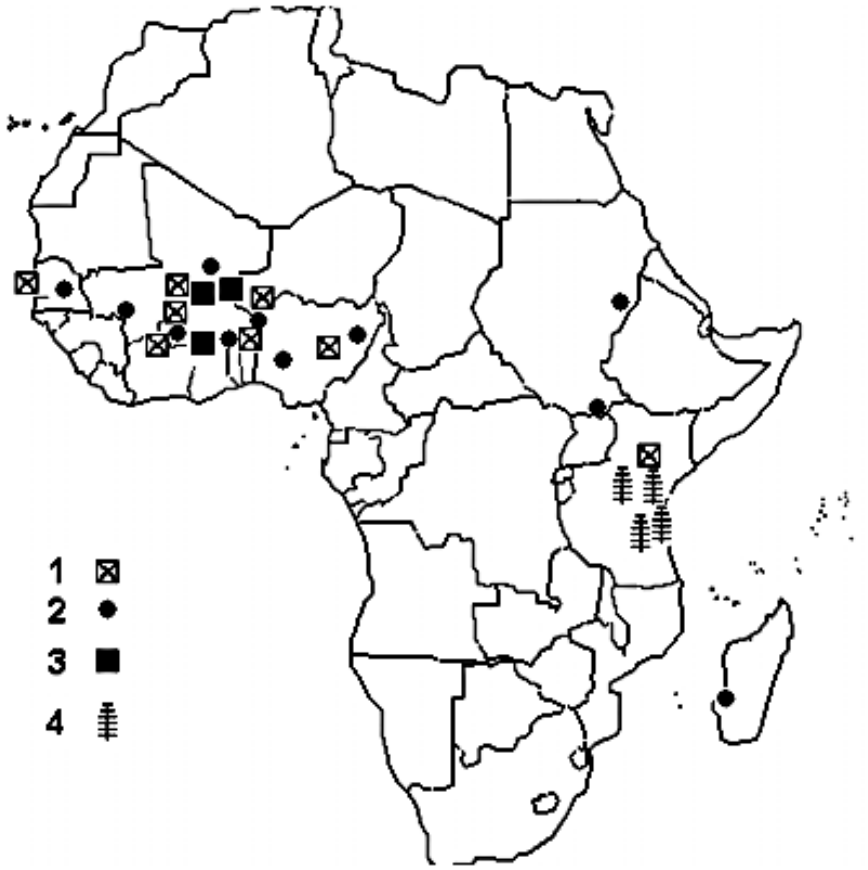

Fig. (1.2)Distribution of four common applications of tamarind in African traditional medicine.

The use of the fruits as a laxative is found from Senegal in the west throughSudan in the east and in the same range, fruits are used to treat fever and malaria. Leaves and bark are used everywhere in central West Africa for woundhealing, whereas only bark is used to treat diarrhoea. In East Africa, only leaves are found in diarrhoea medicine.

Key:

1: Leaves and/or bark used for wound healing.
2: Fruits used as a laxative.
3: Bark used to treat diarrhoea.
4: Leaves used to treat diarrhoea.

has been recorded (Simitu and Oginosako, 2005) and in Tanzania the root is used to treat dysentery (Chhabra et al., 1987).

1.1.8.5 Helminth infections (parasitic worms)

The bark is used in Dogon country (Traoré, 1983cited inFortin et al., 1990) and the Office du Niger area (Bah et al., 2006), both in Mali, to treat schistosomiasis (bilharzia), a worm infection of the gut or urinary tract.Inngjerdingen et al. (2004)confirm the use of the bark in Dogon country for helminth infections, but ascribe it to the treatment of internal wounds caused by the worms. Among the Guiziga and Moundang of Cameroun, crushed and boiled seeds of tamarind were mentioned most often for the treatment of 'red urine' or urinary schistosomiasis (Hewlett and Cline, 2001). In Zimbabwean traditional medicine, root extracts of two other Fabaceae(AbrusprecatoriusandPterocarpusangolensis) are important agents to treat schistosomiasis and have been shown to be lethal to schistosomes (Ndamba et al., 1994). The authors suggest, based on the doctrine of signatures, a link between the red colour of Fabaceae extracts and the main symptom of schistosomiasis: haematuria (bloody urine). Tamarind leaves are used in the extraction of Guinea worms in Nigeria, and afterwards in the treatment of wounds, left by the parasite (Fabiyi et al., 1993).Keita and Coppo (1993)describe another way in which tamarind is used as a vermifuge (literally 'worm-expulsor'), based on its laxative effect: "...Cettepréparationpeutprovoquerdiarrhée et evacuation d'eventuelsvers par les selles 4 (Keita and Coppo, 1993)". The preparation, a sour macerate of tamarind fruits and leaves ofCombretummicranthum, was applied as a laxative and for the expulsion of unwanted 'passengers'. In Ethiopia, a macerate of the seeds is used as vermifuge (Le Floc'h et al., 1985) and in Niger, it is the fruits that are used for this purpose (Adjanohoun, 1985;

Anonymous, 1993). An extract of the leaves and the root is used to treat ankylostomiasis (hookworm) in parts of Tanzania (Haerdi, 1964).

1.1.8.6 Fever and malaria

Fruits are known as a febrifuge in Madagascar (Norscia and Borgognini-Tarli, 2006) and throughout the Sudan (Dalziel, 1937).

In Benin (Fandohan, 2007) and Sudan (El-Kamali and El-Khalifa, 1999) the fruits are used to treat malaria. Malaria is treated with tamarind leaves in Ghana (Asase et al., 2005), Benin (Fandohan, 2007) and Nigeria (Bhat et al., 1990). The use of the fruit pulp as a febrifuge seems to be connected to its use as a laxative in the Sahel and Sudan regions. Both problems are not only treated with the same ingredient (e.g.Kerharo and Adam, 1974) all across the savanna belt from Senegal to Ethiopia, but also records of identical recipes based on tamarind fruit pulp exist for the treatment of malaria or fever and constipation. This is the case in Senegal (Dalziel, 1937), Benin (Fandohan, 2007) and Sudan (El-Kamali and El-Khalifa, 1999) where the recipe involves preparing a solution of tamarind pulp and water, sometimes involving a boiling step.

1.1.9Chemical composition of tamarind seed:

Morton (1987) indicated that the seed of tamarind contains approximately 63% starch, 14-18% albuminiods and 4.5-6.5% of semi drying oil. Seeds of the tree legume *tamarindusindica* were evaluated as a potential source of food or food ingredients (Marangoni et al.,1988). Crude protein and nitrogen free extract comprised 15.5% and 59% of the seed respectively. The crude fats present are 4.5% which contain a relatively large proportion of unsaturated

fatty acids. The principle sugars of the seeds are mannose glucose and ribose. Moisture, ash, and crude fiber were found as 9.4%, 3.2%, and 8% respectively

Yusuf et al., (2007) evaluated the nutrient content of the whole seed and seed nuts of tamarind, they found that 21.25-22.2% was crude protein, crude fiber was 2.33-3.82% moisture content was higher in seed nuts at about 19.9% the mineral content of the seed is higher than the seed coat.

The chemical composition of the whole seed of tamarindusindica as investigated by Ishola et al., (1990), Bhattacharya et al., (1993) and Moradetal., (1978) showed moisture content range between 9.4-11.3%, proteins 13.3-26.9% fat/oil 4.5-16.2% crude fiber 7.4-8.8%, total ash1.6-4.2%.

Ibrahim et al., (1959) in their evaluation of tamarind seed grown in Sudan found seven hydrocarbons in the unsaponifiable matter of seed and GLC of methylated fatty acids revealed the presence of Palmatic, Oleic, Linoleic, and eicoasnoic as the major fatty acids of the seeds.

1.2Seed oil:

The seed oil is golden yellow, semi-drying oil, which in some respects resembles groundnut oil. The major fatty acids were palmatic, oleic, linoleci, and eicosanoic. The lipids ctontained a relatively large proportion of unsaturated fatty acid, with linoleic acid (36-49%) in the highest concentration. Other major fatty acids are oleic acid (15-27%) and palmatic acid (12-20%) singh, 1973).

Seeds given an amber coloured oil, free of semll and sweet to taste, which resembles linseed oil (Watt, 1893). As in the pulp, the saponification is high, because it contains low molecular weight of fatty acids the iodine value of seed lipids is much lower than in pulp lipids suggesting lower unsaturation and probably higher stability of seed oil. Andriamanantena et al. (1983) evaluated the fatty acid composition of tamarind seed oil:palmatic (14-20%) Stearic(6-7%), Oleic(15-27%), Linoleic (36-49%), Arachidic (2-4%), Behenic (3-5%) and Lignoceric (3-8%).

Tamarind seeds also contain 6 to 8 percent of oil rich in unsaturated fatty acids. Due to the presence of unsaturated oil the tamarind starch develops yellow colour and rancidity which affects the quality of starch. Extraction of oil from starch, improves the latter's quality and utility and huge quantities of oil would also be produced. The oil is recovered from dehulled kernels by extraction after they are flaked or converted into cake by being passed in expellers. The oil is suitable for use in the production of soaps (IS9587.1980).

The seed kernel of tamarind contains 10-15% by weight oil with amber coulor, free of semll and sweet to taste, which resembles peanut oil, (Allen and Allen, 1981). It could be used for making varnishes, paints and burning oil in lamps (Watt, 1983). The oil is said to be palatable and of culinary quality (Morton, 1987).

The physicochemical properties of the oils were analyzed. The T. indica seeds contain crude oil and fatty acid.i.e.8% and 2.92% respectively (Balaji *et. al*, 2014).

1.3 Oil extraction:

Balaji et. al, (2014), reported study deals with extraction of oil by use of solvent extraction. Four main operating parameters affecting the solid liquid extraction of T. indica seeds were optimized based on the maximum oil yield. The optimum conditions for the lab scale solid liquid extraction was obtained at temperature reflux (around 80C°), extraction time 6*h*, solid to solvent ratio of 1:6w/v, agitation speed 100pm and ethanol as a solvent. Ethanol gives better oil yield compared to hexane, chloroform, methanol, isopropanol and petroleum ether. Based on the observations made above, it was concluded that ethanol, a green and safe solvent can be a better alternative to other solvents.

Andriamanantena*et.al*,(1983) extracted the oil with hexane and a mixture of chloroform and methanol; the yield was 6.0-6.4% and 7.4-9,0%, respectively.

1.4 Oil characterization:

Balajipanchal et. al,(2014) reported the results of physical and chemical properties of the ethanol extracted oil from T. indica seeds was greenish in colour. The Kinematic viscosity (40C°) was 38.0±00.1mm2/sec. Specific gravity (25c) was 0.911±0.40gcm3. Acid value was 0.5±0.02mgKOH/g. Iodine value was 95.00±40gI/100g. Saponification value was 186.10±0.30mgKOH/g. peroxide value was 4.61±0.30 mgo2/g. state of room temperature was liquid. As well is as determination free fatty acid composition (%) of T.indica seed oil by Gas Chromatography-Mass spectrometry (GC.MC) to be found Oleic acid (C18:1)0.19%, Linoleic acid (C18.2) 0.41%, Myristic acid (C14:1)1%, Luric acid (C12:0)0.32%, Octanoic acid (C8:0)0.3%, palmitic acid (C16:0)0.13%, Stearic acid (C20:0)0.06%, Behenic acid (C22:0)0.02%.

1.5Oil Uses:

In Bengal, the oil is used for making to paint idols (Rama Rao, 1975; Anon, 1976) and light lamps (Lewis and Neelakantan, 1964 a; Salim*et al*., 1998). The oil is said to be palatable and of culinary quality (Morton, 1987). In Indonesia, oil extracted from the seed is used as a hair dressing.

Research results indicate that the T. indica seed oil can be used as a potential alternative to nutritional food. Terminaliacatapa seed oil injection has been used in clinical trials for the treatment of rectal prolapsed in children (Balaji et. al,2014). After refining, the oil can be used as cooking oil. Also it can be used in the soap making

The production of new safe and functional martial, obtained by clean environmentally sound is a new goal of industry. Animal feed and fertilizers are traditional uses of by-productions. Theses by-products may be turned into functional components (flavor, pigment, antioxidants, antimicrobial preservatives, stabilizer and thickening agent), depending on different factors. Of these is the extraction technology applied, which must be highly efficient, mild, safe, clean and sustainable. Thus with an increasing interest in new oil sources, the seeds of wild plants including the tribal pulses receive more attention. (Janardhanan and Vadivel, 1994).

Human beings from time immemorial have been using plants for a multitude of purposes. Oils have been an integral part of human foods, being essential for health. Industrially, they play an important role in the development of different areas of chemical products, pharmaceutical, cosmetics, paints and most importantly, food(Atef, 2010). Oil are naturally occurring esters of long straight –chain carboxylic acid. They may belong to the saponifiable group (contain an ester group) of lipids. Lipids are biologically produced material that is relatively insoluble in water but soluble in polar and nonpolar organic

solvents. Edible oils are constituted of triacylglycerol molecules, mainly formed by unsaturated (oleic, linoleic. Linolenic acid etc.) and saturated fatty acids (palmiticacidstearic acid etc.) etserified to glycerol units (Aanderssonet., 2010).

Kernels have been used as a food either alone or with cereals. Tamarind kernel is used to devolving food products such as jelly and marmalades (Bhattacharya et. al, 1983). Rao and Subramanin (1984) and Marangoi et.al, (1988) have attempted to produce protein concentrates or cereals or meals from kernels proteins.

There is a lack of information in the literature about the utilization of the seed kernel in Sudan. The only tribes utilize the tamarind seed kernel are Acholi and Madi, in southern Sudan where it is added to cassava flour used to make porridge (Lawerance and Cirino, 1999). In northern Sudan it was concluded that tamarind kernels, considered as waste, can be converted in to a useful by-product, which can be used as a promising substitute source of pectin (Huda, 2009).

In Sudan the tamarind is found as a wild plant and was only used as a beverage especially in Ramadan month where, the seeds are discarded. The chemical composition of some of the indigenous plant of the Sudan including tamarind was evaluated, the seed was found to be rich in protein, sugar and potassium, thus can suffices the human needs and should be used as famine food (Abu Zaid,1999). The seed comprises the seed coat or testa (20-30%) and kernel or endosperm (70-75%)(Coronel, 1991;Shankaracharya, 1998). Tamarind seed is the raw material used in the manufacture of tamarind seed kernel powder (TKP), polysaccharide (jellose), adhesive and tannin.The

importance as an alternative source of protein, rich in some essential amino acids. Unlike the pulp the seed is a good source of protein and oil. There has been considerable interest amongst chemists, food technologists and nutritionists in the study of the properties of tamarind seeds. From this point of view, the by-product like tamarind seed can be used as a cheap source of oil to increase the added value of tamarind seeds. The oil yield, fatty acid composition and the physicochemical and quality characteristics of Tamarindusindica Linn seed oils obtained by solvent extraction were determined as well as optimized process conditions.

T. indica oil was tested for its physical and chemical properties including percentage of fatty acid, kinematic viscosity, saponification value. The stability of T. indica oil during storage at room temperature and during heat treatment was studied (Balajiet,al., 2014).

On other hand the chemical composition of the leaf oil of tamarindusindica L. was studied by GC\MS. Thirteen components were identified, of which limonene (24.4%) and benzyl benzoate (40, 6%) were most predominant (Jorge pion, Julio, Renato and Juan Aguero, 2002). Most research, on tamarind done in Sudan was on the pulp and for medicinal aspects. Khalid et,al,. (1007) investigated the potential of anti lesihmanailactivityof some Sudanese medicinal plants. The results indicated that the methanolic extract of tamarind failed to exhibit any significant anti-leshimania activity against leishmania at concentration less than 1oomg\ml. Mohmoud and Homeida(1994), indicated that a significant reduction was observed in the AUC plasma concentration versus time and C max (the peak plasma concentration) of chloroquine as a result of co administration with each of the three beverages (Tamarind, hibiscus and lemon), also a parallel reduction

in the drug anti-malarial efficiency was expected. Imbibe and Abu Alfutuh(1992) investigated the molluscicidal activity of tamarind pulp and found that the activity was greater in the sample extracted with methanol than with water, this was referred to the presence of saponins. Tamarindial extracted from tamarind pulp was found to have fungicidal and bactericidal properties (Imbabiet,al,.1992). El Sheikh (1987) studied the toxicity of certain Sudanese plants extracts, including tamarind, on the different stage of Schistosomamansoni. The tamarind extract showed toxic effect at50 ppm concentration for the maracidia and cercaria, while was highly toxic on the adult worm.

Research concerning the chemical, technological and usage of tamarind seed in Sudan are scarce. This research is investigating the proximate analysis of TamarindusIndica Seeds and Characterization of the seed oil could be considered as milestone and guide for further research.

1.6 Objectives of the study

This research is therefore to investigate the properties and characterization of the Tamarind indicia seeds oil. To achieve these objectives, the following steps were attempted:

- Sample preparation of Tamarind indica seeds.
- Proximate analysis of seeds(Fiber, Moisture, Protein, Ash, ICP).
- Extraction of oil from seeds by solvent extraction.
- Determination of some physiochemical properties of extracted oil.
- Determination of antimicrobial of the extracted oil.
- Determination the percentage of the vitamin C in tamarind juice.
- Identification of the major components of the oil using Gas Chromatography-mass spectroscopy.

2. Materials and Methods

2.1Chemicals:

- Potassium hydroxide(KOH) -99.9%- BDH chemicals ltd poole-England.

- Sodium hydroxide(NaOH)-99.6%. Lab tech chemicals.

- Sulfuric acid- 99.5%- d=1.84 g/cm^3- ALPHA CHEMIKA – India.

- Ethanol(CH_3CH_2OH)- 96%- African Modern Distillation for ethanol Sudan.

- Chloroform- 99.8% - Lab tech chemicals- India.

- Glacial acetic acid - 99%- d= 1.040 g/cm^3- S D fine chem limited – India.

- Hydrochloric acid (HCl)- 35%- d= 1.200 g/cm^3- ALPHA CHEMIKA – India.

- Sodium thiosulphate-98%- S D fine chem limited – India.

- Phenolphthalein indicator - S D fine chem limited – India.

- Starch- Chadwell health ESSEX – ENGLAND.

- Potassium iodide(KI)-66%- S D fine chem limited – India.

- Normal hexane-97%-d= 0.6606g/ml- Chevron philipes chemical company.

- Nitric acid(HNO_3)- 99.9%- d= 1.5129 g/cm^3 ALPHA CHEMIKA – India.

- Sodium chloride(NaCl)- . 99.9%- Lab tech chemicals.

-distilled water

2.2Instruments.

- Soxhelt extraction system (Duran UK)
- Sensitive balance(GH252) UK.
- Rotatory evaporator (Buchi Switzerland)
- Moisture analyzer (Dsh-50 -10Auto).
- Inductivity Coupled Plasma(ICP –OES725 ES)(Vista-MPX-CCD).
- Electric muffle furnace 575(TAPP T211 om-39

-Gaschromatography-Massspectrometer(GC/Mass)QP2010-Ultra'Simadzu Company-Japan.

2.3 Collection of samples and preparations:

Five newly harvested fruit samples of different sizes were collected from Ali Ibrahim shop for tamarind juice. the hard outer shells of the fruits were broken and the dark brown seeds were separated.

2.4 Proximate analysis:

2.4.1Oil content:

100 grams of Tamarind seeds were crushed to a coarse powder by using mortar and pestle. The coarsely powdered sample was successively extractedbyhexaneusingsoxhletextractor. Extraction was carried out for six hours till the colour of solvent at the last siphoning time turned colorless. Solvent was then evaporated under reduced pressure using rotary evaporator. The extracted oil was left in open beaker at room temperature for complete

evaporation of the solvent. The yield percentage was calculated as follow: Oil content= (Weight of oil obtained / weight of plant sample) X100%

2.4.2 Protein content:

(1g) of sample was weighted and transfer to a Kjeldahldigestionflask.(1g) of catalyst mixture (90% anhydrous sodium sulphate and 10% copper sulphate) were added followed by 3 ml conc. Sulphuric acid The flask was heated gently, cooled and digested into distilling flask with 15 ml of NaOH 40%soluation. (50ml) 0f boric acid solution and 3 drop of methyl red were placed in receiving flask. The distillation apparatus was connected up with delivery tub dipping below the boric acid solution. The distillate solution was titrated against o.1NHCL. The percentage of nitrogen was calculated: 1ml o.1 N=0.00014g N. and then crude protein was calculated using approximate factor Nx6.25.

2.4.3 Moisture content

About 2 grams of crushed seeds were analyzed by using Moisture analyzer device, the experiment was repeated three times and the average weights were recorded.

2.4.4 Ash content

Determination the total ash was preformed according Pearson (1968), by weighted out (5g) of the sample into platinum dish which had previously been ignited and cooled before weighted. Then the dish and content were ignited, first gently on fire and then on electric muffle furnace at 550^0C. The dish and content were transferred to desiccators for 1 0 minutes. Then the ash content was calculated as a percentage.

Ash content = $\frac{\text{weight of ash}}{\text{weight of sample}}$ x100%

2.4.5 Fiber content

Five gram of the extracted sample was dried in air and transferred to 500 ml conical flask. (200)ml of 0.0225N sulphuric acid was added and brought to boiling point.the content was filtered using Buchner funnel while it was hot, washed with (200) ml NaOH 0,313N and boiled gently to boiling point 30 minutes. Allowed to stand for 1 minute and then filtered through ash less dry weighted filter paper and washed with HCL 1%, hot water until free from acid and alcohol. Then dried at 105Ċ to constant weight. The paper and content was ignited at 550Ċ for 1 hour. The weight of the ash was subtracted from increase of weight in the paper and the difference is reported as fiber.

2.5 Physical properties:

2.5.1 Oil Density

The density of water was determined with help of density bottle, 5 ml capacity. The pre weighted and dried specific gravity bottle was filled with distilled water up to the mark and weighted accurately on sensitive balance. Then the gravity bottle was cleaned, dried and filed with oil to calculate the density of oil by the same method.

Density = $\frac{\text{Mass}}{\text{Volume}}$

Density of water= $\frac{\text{weight of water}}{\text{Volume o water}}$

Density of oil = $\frac{\text{weight of oil}}{\text{Volume of oil}}$ x density of water.

2.5.2Oil Color

The sample was already liquid, filtered through goash crucible No.3 to remove any impurities and the last trace of moisture to make sure that the sample wascompletely dried and free from impurities. The glass cell was cleaned with carbon tetrachloride and allowed to dry. Filled with the clear filtrated sample and placed in position in the tintometer, placed along side of it such red, yellow, blue or neutral Lovibond glass slides or any combinations of theses to match the coulor shade of the oil , the coulors of the oil and of the combination of the glassslide was observed through an eyepiece. Report the colour of the oil in terms of Lovibond unit as follows:

colour reading in cell =(ay+5bR)

where: -

a=the sum total of the various yellow(Y) slides used

b= the sum total of the various red (R) slide used.

2.6 Chemical properties:

2.6.1 Acid value:

One gram of oil was weighed and dissolved with 50ml of ethanol in a conical flask and about one milliliter of phenolphthalein indicator was added. The mixture was boiled for about five minutes and titrated to pin point end point with 0.1 N potassium hydroxide solutions. Acid value as calculated:

$$\text{Acid value} = \frac{56.1 \times V \times C}{W}$$

Where:

56.1: equivalent weight of KOH

V: the volume in ml of standard volumetric KOH solution used

C: is the exact concentration on KOH solution used (0.1N)

W: is the weight of oil (1g)

The calculations in terms of different fatty acids are as follows:

A) Free fatty acid in term of Oleic acid, % by weight = $\frac{28.2VN}{W}$

B) Free fatty acid in term of Lauric acid, % by weight = $\frac{20.0VN}{W}$

C) Free fatty acid in term of ricinoieic acid, % by weight = $\frac{29.8VN}{W}$

D) Free fatty acid in term of palmtic acid, % by weight = $\frac{25.6VN}{W}$

2.6.2 Saponification value:

2 g of oil were weighed into a 250-ml flask, 25 ml of the ethanolic of potassium hydroxide solution were added, and connected to reflux air condenser to the flask. Heated on a water-bath for one hour, boiled gently until the sample was completely saponified as indicated by absence of any oily matter and appearance of clean solution. After the flask and condenser had cooled One milliliter of phenolphthalein indicator solution was added, and titrated with standard hydrochloric acid. The blank was prepared and conducted to determination at the same time.

$$\text{Saponification value} = \frac{28.05\ (V2-V1)}{W}$$

V1: is the volume of titrant used in oil titration

V2: is the volume of the titrant used in blank titration

W: is the weight of the oil

2.6.3 Determination of Peroxide value

2.5 g oil samples were weighed in a 250 ml conical flask and 30 ml of solvent mixture (2:3) of chloroform and glacial acetic acid were added to the flask content was well Shaken, then Half ml of saturated potassium iodide (KI) solution was added to the solution and allowed to stand for 1 min thereafter, 30 ml of distilled water were added and titrated with 0.01N sodium thiosulfate solution using starch indictor until the yellow color was discharge. A blank was prepared alongside the oil samples.

$$\text{Peroxide value} = \frac{10\ (V2-V1)}{W}$$

Where:

V1: is the volume of titrant used in oil titration

V2: is the volume of the titrant used in blank titration

W: is the weight of the oil

2.6.4Determination of Ester value

Ester value was obtained by subtracting the acid value from saponification value.

2.6.5 Determination of Vitamin C content

50 mls of the saturated tamarind juice were prepared by dissolving excess grams of tamarind in 50 ml of distilled water, the solution was filtered andtransferred by pipette into 250 ml volumetric flask the solution was diluted to the mark with distilled water.10 ml of the solution was transferred into titration flask and 20ml of iodine were added and 1ml of starch. The solution wastitrated against thiosulphate (0.05N) solution the experiment was repeated three times until constant value was reached

Vitamin C $=\frac{B-s}{W}\times 0.0891\times 10$

Where:

B=is the volume of the titrant used in blank titration.

S=is the volume of titrant used in oil titration.

W= weight of sample.

2.6.6 Determination of minerals (ICP Analysis)

0.5g/50 ml of sample was burned for five hours by using furnace and then 5 ml of hydrogen peroxide and 5ml of nitric acid and 5 ml of hydrochloric acid were added.

Aprepared solution containing analyte elements is aspirated into the plasma generated by inductively coupled plasma source; the optimized elements produced characteristic emission spectral lines,which are separated by simultaneous optical spectrometer. The intensity of spectral line of an element is proportional to its concentration.

2.6.7 Determination of antimicrobial activity

2.6.7.1 Preparation of bacterial suspensions:

One ml aliquots of a 24 hours' broth culture of the test organisms were aseptically distributed onto nutrient agar slopes and incubated at 37º C for 24 hours. The bacterial growth was harvested and washed off with 100 ml sterile normal saline, to produce a suspension containing about 10^8- 10^9colony forming units per ml. The suspension was stored in the refrigerator at 4° C till used.

The average number of viable organisms per ml of the stock suspension was determined by means of the surface viable counting technique. Serial dilutions of the stock suspension were made in sterile normal saline solution and(0.02 ml) volumes of the appropriate dilution were transferred by micro pipette onto the surface of dried nutrient agar plates. The plates were allowed to stand for two hours at room temperature for the drops to dry and then incubated at 37 °C for 24 hours. After incubation, the number of developed colonies in each drop was counted. The average number of colonies per drop (0.02 ml) was multiplied by 50 and by the dilution factor to give the viable count of the

stock suspension, expressed as the number of colony forming units per ml suspension.

2.6.7.2 Preparation of fungal suspension:

The fungal cultures were maintained on sabouraud dextrose agar, incubated at 25 °C for four days. The fungal growth was harvested and washed with sterile normal saline and finally suspension in 100ml of sterile normal saline, and the suspension were stored in the refrigerator until used.

2.6.7.3 Testing of antibacterial susceptibility

Disc diffusion method

The paper disc diffusion method was used to screen the antibacterial activity of plant extracts and performed by using Mueller Hinton agar (MHA). The experiment was carried out according to the National Committee for Clinical Laboratory Standards Guidelines (NCCLS, 1999). Bacterial suspension was diluted with sterile physiological solution to 10^8cfu/ ml (turbidity = McFarland standard 0.5). One hundred microliters of bacterial suspension were swabbed uniformly on surface of MHA and the inoculum was allowed to dry for 5 minutes. Sterilized filter paper discs (Whatman No.1, 6 mm in diameter) were placed on the surface of the MHA and soaked with 20 µl of a solution of each plant extracts.The inoculated plates were incubated at 37 °C for 24 h in the inverted position. The diameters (mm) of the inhibition zones were measured.

2.6.8 Gas Chromatography-Mass spectrometry (GC-MS) analysis:

2.6.8.1 Sample preparation (Methylation):

2ml of sample was taken into test tube. (7 ml) of alcoholic sodium hydroxide that prepared by dissolving (2g) sodium hydroxide in 100 ml methanol was added.(7ml) of alcoholic sulphuric acid(1%) that prepared by mixing (1ml) conc. sulphuric acid+99 ml methanol was added. Then shacked for 3 minutes and left to overnight. (2ml) of saturated NaCl was added. Another (2ml) of hexane was added, shacked for 3 minutes and the hexane layer was collected.(5ml) from collected hexane was diluted with (5ml) diethyl ether and (1g) 0f sodium sulphate as drying agent. Filtered through syringe filter 0.45um.

2.6.8.2 Sample injection:

(1u1) was directly injected to GC.MS-QP2010 Ultra equipped with Rtx-5 MS, 30 m length, o.25mm diameter and 0.25ml thickness. The column temperature was kept at 60c for 10 min, with increase at 10c per min up to injector temperature 300c, split ratio 1:0, the carrier gas (Helium0flow rate 1.5 ml/min. the compound were identified by the GC-MS intensity of retention time (RT) and by comparison with those present in NISTIIS.LIB. the results were expressed as the relative percentage of each individual compound present in sample given by the corresponding RT.

3. Results and Discussion

3.1 Proximate composition of tamarindusindica seed

Table 1: Proximate chemical composition of tamarindusindica seed:

Test	Result%
Oil	3.53%
Moisture	8.38%
Ash	2.47%
Protein	20.78%
Fiber	5.04%

Tamarind seeds were analyzed for their chemical composition. The proximate chemical composition of tamarind sample was conducted to estimate the proximate composition hence; the data presented in table 1 shows the proximate composition of tamarind seed. The results were expressed on dry weight basis

The oil content value shown in table (1)was (3.53%) which is lower than the value of (4.5-16.2%) estimated by Isholaet. al., (1990)Bhattacharya et. al.,(1993) and Morad et.al., (1978) for whole seed.

The moisture content of tamarind whole seed was found to be (8, 38%). This value is lower than the value of (19.9%) reported by Yusuf *et.al.,* (2007), and lower than the range of (9.4-11.3%) found by Isholaet.al.,(1990), bhattacharya et. al., (1993) and Morad*et.al.,* (1978). According to Pearson (1968) classification of oil based on their moisture content, Tamarind seeds oil classification as semi-drying oil

The protein content of tamarind whole seed was found to be (20.78%) which is higher than the value (21.25-22.2%) evaluated by Yusuf *et.al.*, *(*2007), and lies within the range of (13.3-26.9%) investigated by Isholaet. *al.*, (1990), Bhattacharya *et.al.,* (1993) and Morad*et,al.,* (1978).

The ash content of tamarind whole seed was found to be (2.47%), which lies within the range of (1.6-4.2%) reported by Ishole*et.al.,* (1990), Bhattacharya *et.al.,* (1993) and Morad*et.al.*, (1978).

The fiber content value was (5.04%) is lower than the value (7.4-8.8%) reported by Ishole*et.al.,* (1990), Bhattacharya *et.al.,* (1993) and Morad*et.al.*, (1978) For seed.

3.2 physical and chemical properties of oil from T. indica seeds

Table 2: physical and chemical properties of oil from T. indica seeds:

Test	Result
Colour	Red =4.3 Yellow =7.3 Blue =3.5
Density	0.855g/cm3
Saponificatin value	196.6mgKOH/g
Peroxide value	17.2mgO2/g
Acid value	3.9mgKOH/g
Ester value	192.7mg/g
Free fatty acid	as Oleic acid = 1.9% as Lauric acid =1.4% as Ricinolic acid = 2.08% as palmitic acid =1.79%
Vitamin c	4.32mg/100g

Table (2) present the results of the physicochemical analysis of oil of T. indica was visually green with yellow in colour, liquid at room temperature ($30c^{o}$) and has density of $(0.855)gc^{3}$.

The saponification value (196.6)mgKOH/g is a higher than the value (186.10)found by Balaji Panchal et.al., (2014) such value indicates the

average molecular weight of triglycerides in the oil.High saponification value in tamarind oil suggests that, it could be used for production of soap.

The acid value (3.9) mgKOH/g which is higher than the value (0.5) reported by Balaji Panchal et.al., (2014) the acid value calculation lead to (1.97%)free fatty acid as Oleic acid, (1.4%) as Lauric acid, (2.08%) as Ricinoleic and (1.79%) as Palmitic acid.

The peroxide value was (17.2) mgO_2/g oil in *T. indica*, although it is acceptable for crude oil but it is relatively high.

3.3 Macronutrients contents of T. indica seeds

Table (3 -1)Macronutrients contents of T. indica seeds:

Elements	Concentration in seeds (ppm)
Na	7.080
K	4557
Ca	2017
Mg	1755
P	1399

Table (3-2)Micronutrients contents of T. indica seeds:

Elements	Concentration in seeds (ppm)
Co	0.0400
Cu	6.250
Fe	138.5
Mn	4.930
Mo	0.3600
Ni	1.280
Zn	22.21

Table(3-3)Toxic and hazardous elements inT.indica seeds:

Elements	Concentration in seeds (ppm)
Al	239.1
Ba	<0.0006
Cd	<0.0005
Cr	<0.0006
Li	<0.0007
Pb	<0.0013
Si	315.1
Sr	<0.0006
Ti	20.35
V	3.550

Mineral contents of T. indica seeds:

The results obtained by using inductively coupled plasma (ICP) analysis showed that the percentage ofheavy metals was: Cadmium <0.0005 ppm for the seeds. The concentration of trace elements in the seed were; Aluminum (239.1ppm) Barium (<0.0006 ppm) Cobalt (0.0400ppm), Copper (6.250ppm), Iron (138.5ppm), Manganese (4.930ppm), Sodium (7.080ppm), Vanadium (3.550 ppm), and Zinc (22.21ppm).

Jaspher(2016) reported that: Mineral element of tamarind seed have been determined. The concentrations of trace elementin the seed were;Iron(37.0mg/100g),Magnesium(21.8mg/100g)potassium(11.3mg/100g) , Zinc(13.2mg/100g), Sodium(168.4mg/100g),and Calcium(161.1mg/100g). The minerals concentration of the tamarind seed were characterized with high concentration of Sodium, calcium and magnesium [Na (168.4ppm), Ca (161.1ppm) and Mg (196.0ppm)] as shown in tables above(3-1)(3-2)(3-3).

Very highcontent of some toxic elements such as aluminum and silicon due to presence of wedges fungus that increase the absorption of these elements by tamarind tree.

3.4 Anti-microbial activity

The n- hexane extract of the shade seeds of *Tamarindusindiaca*. Are tested for the Anti-microbial activity.After the incubation the diameter of the resultant growth inhibition zones was measured, averaged and the results are summarized in table (4).

Table (4)antimicrobial activity of the n-hexane extract:

Bacterial and fungi	Zone of inhibition (diameter,mm)
Bacillus subtillis	-
Staphylococcusaureus	_
Escherichia coli	13
Pseudomonas aeruginosa	-
Candida albicans	14

The normal Hexane extract showed activity against the bacteria *Escherichia coli* and fungi*Candida albicans* See fig (5) (6)

1-14→ low activity

14-18 → Medium activity

18→ high activity

3.5 GC-MS analysis of the *T. indica*oil:-

The GC-MS analysis of the T.indica seed oil shown in figure 1, where seventeen components were identified. The fatty acid composition data presented in table 4 consist mainly of linoleic acid (44.956%) followed by oleic acid (23.98%), palmitic acid (11.948%), stearic acid (4.476%), arachidic acid (3.032%), octadecanoic (2.097%), myristic acid(0.1056%), palmitioleic acid (0.058%), margaric acid (0.051%) some other free fatty acids were detected as major component, while myristic acid which appear as main component in fatty acid analysis chromatogram reported by

BalajiPanchal*et,al* (2014). The detected levels of antinational fatty acid, behenic acid in T.indica (0.00%) is lower than the value (0.02%) reported by Balaji*et,al* (2014). Linoleic and linolenic acids are the most important essential fatty acids requited for growth, physiological functions and maintenance.

The values of some of the fatty acids were found to be different from that the earlier reported by Balaji*et,al* (2014), which found to be oleic acid (0.19%), Linoleic acid (0.41%), Myristic acid (1%), Luric acid(0.32egra%), Octanoicacid (0.3%), Palmitic acid |(013%), Stearic acid (0.4%), Lignoceric acid (0.14%), Arachidic acid (0.06%), Behenic acid ().02%) .

This could due to the variation in environmental conditions in which the plants were grown. The levels of fatty acids were known to vary largely with season and geographical location. The variation in the fatty acid composition and their percentages could be due to the fact that the plant seeds are from different ecological origin. The variation in the composition and oil yield observed in this study could be related to several factors for example changes in temperature, extraction and environmental effect. The composition of the fatty acids in the plant fruit seed oils studied showed presence of various components which may be of nutritive value since they contain appreciable quantity of essential fatty acid,which are long-chain polyunsaturated fatty acid derived from linolenic, linoleic and oleic acids, that play important role in human life.

These fatty acids play an important role in modulating human metabolism and reduce cholesterol levels, this suggests that tamarind oil may be useful as cooking oil.

Tamarind fruit contain 4.32mg/100ml of vitamin C content that are essential for skin care.

Table 5: Fatty acid composition (%)of*T. Indica* seed oil:

Fatty acid	Determined values(%)
Linoleic acid	44.956
Oleic acid	23.98
palmitic acid	11.948
stearic acid	4.476
arachidic acid	3.032
Octadecanoic	2.097
myristic acid	0.1056
palmitioleic acid	0.058
margaric acid	0.051
Docosanoic acid	1.988
Tetracosanoic acid	3.590

1.3 GC-MS chromatogram of Tamarindusindica seed oil:

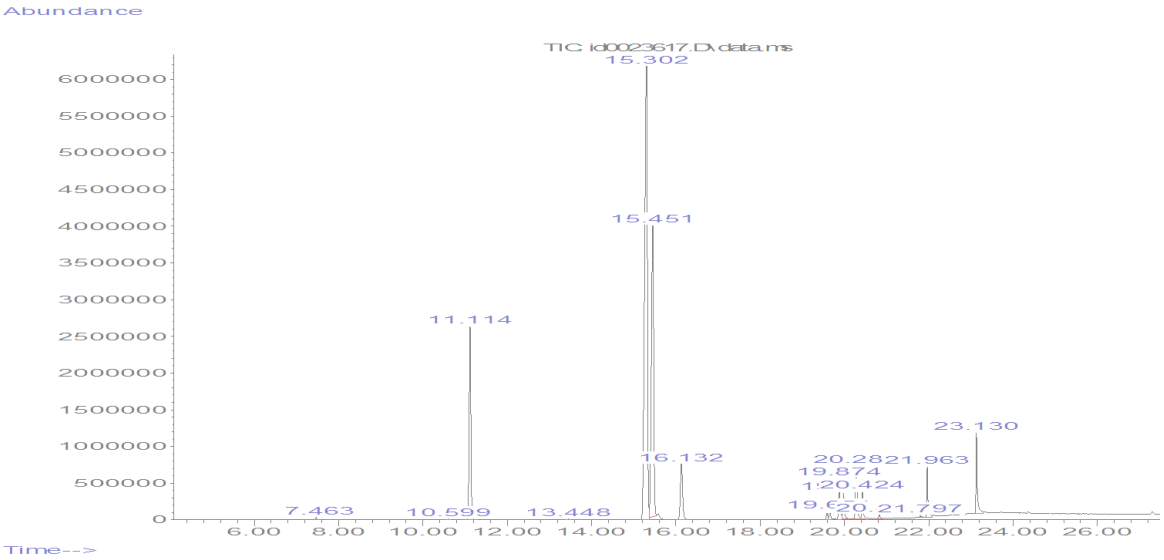

Table (6) GC-MS analysis result of tamarind oil

Component name	Method	AREA	AREA%
Methyl tetradecanoate	GC-MS	66638	0.1056
9-Hexadecenoic acid, methyl ester		36446	0.058
Hexadecanoic acid, methyl ester		7543048	11.948
Heptaecanoic acid, methyl ester		32245	0.051
10,13-Octadecadienoic acid, methyl ester		28381864	44.956
9-Octadecenoic acid,methyl ester		15138509	23.98
Methyl stearate		2826005	4.476
Methyl 2-octylcyclopropene-1-heptanoate		213010	0.337
Methyl 9-cis,11-trans-octadecadienoate		279997	0.444
Oxiraneoctanoic acid, 3-octyl-, methyl ester		1323632	2.097
cis-13-Eicosenoic acid, methyl ester		860732	1.363
Eicosanoic acid, methyl ester		1913904	3.032
9.cis.,11.trans.t,13.trans.-Octadecatrienoic acid,methyl ester		813269	1.288
6,9,12,15-Docosattetraenoic acic,methyl ester		138520	0.219
Methyl 11- docosenoate		43098	0.0683
Docosanoic acid, methyl ester		1255165	1.988
Tetracosanoic acid, methyl ester		2266717	3.590

Conclusions:

- Tamarind oil has good quality when compared with edible oils and also have potential for medicinal uses
- The physiochemical properties analysis of the oil show high saponification value (196.6mgKOH/g), and high peroxide value (17.2mgO_2/g).
- The GC-MS study identified seventeen components, of which linolice acid (44.956), is predominant, followed by Oleic acid (23.98), palmitic acid(11.984), and stearic acid (4.476), this indicate that the , the stability of the oil is high
- The obtained results showed that tamarind fruit and seeds have considerable contents of essential minerals that are, important for human health.
- Tamarind fruit containhigh content of vitamin (C).

Recommendations:

- Other simple and economic method of extraction, which can be effectively applied on wide area of industry.
- Different types of solvent may also be needed to show if there is any effect of solvent type on the oil extraction.
- More specific chemical and physical analysis may be required to obtain more details information about tamarind tree,fruit and seeds.
- Further research to evaluated effects of *T. indica*treatment on the anti-oxidant principle of extracted oil.
- Isolation of essential fatty acid component in the oil that has a great nutrition value.
- To encourage the research of other possible part of tamarind that contains percentage of oil, such as pulp and leaf.
- In Sudan no young tamarind trees are observed therefore real agricultural efforts out to be exertedfor keeping the growth of new generation of tamarind trees

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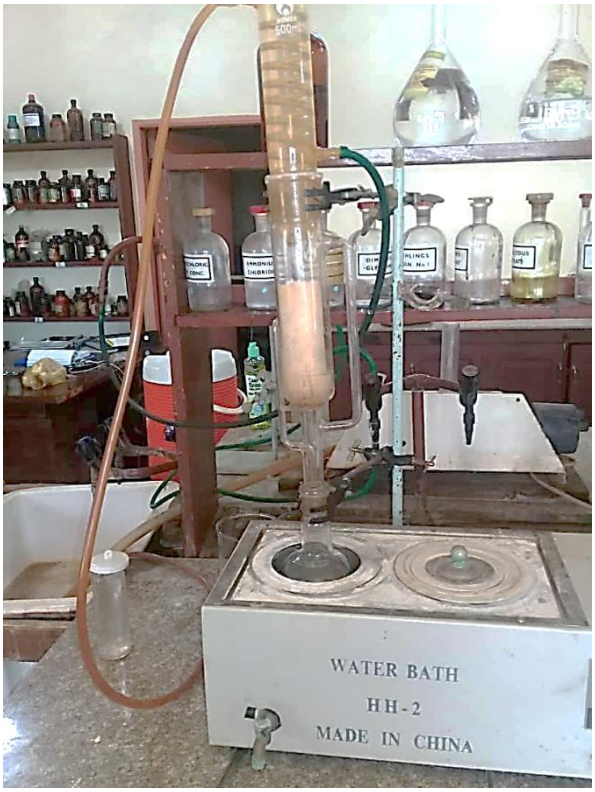
Appendix 1

Raw tamarind fruit

Tamarind seed sample

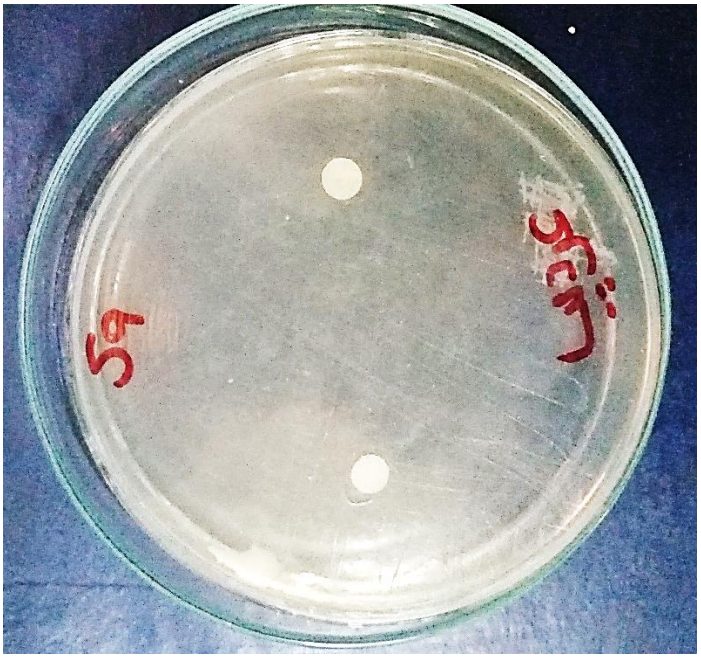
Tamarind powder sample



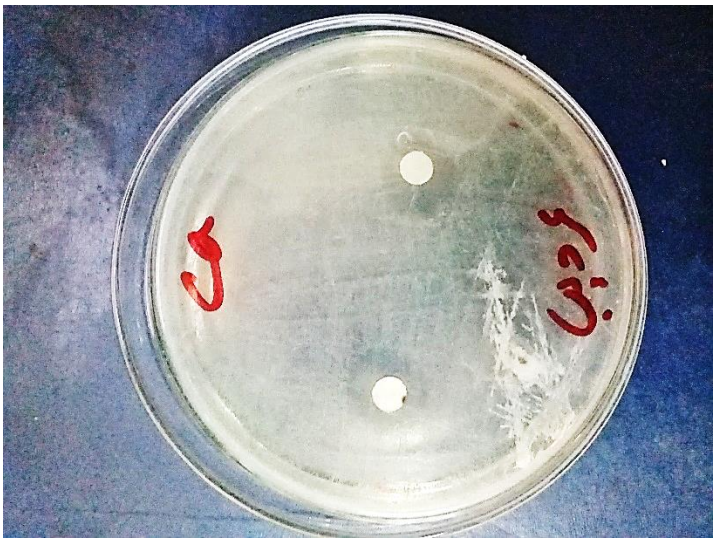
Start of extraction

extracted oil

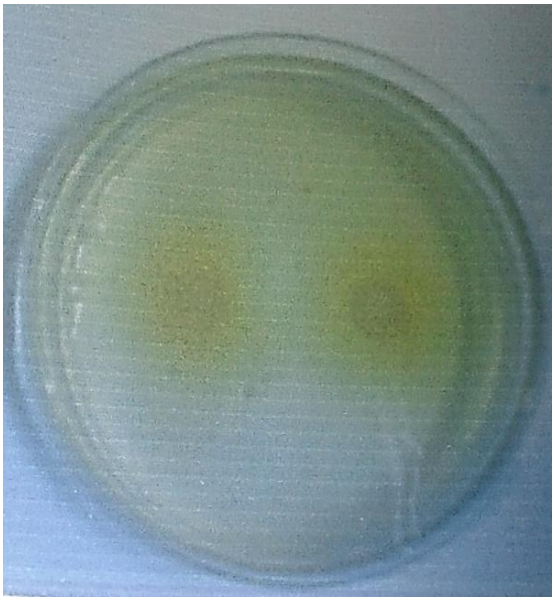
Appendix 2



Inhibition zone 0f n-hexane extract of the seed tamarindusindiaca against *Staphylococcusaureus.*



Inhibition zone 0f n-hexane extract of the seed tamarindusindiaca against*candidaalbicans*.



Inhibition zone of n-hexane extract of the seed tamarindusindiaca against*Escherichia coli*