Talukdar, AD, Basar, N, Nath, D, Saha, P, Nahar, L and Sarker, SD

Antioxidant property, traditional uses and chemical composition of seed oil plants of North-east India: A mini- review

Chemical composition, antimicrobial and antioxidant properties of seed oil plants of North-East India: A review

ARTICLE · AUGUST 2015

DOI: 10.5667/tang.2015.0010

8 AUTHORS, INCLUDING:

Sanjoy Singh Ningthoujam

Ghanapriya Women's College, Imphal, India

13 PUBLICATIONS **11** CITATIONS

SEE PROFILE

Manabendra Duttachoudhury

Assam University

97 PUBLICATIONS **148** CITATIONS

SEE PROFILE

Satyajit Sarker

Liverpool John Moores University

541 PUBLICATIONS **3,382** CITATIONS

SEE PROFILE

Norazah Basar

Universiti Teknologi Malaysia

20 PUBLICATIONS **36** CITATIONS

SEE PROFILE

TANG [HUMANITAS MEDICINE]

Review

Chemical composition, antimicrobial and antioxidant properties of seed oil plants of North-East India: A review

Priyanka Saha[1], Anupam Das Talukdar[1*], Sanjoy Singh Ningthoujam[1,2], Manabendra Dutta Choudhury[1], Deepa Nath[1,3], Lutfun Nahar[4], Satyajit Dey Sarker[4], Norazah Basar[4,5]

[1]Department of Life Science and Bioinformatics, Assam University, Silchar 788011, India; [2]Department of Botany, Ghanapriya *Women's College, Imphal, Mani*pur, India; [3]Department of Botany and Biotechnology, Karimganj College, Karimganj-788710. Assam India; [4]Medicinal Chemistry and Natural Products Research Group, School of Pharmacy and Biomolecular Sciences, Liverpool John Moores University, Byrom Street, Liverpool L3 3AF, UK; [5]Department of Chemistry, Faculty of Science, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia

ABSTRACT

Apart from being used as food, seed oils have also been used traditionally as medicinal products by several communities. However, the full medicinal potential of many seed oil plants is yet to be properly reviewed, particularly for their antimicrobial and antioxidant properties. North-East India has rich resources of seed oil plants. The availability of detailed information on these plants is quite limited. This review aims to explore and evaluate these seed oil plants of the North-East India with particular emphasis on their antimicrobial and antioxidant activities as well as chemical compositions. A comprehensive literature search on seed oil plants of this region has been performed. Seed oil yielding plants of this region can be categorized into two categories: plants that are used traditionally as sources of edible or medicinal oils and plants that are used for purposes other than as sources of oils. Many seed oil plants of this region have been reported to possess antimicrobial and antioxidant properties, and to produce various types of compounds. This review also highlights the importance of these plants in contributing to the local as well as the national economy of India.

Keywords antioxidant, antimicrobial, seed oil, chemical composition, North-East India, epidemiological study

INTRODUCTION

The beneficial uses of seed oil plants have been known since time immemorial. Apart from their uses as food items, oils extracted from seeds are also used for different purposes ranging from medicinal to biofuels. Their chemical compositions, physical and chemical properties generally determine their applications for different purposes.

Many microbial diseases worldwide have become a serious threat to human health because of the emergence of drug-resistant or multi-drug resistant (MDR) microbial strains (Tabassum et al., 2013). Emergence of resistance to the existing drugs (Rio s and Recio, 2005) led the scientists to search for the new alternatives including seed oil producing plants and their oil (Aktar et al., 2014), which are known for their antimicrobial properties. Several in vitro studies have been published confirming the effect of seed oils and their major compounds on pathogenic microbes (Burt, 2004). However, there are only limited data available on the antifungal activity of these seed oils against fungal pathogens.

Determination of antioxidant properties of seed oils is also significant in view of maintaining food quality and preventing many physiological problems such as oxidative stress related complications, liver cirrhosis, and cancer. Food deterioration may occur due to the presence of oxidation-prone ingredients in food items (Shukla et al., 1997). One of the current approaches to prevent this oxidative degradation is addition of natural antioxidants in food items. It is also believed that natural antioxidants can stabilize or deactivate the free-radicals. In living cells, free-radicals may incorporate highly reactive oxygen and attack healthy cells through a range of biochemical reactions (Aluyor and Ori-Jesu, 2008). These free-radical initiated reactions may subsequently lead to cancer initiation and accelerated ageing process. Plant seed oils are reported to possess antioxidant properties that can prevent oxidative stress. The antioxidant property of seed oil is generally attributed to the presence of triglycerides and various natural antioxidant components in them. Formerly, very little or no attention was given to seed oil producing plants as a source of antioxidants (Schmidt et al., 2005). However, in recent years, renewed focus on seed oils as sources of novel antimicrobial and antioxidant compounds has been observed (Jarret et al., 2011).

The region of North-East India is endowed with two biodiversity hotspots of Indo-Burma and Eastern Himalayas. This region consists of eight states of India-Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. Many oil-rich seed bearing plants grow in this region in wild or in cultivated conditions. People residing in this region are using these plants for wide-ranging purposes including consumption as food items and also for medicinal

*Correspondence: Das Talukdar Anupam
E-mail: anupam@bioinfoaus.ac.in
Received May 8, 2015; **Accepted** August 17, 2015; **Published** August 31, 2015
doi: http://dx.doi.org/10.5667/tang.2015.0010

Table 1. List of plants with oil yielding seeds traditionally used in North-east India with their antioxidant compound (1)

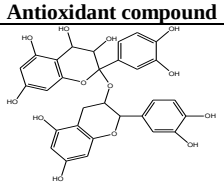
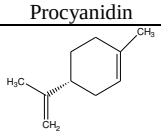
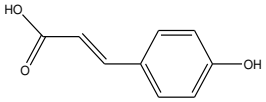
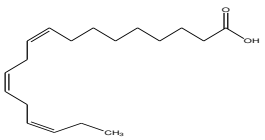
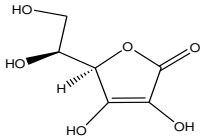
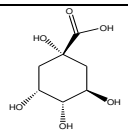
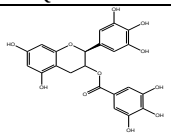
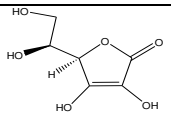
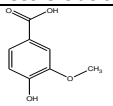
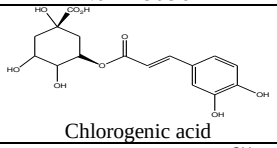
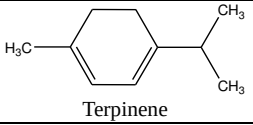
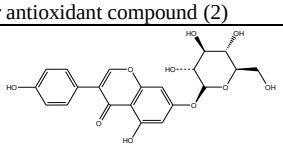
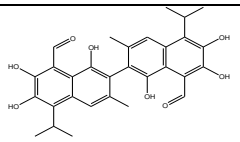
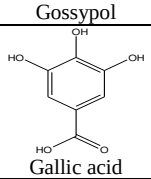
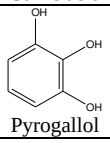
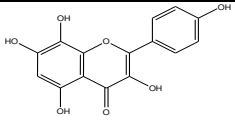
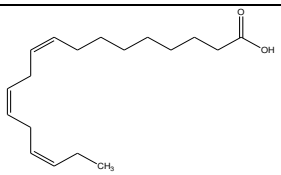
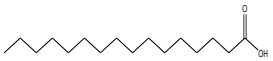
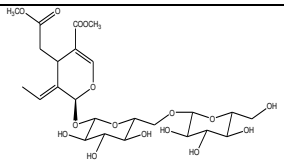
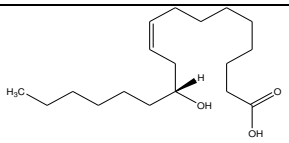
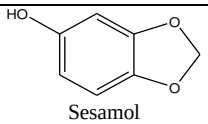
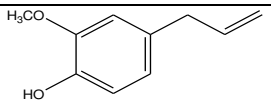
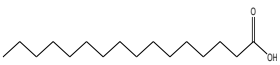
Name of plant	Local name	Location	Types of uses	Main chemicals	Antioxidant compound	References
Abelmoschus esculentus (L.) Moench.	Lady's finger (ENG) Bhendi (ASM), Bhelandri (MNI)	Assam, Manipur, and Nagaland	Food, food supplement	Oleic acid, linoleic acid, palmitic acid, and palmitoleic acid	 Procyanidin	Jarret et al., 2011; Robert et al., 2011
Isomeles indica (L.) Kuntze	Bon til (ASM), Thoiding Angouba (MNI), Uneimias(KHS)	Assam and Manipur	Medicinal	D-Limonene, D-α-thujone, and 1-8, cineole	 D-limonene	Islam, 2009
Arachis hypogaea L.	Leibak Hawai (MNI) Mungphali (HIN)	Assam, Manipur	Food	p-Hydroxybenzoic, p-coumaric, syringic ferulic, and caffeic acids	 p-coumaric acid	Bennioin, 1995; Hoppe et al., 1997; Murakami et al., 1984; Schmidt and Pokorný, 2005
Brassica juncea (L.) Czern.	Kadugu, Rai (HIN), Indian mustard (ENG)	Assam	Cosmetics	Oleic and linolenic acids	 Linolenic acid	Amarowicz et al., 1996; Amarowicz et al., 2000; Fukuda et al., 1986a, b; Saikia et al., 2006
Brassica rapa L.	Hanggam (MNI)	Assam, Manipur	Food, biofuel	Sinapine, esters of phenolic acids	 L-ascorbic acid	Amarowicz et al., 2000; Chopra et al., 2002; Dahanukar and Thatte, 1989; Fukuda et al., 1986; Gopalakrishnamn et al., 2003; Schmidt and Pokorný, 2005
Capsella bursa-pastoris (L.) Medik.	Shepherds purse (ENG)	Assam, Manipur	Medicinal	Quinic acid, palmitic acid, and β-sitosterol	 Quinic acid	Dutta and Sarma, 2011; Grosso et al., 2011; Finley et al., 2011
Carthamus tinctorius L.	Kusum (BEN), Kusumlei (MAN)	Assam, Manipur	Food supplement, medicinal	Hydroxybenzoic, p-coumaric, and cinnamic acids	 Gallocatechin	Arnao et al., 2001; Nzaramba et al., 2009; Valko et al., 2007
Cocos nucifera L.	Naariyaal (HIN), Yubi (MNI)	Manipur, Tripura	Food, medicinal	Lauric, oleic, and stearic acids	 Ascorbic acid	Bennion, 1995; Oliveira et al., 2009; Schmutterer, 2003; Saikia et al., 2006
Croton tiglium L.	Croton (ENG)	Assam	Fish Poison	Phorbol	 Vanillic acid	Kaushik and Agnihotri, 2000
Diploknema butyracea (Roxb.) H.J.Lam	Chiuri (NEP)	Arunachal Pradesh, Sikkim, Tripura	Food	Palmitic and oleic acids	 Chlorogenic acid	Applewhite, 1978; Kankha et al., 2010; Majumder et al., 1998
Dysphania ambrosioides (L.) Mosyakin & Clemants	Tersing Pambi (MNI)	Arunachal Pradesh, Manipur	Medicinal	Limonene, p-cymene, and terpinene	 Terpinene	Chopra et al., 2002; Islam, 2009; Sowemimo et al., 2007

Table 1. List of plants with oil yielding seeds traditionally used in North-east India with their antioxidant compound (2)

Glycine max L.	Nung Hawai (MNI)	Assam, Arunachal Pradesh, Manipur	Medicinal	Syringic, vanillic, ferulic, salicylic, p-coumaric acids, and esters of caffeic and sinapic acids	 Genistin	Hoppe et al., 1997; Howell, 1996; Wang et al., 2002
Gossypium arboreum L.	Lasing (MNI), Cotton (ENG)	Assam, Mizoram, Manipur, Nagaland	Medicinal	Sinapic, ferulic, p-hydroxybenzoic acids, quercetin, and rutin	 Gossypol	Deorani and Fennema, 1985; Hron et al., 1999; Kazeem et al., 2013
Helianthus annuus L.	Numitlei (MNI)	Manipur, Meghalaya	Food	Chlorogenic, caffeic, p-hydroxybenzoic, p-coumaric, and cinnamic acids	 Gallic acid	Ingale and Shrivastava, 2011; Leung et al., 1981
Juglans regia L.	Walnut (ENG), Heijuga (MNI)	Sikkim	Food, medicinal	β-Tocopherol, γ-tocopherol, and δ-tocopherol	 Pyrogallol	Clara et al., 2000; Joanna et al., 2003; Li et al., 2007; Ozcan, 2009
Linum usitatissimum L.	Alsi (HIN), flax (ENG)	Arunachal Pradesh, Mizoram	Food supplement, medicinal	Omega-3, sinapic, p-hydroxybenzoic, coumaric, ferulic acids, and lignans	 Herbacetin	Amarowicz et al., 1994
Madhuca longifolia (J.König ex L.) J.F.Macbr.	Mahua (BEN)	All states of North-east India	Biofuel, medicinal	Oleic, linoleic, palmitic, and stearic acids	 Linoleic acid	Marikkar et al., 2010
Mesua ferrea L.	Nag champa (HIN)	All states of North-east India	Industrial	Palmitic, oleic, and stearic acids	 Palmitic acid	Choudhury et al., 1998; Sayeed et al., 2004; Sowemimo et al., 2007
Olea europaea L.	Olive (ENG)	Manipur, Arunachal Pradesh	Food, medicinal	Hydroxytyrosol, Secoiridoids, and oleuropein	 Nüzhenide	Paiva-Martins et al., 2011
Ricinus communis L.	Kege (MNI), Endebelai (BOD)	Manipur, Assam	Fuel	glycerides of ricinoleic acid	 Ricinoleic acid	Amarowicz et al., 1994
Sesamum indicum L.	Thoiding (MNI),	Assam, Manipur, Tripura.	Food	Lignans, and coumaric, ferulic, vanillic and sinapic acids	 Sesamol	Fukuda et al., 1986a, b; Schmidt and Pokorný, 2005
Syzygium aromaticum (L.) Merr. & L.M.Perry	Laung (MNI)	Meghalaya, Mizoram,	Food, medicinal	Eugenol, butylated Hydroxytoluene, and butylated hydroxyanisole	 Eugenol	Aluyor and Ori-Jesu, 2008; Jarret et al., 2011; Seongwei et al., 2009
Tetranthera angustifolia (Blume) Nees	Black samson (ENG)	Arunachal Pradesh	Medicinal	Palmitic and stearic acids	 Palmitic acid	Aluyor and Ori-Jesu, 2008; Shukla et al., 1997

ASM – Assamese; BEN- Bengali; BOD – Bodo; ENG – English; HIN – Hindi; KHA – Khashi; MNI – Manipuri; NEP – Nepali; MIS – Mishmi.

applications. Enumeration of traditionally used seed oils in this region may help in highlighting the associated biochemical properties. Moreover, exploring those plants, which are not traditionally used by the people, could open up a new vista for production of seed oils having antioxidant properties. To the best of our knowledge, there is no up-to-date review published on the seed-oil plants of North-East India focusing particularly on their antimicrobial and antioxidant potential as well as their chemical compositions. Therefore, this mini review aims to review and document traditionally used and unused seed oil plants of North-East India and also to look into their chemical compositions with special emphasis on antimicrobial and antioxidant properties.

METHODS

A shortlist of the seed oil yielding plants from the region of North-East India has been prepared from published literature, both from printed and electronic resources. Scientific names reported in the form of synonyms were standardized by cross checking with the Plant List (www.theplantlist.org). A comprehensive survey of literature was performed using the electronic databases, viz., PubMed (http://pubmed.ncbi.nlm.nih.gov), Science Direct (www.sciencedirect.com) and Google Scholar (http://scholar.google.com) as well as various printed sources. Only experimentally verified chemicals were considered and their antioxidant properties were compared with records from PubChem (http://pubchem.ncbi.nlm.nih.gov) and CHEMBL (https://www.ebi.ac.uk/chembl) databases.

RESULTS

Seed oil yielding plants reported from North-East India have been categorized into (i) seed oils traditionally used by the ethnic communities for their oils, and (ii) seed oils not traditionally used by the ethnic communities, but used for other plant parts.

Seed oil plants traditionally used in North-East India

A total of 26 seed-bearing plants from North-East India have been reported for their traditional and commercial uses in this region (Table 1). Vegetable oils, predominantly seed oils, are generally procured from seeds, nuts or fruits by means of traditional processing techniques, such as the net variety system, the steam distillation, hydrodistillation technique and so on.

Seed oils not traditionally used in North-East India

There are further 38 seed oil yielding plants that grow in North-East India, but their oils are not traditionally used by the indigenous people (Table 2). In certain cases, other plant parts are used by the people of the region. Scientific extraction and utilization of oil from these could enrich the seed oil resources of the region.

Among these plants, Nigella sativa seed oil, popularly called as 'Black seed oil' (Islam et al., 2009), is composed mainly of oleic, palmitic, and stearic acids, phytosterol, stigmasterol, and stearic acid. Neem plant (Azadirachta indica), generally found in various parts of the North-East India, is not used for its oil, but for other purposes. The seed oil of this plant has been studied extensively for the presence of triterpenoids and especially azadirachtin (Copping, 1995). Other bioactive compounds present in this oil include campesterol, α-sitosterol, and stigmasterol. Canola oil is another distinctive variety of rapeseed oil, which contains erucic acid, can be used as edible oil for use in salad dressing and other allied purposes.

Usage categories of seed oils in North-East India

Seed oil producing plants reported from North-East India are used for wide-ranging purposes including uses as edible oils, various industrial items and as an alternative source of energy. Traditional uses of seed oil plants can be categorized into biofuel, cosmetics, fish poison, medicinal, food, food supplement and industrial uses. Most of the uses of the seed oil are for medicinal purposes, followed by use as food. Main consumption pattern of these seed oil plants have been highlighted in the following sections.

Edible oils

Consumption as edible oils is one of the most important and popular uses of plant-seed oil. The commonly used plant seeds oils from North-East India include mustard, sunflower, safflower, and coconut oil. Mustard oil is cultivated from different species of the mustard family (Brassicaceae), such as Brassica juncea, Brassica nigra, Brassica rapa, etc.

Sunflower oil is a mixture of monounsaturated and polyunsaturated fatty acids extracted from sunflower. Although not used by the people of North-East India in the past, the plant is now cultivated in many parts of this region for seed oil.

Another important seed oil bearing plant is Safflower, which produces two types of oil - one containing high monounsaturated fatty acids (oleic acid) and the other having high polyunsaturated fatty acids (linoleic acid). Oil containing monounsaturated fatty acids is mainly used for edible purposes, while the linoleic acid rich oil is used for painting and industrial purposes. Coconut oil is also used for edible purposes in this region.

Rice bran oil is the bi-product of milling and it is emerging as important edible oil in this region. Although it was not used in the past, nowadays its popularity has increased considerably because of its health benefits.

Food supplements

The food supplements are generally the substances that give full source of carbohydrate and protein, and provide resistance against microbial attack and improve the immune system. Only three species of seed oil yielding plants in North-East India (Abelmoschus esculentus, Carthamus tinctorius, and Linum usitatissimum) are used as food supplements. Abelmoschusesculentus, because of its oil and protein content, is recognized as a source of nutritional supplement. Due to the presence of unsaturated fatty acids such as linoleic acid, this oil is good for human consumption (Adelakun et al., 2009).

However, there are many other plants available in North-East India, which can be used as food supplements. For example, evening primrose seeds, which are generally used for the extraction of oil, are crucial for dietetic purposes (Tabassum and Singha, 2013). Extracted meal is rich in phenolics. Soybean or peanut grits, flours, pastes are regularly used in many other parts of the world as food stabilizers. In certain cases, walnuts, poppy seeds, which are rich in edible oil, are occasionally consumed as food ingredients, flavourings, salad-dressing and addictive.

Medicinal

In North-East India, 15 different plant seed oils are used as medicinal materials. Rapeseed oil obtained from Brassica rapa is used as laxative. In the traditional medicine, this oil is used as antiscorbutic, embrocation, and to treat muscular rheuma tism, stiff neck, dengue, fever, bronchitis, etc (Tenore, 2011).

Table 2. List of NorthEast Plants with oil yielding seeds which are not traditionally used (1)

Name of oil	Name of plant	Local name	Location	Important constituents	Uses	References
Pomegranate seed oil	Punica granatum L.	Kaphoi (MNI)	Northern India	Myristic and margaroleic acids	Medicinal	FAO ,2009 Schubert et al., 1999
Rice bran oil	Oryza sativa L.	Rice (ENG), Chawaal (HIN)	Assam, Brahmaputra valley	Oryzanol, and palmitic, oleic and linoleic acids, and tocopherols	Food	Craker, 2004
Neem seed oil	Azadirachta indica A.Juss.	Nim (BEN), Vembu (TAM)	Assam, Eastern Himalayas, Manipur	Linoleic, hexa decanoic, and α-linolenic acid	Biopesticide	Islam, 2007; Schmutterer, 1995
Tobacco seed oil	Nicotiana tabaccum L.	Tobacco (ENG) Tupakka(TAM)	Andrapradesh, Karnataka, West Bengal,	Glyceride, phospholipids, sterols, tocopherols	Biofuel	Frega et al., 1991; Usta, 2005; Zlatanov and Angelova, 2007
Rubber seed oil	Hevea brasiliensis (Willd. ex A. Juss.) Müll. Arg	Rubber (ENG)	Assam, Madras	Oleic, linoleic linolenic, and glutamic acids	Fuel	Eka et al., 2007; Ramadhas et al., 2005
	Calophyllum inophyllum L.	Nagchampa (BEN)	Maharastra	Coumarins	Fuel, anti-HIV	Dutta and Sarma, 2011; Spino et al., 1998; Sowemimo et al., 2007
	Thevetia peruviana (Pers.)	Captain cook tree(ENG), yellow leander(ENG), lucky nut (ENG)	Eastern foothills of the Himalaya	Linoelaidic, linoleic, and α-linolenic acids	Fuel, biopesticides	Deka and Basumatry, 2011; FAO, 2006; Grosso et al., 2011; Kareru et al., 2010
Hemp oil	Cannabis sativa L.	Hemp,marijuana (ENG), dagga (AFR)	Gujrat, Karnataka	Linoleic, linolenic, stearidonic, eicosaenoic acids, β-sitosterol, and cannabinoids	Medicinal, biopesticides, fuel	Al-Khalifa et al., 2007; Lampi et al., 1997; Tambe et al., 1996
Corn oil	Zea mays L.	Corn (ENG), bhutta (BEN)	Jammu and Kashmir, Gujrat, Bihar, West Bengal	Campesterol, campestanol, sitosterol, stigmasterol, and sitostanol	Food, fuel	Johnson and Lusas 1983; Juyoung et al., 2010.
Bitter gourd oil	Momordica charantia L.	Bitter gourd or bitter melon (ENG), karela (BEN)	Assam, West Bengal	Apiole, trans-Nerolidol, and β-bisabolol	Antidiabetic, Medicinal	Anjum et al., 2013; Braca et al., 2008; Craker, 2004; Simionatto et al., 2005
Pumpkin seed oil	Cucurbita pepo L.	Pumpkin (ENG), kumra (BEN)	Assam, West Bengal	Linoleic, linoleinic, and palmitic acids	Prevents prostate cancer, purifies blood	Ardabili et al., 2011; Elmatbaea, 2006
Atermelon seed oil	Citrullus vulgaris Schrad. ex Eckl. and Zeyh.	Tarmuj (BEN), tarbuj (HIN), kalinda (TAM)	Assam, Gujrat, Rajasthan	Linoleic and stearic acids	Cooking, frying, food supplement	Mabaleha, 2007; Milovanović and Jovanović, 2005
Black seed oil	Nigella sativa L.	Black seed (ENG), kalonji (GUJ), black cumin (ENG), kala jeera (BEN)	Gujrat, South India	Oleic, palmitic, stearic acids, and phytosterol	Medicinal	Jeet et al., 2007
Amaranth oil	Amaranthus cruentus L.	Bari (ASM), rajgira (HIN), Chaulai (BEN)	Bihar, Uttarpradesh	Linoleic and linolenic acids, and lysine	Medicinal, regeneration of brain cells	He et al., 2003
Apricot oil	Prunus armeniaca L.	Chuli (LAD) Khubani (URD)	Himalayan Ladakh in the Jammu and Kashmir	Aarachidic, ecosenoic, linoleic, stearic, and palmitoleic acids	Medicinal, food supplement	Dwivedi and Ram, 2006
Ben oil	Moringa oleifera Lam.	Horseradish tree (ENG), ben oil tree (ENG), drumstick tree ENG)	Tamil nadu, Kerala	Behenic and oleic acids	Cosmetics	Burkill, 1996.
Borneo tallow nut oil	Shorea robusta Gaertn. f.	Sal (BEN), Salwa (HIN), Guggilu (MAR), rala (MAR)	Assam, Karnataka, Mysore	Arachidic, Oleic, linoleic, palmitic, and stearic acids	Cosmetics, woodings, flavouring agent	Bakkali et al., 2008
Cocklebur oil	Xanthium strumarium L.	Cocklebur (ENG), broad bur (ENG), burdock datura (ENG)	Gujrat, karnataka	Monoterpernes, sesquiterpenes	Medicinal	Pandey and Rather 2012; Scherer and Godoy, 2009

Table 2. List of NorthEast Plants with oil yielding seeds which are not traditionally used (2)

Coriander seed oil	Coriandrum sativum L.	Cilantro (ENG), dhania (BEN), Phadigom (MAN)	Assam, Meghalaya	Petro selenic acid	Food and food supplement	Mabaleha et al., 2007
Kenaf seed oil	Hibiscus cannabinus L.	Shougri (MAN), Ambaadi (MAR), Mesta (BEN)	Assam, Manipur	Linoleic, α-linolenic, and oleic acids	Biofuel, cosmetics, vegetable oil	Hopkins et al., 1959; Mishra et al., 1992; Mohamed et al., 1995
Papaya seed oil	Carica papaya L.	Papita (HIN), pepe (BEN), papaya (ENG)	Assam, West Bengal	Free fatty acid, crude fibre,	Food and nutritional value	Afolabi et al., 2011; Fokou et al., 2009
Perilla seed oil	Perilla frutescens (L.) Britton	Perilla (ENG)	Gangtok, the Himalayas	Apigenin, chrysoeriol, luteolin, and rosemarinic and caffeic acids	Medicinal	Kwon et al., 2002
Poppyseed oil	Papaver somniferum L.	Poppy seed (ENG), posto (BEN)	Assam	γ-Tocopherol, campesterol, stigmasterol and sitosterol	Medicinal	Huda et al., 2001; Le, 2009
Taramira oil	Eruca sativa Mill.	Tara mira (HIN), rocket salad (ENG)	Haryana, Madhya Pradesh, Punjab, Rajasthan	Erucic, palmitic, and linolenic acids	Medicinal	Miyazawa et al., 2002; Lazzeri et al., 2004
Tea seed oil	Camellia sinensis (L.) Kuntze	Tsubaki (ASM) Tea (ENG) Cha, chai (HIN), Thayilai (TAM)	Assam, Darjeeling	Palimitoyl oleoyl glycerol	Medicinal, cosmetic industry	Pholen and Pohtee, 2011
Tigernut oil	Cyperus esculentus L.	Chufa sedge (ENG), nut grass (ENG), yellow nutsedge (ENG), tigernut sedge (ENG)	Florida	Linoleinic, palmitic, myristic, and esteiric acid	Medicinal and cosmetics	Abano and Amoah, 2011; Arafat et al., 2009
Tomato seed oil	Lycopersicon esculentum (L.) Karsten	Tomato (ENG)	Meghalaya, Sikkim	Palmitic acid	Medicinal	Canella and Castriotta, 1980
Pongamia oil	Pongamia pinnata (L.) (Pierre).	Honge (KAN), Karanja (HIN)	Himalayan ranges	Arachidic, behenic, eicosenoic, linolenic, lignoceric, oleic palmitic and stearic acids	Biofuel	Scott et al., 2008
Vernonia oil	Vernonia anthelmintica (L.) Willd	Ironweed (ENG)	Uttar Pradesh	Arachidic, behenic, eicosenoic, and vernolic acids	Industrial use	Edgar et al., 2002
Pine nut oil	Pinus kesya. Rai Dellenia	Pine seed or cedar nut (ENG)	Meghalaya, Sikkim, Uttarakhand	Palmitic, pinolenic, and stearic acids	Medicinal use	Lee et al., 2004
Carrot seed oil	Daucus carrota L.	Carrot (ENG), gajar (BEN)	Assam, Meghalaya	Aromadendrene, Farnesene levomenol, vitamin A aldehyde, isolimonene	Medicinal	Bulow and König, 2000
Chaulmoogr oil	Hydnocarpus kurzii (King) Warb.	Nirati (ASM), Chaulmugra (HIN)	Arunachal Pradesh, Manipur, Tubaraka	Isogadolic acid	Medicinal	Gunstone, 2002
Cuphea oil	Cuphea carthagenensis [Jacq.] Macbr.	Cuphea (ENG), cigar plant (ENG)	Central Asia	Capric acid	Industrial, biofuel	Winthrop and Terry, 2006
Mango oil	Mangifera indica L.	Aam (BEN), mango (ENG)	Assam, Barak valley, West Bengal	Arachidic, linoleic, oleic, palmitic, and stearic acids	Medicinal, food industry	Mahale and Goswami, 2011
Rose hip seed oil	Rosa moschata J. Herrm.	Lemon Myrtle, Lemon Scented Myrtle, Lemon Ironwood (ENG)	Karnataka, Sikkim	Linoleic acid	Cosmetics industry, medicinal	Moris, 2006
Beech nut oil	Fagus sylvatica L.	Copper beech, Purple beech (ENG)	Europe, North America	Linoleic, oleic, and palmitic acids	Edible oil, Medicinal	Gunstone, 2002
Cashew oil	Anacardium occidentale L.	Kaju (BEN, HIN)	Karnataka, Malabar coast, Kerala, Tamilnadu	Triglycerides, tocopherols, and linoleic acid	Foods and food supplement	Aremu, 2006; Eromosele and Paschal, 2002
Almond oil	Prunus mygdalus Batsch.	Almond (ENG)	Malabar coast	Linolineic and palmitic acids	Food and cosmetics industries	Jenkins et al., 2002; Mandalari et al., 2010

Table 2. List of NorthEast Plants with oil yielding seeds which are not traditionally used (3)

Grape seed oil	Vitis vinifera L.	Aangoor (BEN), Grape (ENG)	Jammu and Kashmir, uttarakhand	Linoleic, oleic, and palmitic acids	Cosmetics industry	Decorde et al., 2009; Nash, 2004
Argemone Oil	Argemone mexicana L.	Mexican poppy (ENG), Mexican prickly poppy (ENG), Flowering thistle (ENG)	Assam, Manipiur, Tripura	Columbamine, dehydrocorydalmine, jatrorrhizine and oxyberberine	Medicinal	Willcox, 2007

AFR – African; ASM – Assamese; BEN- Bengali; ENG – English; HIN – Hindi; KAN – Kannada; MAR = Marathi; MNI – Manipuri; TAM – Tamil; URD – Urdu; LAD – Ladhaki.

Cocos nucifera is used in various parts of this region for treating cholera and as a nutritional supplement (Deorani and Shama, 2007). In other parts of the world, it is also used as an aphrodisiac, diuretic, and to treat loss of hair and debilitating diseases, fever and urinary disorders (Chopra et al., 1996). Croton tiglium is recognized as fish poison in North-East India as well as in other parts of India (Amarowicz et al., 2000). However, jayphala oil obtained from this plant is used as a purgative, irritant, cathartic and in snake-bites in other parts of India (Chopra et al., 1996).

Trachyspermum ammi is found in North-East India, but not traditionally used. However, ajwain oil obtained from this plant is used for the treatment of abdominal pain, bronchial problem, diarrhoea, dyspepsia, and hemorrhoids (Jeet et al., 2007). Likewise, Ocimum americanum, Syn Ocimum canum (tulsi) is a ubiquitous plant in North-East India, (Burt, 2007), particularly in Assam and Manipur, but tulsi oil is not used widely in this region. However, its usage has been reported in other parts of India for its anti-stress, antioxidant, immunomodulatory and anti-radiation properties. This oil appears to have the potential for prevention and treatment of cancer (Burt, 2007).

Methi seed oil, obtained from Trigonella foenumgracecum, is used as carminative, tonic, aphrodisiac, dysentery and to treat smallpox (Parekh and Chanda, 2008). Medicinal properties of the plant seed oils are generally attributed to the presence of various constituents of polyphenols, carotenoids, tocopherols, tocotrienols, ascorbic acid, and thiols.

Biofuel

There are some instances of using plant seed oils as biofuel by the traditional people in the North-East India (Yuan-Chuen and Huang, 2008). Oils extracted from mustard seeds, coconut and castor are used for religious and ritual purposes (Tenore et al, 2011). Whilt large scale extraction of seed oils for their uses as biofuel is still in its infancy, seed oil plants are slowly emerging as an important sources of biofuel and starting to pave the way towards new sources of non-renewable energy. To meet the ever-increasing demands for energy, attempts have been made to produce biodiesel from variety of plants, mainly non-edible plants found in North-East India. Calophyllum inophyllum, Hevea brasiliensis, Jatropha curcas, Madhuca indica, and Pon gamia pinnata are just a few examples (Gogoi et al., 2011).

Cosmetics

A variety of plant seed oils have been providing the essential ingredients for various cosmetics since time immemorial. In spite of the presence of many plants in North-East India, traditional use of seed oil for cosmetics is rather rare. However, oil from Brassica juncea is mixed with the extracts of Cynodon dactylon and Curcuma longa to produce skin care products and cosmetics in some parts of Assam (Saikia et al., 2006). Considering the abundance of seed oil plants in this region, one might foresee an emerging trend in using these seed oil producing plants as a source of essential components of cosmetics in industrial scale. Seed oils from grape, papaya and mulberry may also be considered for use in cosmetic industries

Table 3. Smoke points of some plant seed oils used in North-east India

Oil	Smoke Point (°C)
Mustard oil	254
Sunflower oil	227
Safflower oil	107
Coconut oil	177
Rice bran oil	254

Industrial uses

There are no reported traditional industrial applications of seed oils in the region. Despite that, seed oil growing in this region, can be utilized for industrial purposes, from painting to lubricant industries. Camellia sp., growing abundantly in Assam, has its future in oil industry (Kaplowitz and Tsukamoto, 1996). Vegetable oils obtained from soyabean and castor, can be used as transformer coolant oils (Schmidt and Pokorný, 2005). Palm oil can be used in isolation as a fluxing dip in the tin plating in steel industries, while olive oil can be used as a yarn lubricant (Kaplowitz and Tsukamoto, 1996).

Chemical properties and characteristics of seed oils

Chemical characteristics of seed oils generally depend on the fatty acid composition. Presence of other compounds provide unique characteristics of seed oil. Mustard oil is characterized by the pungent odor owing to the presence of allyl isothiocyanate, which serves as defence against herbivores. This compound is stored inside the compartment of the plant cells in the form of glucosinolate (Ratzka et al., 2002). Mustard oil contains generally high amount of monounsaturated fatty acids, such as erucic acid and oleic acid, and lower amounts of polyun satu rated fatty acids comprising omega-3 α-linolenic acid and omega-6 linoleic acid. This oil also contains a little amount of saturated fats, sinapines and esters of phenolic acids (Schimdt and Pokorny, 2005).

Main components of sunflower oil are linoleic, oleic, palmitic, and stearic acids (Gunstone, 2011). Sunflower oil can be categorized by the amount of oleic acid present, high oleic acid sunflower oil (containing more than 70% of the total fatty acids) and mild oleic acid sunflower oil (containing less than 70% of the total fatty acids. Other important components are chlorogenic, caffeic, p-hydroxybenzoic, p-coumaric and cinna mic acids (Amarowicz et al., 2000). In other parts of the world, sunflower oil is used in manufacturing solid sunflower butter. Nowadays people prefer refined product of this oil for edible purposes. Though linolenic acid and linoleic acids are important for human nutrition, they may cause oxidative instability in the oil (Wang, 2002).

Coconut oil exists as solid in room temperature because of its relatively high proportion of saturated fatty acids (92%) particularly lauric acid (Adelakun et al., 2009). Important fatty acid generally includes capric acid, caprylic acid, lauric acid, linoleic acid, myristic acid, oleic acid, palmitic acid, and stearic acid (Chowdhury et al., 2007). Palm, olive, cottonseed, peanut, and sunflower oils are classed as oleic-linoleic acid oils contain high proportion of unsaturated fatty acids, such as

Table 4. Fatty acid constituents of some major seed oil found in North-east India

Name of oil	Oleic acid	Palmitic acid	Linolenic acid	Stearic acid	Linoleic acid	Omega-3-fatty acids	Omega-6-fatty acids	Trans-Nerolidol	Petro-selenic acid	Erucic acid	Lauric acid	Myristic acid	Palmitoleic acid	Arachidic acid
Mustard oil	+	+	+	+	+	+	-	-	-	+	+	-	+	-
Sunflower oil	+	+	+	+	+	-	-	-	-	-	+	+	+	-
Jatropha oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coconut oil	-	-	-	-	-	-	-	-	-	-	+	+	-	-
Groundnut oil	+	+	-	+	+	-	-	-	-	-	-	+	+	+
Sesame oil	+	+	+	-	+	-	-	-	-	-	-	-	-	-
Flaxseed oil	-	-	+	-	-	+	-	-	-	-	-	-	-	-
Rice bran oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corn oil	-	-	+	-	+	-	-	-	-	-	-	-	-	-
Safflower oil	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bittergourd oil	-	-	-	-	-	-	-	+	+	-	-	-	-	-
Tomato seed oil	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Soybean oil	-	+	+	+	+	-	-	-	-	-	-	+	-	-
Cotton seed oil	-	+	-	+	-	-	-	-	-	-	-	+	+	-

the monounsaturated oleic acid and the polyunsaturated linoleic acid (Dunn, 2005). Other oils are categorized as the erucic acid oils, which are similar to oleic linoleic acid oils except their unsaturated fatty acid. Rapeseed and mustard seed oils are important oils of this class.

A brief summary of various compositions of fatty acids in the seed oils is given in Table 4. Castor oil (a hydroxy-acid oil), another important oil of this class contains glycerides of ricinoleic acid. Melting point of the specific chemical ingredient plays an important role in maintaining the particular bioactivity expression among the seed oil plants. Mustard oil, proved to be more effective than corn oil, because of the presence of omega-3-polyunsaturated fatty acid in it and also experimentally found effective in preventing color tumor in animals (Dwivedi and Ram, 2003).

Rice bran oil has high content of free fatty acids, wax, and unsaponifiable matter (Shin and Kang, 2001). Its beneficial effects in the health improvement are due to the presence of compounds such as oryzanol, tocotrienols and squalene (Kochhar, 2002). Rice bran oil has high stability in their structure, probably due to the combined effect of oryzanol, phytosterols, squalene, tocopherols, and tocotrineols (Kochhar, 2002).

Antimicrobial properties of the seed oil plants of North-East India

A fair amount of data on the antimicrobial activity of many seed oil producing plants of North-East India is available (Avancini et al., 2000). The phenolic component of the seed oil plants are generally known for their antimicrobial activity. The possible mechanisms of action of natural compounds present in these seed oil plant involves disintegration of cytoplasmic membrane of the bacterial cell, destabilization of the proton motive force (PMF), electron flow, active transport, and coagulation of the cell content (Burt, 2004). The structure of these seed oil compounds disintegrates the external membrane of Gram-negative bacteria, releasing lipopolysaccharides (LPS), and increasing the permeability of the cytoplasmic membrane to ATP. Analysis in the antimicrobial activity of black pepper, clove, garlic, ginger, and green chilli on the human pathogenic bacteria viz. Bacillus subtilis, Enterobacter aerogenes, E. coli, P. aeruginosa, S. aureus, S. epidermidis, S. typhi, and Shiguella flexneri revealed that, aqueous garlic extract was sensitive against all the bacterial pathogens. Many plants are reported to possess not only the antimicrobial activity but also the resistance modifying ability (Shrestha and Tiwari, 2009).

The terpene content of the oil plays crucial role in the antifungal activity. These seed oil plants exhibit cytotoxic and phototoxic activity leading to fungicidal or fungistatic property (Rios and Recio, 2005). Similarly, inhibitory effect of clove extracts have been studied by Sakagami and Kajimura (2000) on the production of verotoxin by E. coli. However, in that study, couple of other plants were also found active against both Gram-positive and Gram-negative bacterial strains.

Mycotoxins mediated diseases, chronic, subchronic, and acute can be treated by seed oils, but their effectiveness depends on the frequency and route of administration and dose of the oils. The other factors include the age, sex the time, and the climatic condition of the plants producing the fixed oils (Table 4).

Cytotoxicity

Studies on C. albicans revealed that the seed oil of F. capillaries not only could inhibit the fungal growth but also could initiate morphological transformations thereby provoking depolarizeation of the mitochondria with the reduction of the membrane potential affecting Ca^{2+} cycle (Tenore et al., 2011). As a result, the proton pump and the ATP pool was affected and the cell death occurred by apoptosis or necrosis. In the yeast cell, the ergosterol constitutes the most abundant sterol which is responsible for maintaining the cell function and integrity (Rodrigouez et al., 1985). The component of the oil of F. capillaries could act on the sterol biosynthesis pathway thereby inhibiting the cell growth by inhibiting the ergosterol biosynthetic enzyme, lanosterol 14α-demethylase. Thus, seed

Table 5. Antimicrobial Activity of the Seed Oil Plants of Northeast India (1)

Name of plant	Biological activity	Mode of action	Therapeutic use	Causative organism	Reference
Abelmoschus esculentus (L.) Moench.	Antibacterial activity	Inhibition of the membrane transport system	Diarrhoea	Bacillus subtilis Staphylococcus aureus Pseudomonas fluorescens	Carvalho et al., 2012
	Antipyloritic activity		Gastritis, Pepticulcer diseases	Helicobacter pylori	Olorunnipa et al., 2013
Anisomeles indica (L.) Kuntze	Anti HIVactivity	Cytotoxic effect to the host cell	AIDS	HIV	Baranwal et al., 2012
	Anti bacterial activity		Gastric, peptic cancer	Helicobacter pylori	Wang, 2002.
Arachis hypogaea L.	Antibacterial activity	Increases the apoptotic pathways	Food poisoning	S. aureus S. epidermidis S. subflava	Shobolev, 2012 Parekh and Chanda, 2008
Brassica juncea (L.) C zern.	Antibacterial activity	Cell Lysis	Food poisoing, Indigestion	V. parahaemolyticus	Yuan and Huang, 2005
	Antifungal activity	Inhibition of the tube formation	Candidiasis, Aspergillosis Sleeping sickness	Aspergillus niger, A. flavus, Trichoderma viride, Candida albicans	
Brassica rapa L.	Antibacterial activity	Modification In the membrane transport system	Dysentry, Dyspepsia,	Gram-positive bacteria Staphylococcus aureus L. monocytogenes Enterococcus faecalis	Tenore et al., 2011
	Antifungal activity	Inhibition in the germ tube formation	Food poisoning	Gram-negative bacteria P. aeruginosa Klebsiella pneumoniae	
			Aspergillosis	Moulds Aspergillus flavus	
			Botrytris	Botrytis cinerea C. herbarum	
			Candidiasis	Yeasts Candida albicans	
Capsella bursa-pastoris (L.) Medik.	Antibacterial activity	Inhibiton of the virulence factor	Oral infection, Dental caries	S. mutans S. sanguis A. viscosus	Soleimanpour et al., 2013.
		Cell wall Lysis	Food poisoning constipation	E. faecalis	Raad et al., 2013.
Carthamus tinctorius L.	Antibacterial activity	Cellwall Lysis Inhibit the proton pump probably	Duodenal and peptic ulcers	Helicobacter pylori	Moghaddam, 2011
Cocos nucifera L.	Antibacterial activity	Cell wall Lysis	Stomach infection, Bowel syndrome	S. aureus	Bankar, 2011 Silva, 2013
Croton tiglium L.	Antibacterial activity	Rapture of the cell membrane	Cough, Skin disease, tooth ache, Paralysis, diarrhoea, dysentery	Mycobacterium smegmatis, Staphylococcus aureus, Bacillus subtilis	Upadhyay et al., 2010.
	Antifungal activity	Inhibition of spore formation	Candidiasis	Candida albicans	
Diploknema butyracea (Roxb.) H.J.Lam	Antibacterial activity.	Cell wall Lysis of the bacterial cell	Diarrhoea, dysentery	Staphylococcus aureus, Bacillus subtilis	Thapa et al., 2013
Dysphania ambrosioides (L.) Mosyakin and Clemants	Antibacterial activity	Inhibition in the protein synthesis	Dysentery Bowel syndrome	B. subtilis Staphylococcus aureus	Ávila-Blanco et al., 2014, Boutkhila et al., 2009

Table 5. Antimicrobial Activity of the Seed Oil Plants of Northeast India (2)

Gaultheria fragrantissima Wall.	Antifungal activity	Mycelial growth Inhibition leakage of the specific ion, Inhibition of the Carbohydrate metabolism	Food borne diseases Food spoiling Food poisoning	Fusarium solani	Shrestha and Tiwari, 2009
Glycine max L.	Antibacterial activity	Cell lysis	Digestional infection	Bacillus subtilis Pseudomonas aeruginosa	Ponnusha et al., 2011
Gossypium arboreum L.	Antibacterial activity	Modification in the membrane transport	Pneumonia Cough, fever	Staphylococcus aureus P.aeruginosa Klebsiella pneumoniae	Saidu and Abdullahi, 2011
Helianthus annuus L.	Antifungal activity	Mycelial growth inhibition	Aspergillosis Food poisoning	Aspergillus niger, Aspergillus flavus,	Rajakannuet al., 2013; Sankaranarayanan et al., 2008
	Antibacterial activity	Cell wall rupture	Dyspepsia dysentry	E.coli Streptobacillus sp.	
Impatiens amplexicaulis Edgew.	Antibacterial activity	Alteration in the membrane transport system	Peptic ulcer Gastritis dyspepsia	Helicobacter pylori	Qayum et al., 2012
Juglans regia L.	Antibacterial activity	Cell wall Lysis, Stoppage of the replication process	Food borne diseases,	Gram positive Bacillus cereus B. subtilis, Staphylococcus aureus Gram negative P. aeruginosa Escherichia coli Klebsiella pneumoniae	Oliveira et al., 2008; Pereira et al., 2007
	Antifungal activity	Inhibition of spore formation	Eye infection, Skin infection	Candida albicans C. neoformans	
Lindera neesiana (Wall. ex Nees) Kurz	Antibacterial activity	Inhibition of the protein synthesis	Diarrhoea	B. subtilis, Staphylococcus aureus	Luitel et al., 2014
Linum usitatissimum L.	Antipyretic activity	Disruption of cell membrane	Typhoid	Salmonella typhi	Kaithwas and Mazumder, 2013
Madhuca longifolia (J.König ex L.) J.F.Macbr.	Antibacterial activity	Modification in the proton pump	Food poisoning Desentry	Gram positive Staphylococcus aureus Bacillus subtilis	Kalaivani and Jegadeesan, 2013
		Cell wall Lysis	Cough	Gram negative Escherichia coli P. aeruginosa	Sarma et al., 2013
	Antifungal activity	Inhibition of membrane bound enzyme	Skin infection Aflatoxicosis	Fungi Aspergillus oryzae Aspergillus niger	
Mesua ferrea L.	Antibacterial activity	Inhibition of membrane permeability	cough,diarrohea, dysentery, dental caries, anemia, fever, piles	Lactobacillus arabinosus Staphylococcus Aureus Shigella spp.	Chahar et al., 2013; Tambekar et al., 2010 The et al., 2013
Olea europaea L.	Antibacterial activity	Cell wall Lysis	Dysentery	Enterococcus feacalis Bacillus cereus	Fiaza et al., 2011
	Antifungal activity	Reduced mycelia growth	Ringworm Superficial mycosis	Alternaria alternaria Aspergillus fumigates Cladosporium herbarum	Pereira et al., 2007
Ricinus communis L.	Antibacterial activity	Inhibition of cell wall synthesis	Food borne disease	Bacillus subtilis	Naz et al., 2012
	Antifungal activity	Attack on fibroblast and endothelial cells	Aflatoxicosis Aspergillosis	Aspergillus fumigatus Aspergillus flavus	

Table 6. Antioxidant components in seed-oil bearing plants of North-east India

	Probable Mechanism	Seed oil	References
Flavonoids	Chelation with metal ions, scavenging or quenching free-radicals or inhibition of enzymatic systems responsible for free-radical generation	Helianthus annuus L.	Fukuda et al., 1986a, b; Leung et al., 1981
Lignans	Scavenging hydroxyl radicals	Sesamum indicum L.	Schmidt and Pokorný, 2005.
Cinnamic acid derivatives	Scavenging free radicals	Carthamus tinctorius L.	Asgarpanah and Kazemivash, 2013; Valko et al., 2007
Tannins	Act as primary antioxidant by donating hydrogen atom or electrons; also as secondary antioxidants. They chelate metal ions like Fe (II) and interere with one of the reaction steps in the Fenton reaction thus retarding oxidation	Glycine max L.	Amarowicz et al., 1996; Hoppe et al., 1997; Wang, 2002
Coumarins	Radical scavenging effect	Helianthus annuus L	Leung et al., 1981
		Arachis hypogaea L.	Chang et al., 2006
		Carthamus tinctorius L	Asgarpanah and Kazemivash, 2013; Valko et al., 2007
Tocopherols	Free radical scavengers	Juglans regia L.	Joana et al., 2003; Li et al., 2007
Polyfunctional organic acids	React with transition metals forming complexes, thus preventing catalytic effect of the metals in the oxidation reaction	Ricinus communis L.	Amarowicz et al., 1994
		Linum usitatissimum L.	Amarowicz et al., 1994
		Brassica rapa L.	Cartea et al., 2010; Miyazawa et al., 2002; Schmidt and Pokorný, 2005

inhibiting the cell growth by inhibiting the ergosterol biosynthetic enzyme, lanosterol 14α-demethylase. Thus, seed fixed oil proved to be potent antifungal agents treating candidiasis, cryptococcosis, and ringw orm diseases and is effective against superficial infection too.

Phototoxicity

Light induced activation of photosensitive components of seed oil produces conjugated cytotoxic adducts of DNA (Averback et al., 1990).The process resulted cell lysis and leakage of many integral proteins of target cell (Bakkali et al., 2004). Microbial population like Aspergillus niger, Aspergillus flavus, Fusarium spp. can be inhibited by blocking synthesis of intracellular and extracellular enzymes synthesis. Application of Croton campestris seed oil in fungal cell resulted parietal thickness and plasma emma disruption (Raad et al., 2013). Aspergillus flavus show ultra-structure deteoration characterized by leakage of various vital ions (Shankaranarayan et al., 2008). Fungal growth inhibition is also associated with nonfunctional fungal hyphae after treatment with Sesamum indicum L. seed oil (Anilakumar et al., 2010)

Antioxidant properties of oil yielding plants from North-east India

Antioxidants protect the biological systems against the potentially harmful effects of several biochemical reactions causing excessive oxidation (Arnao et al., 2001), thereby preventing oxidative stress. Oxidative stress is often results in cancer, artheros clerosis, cardiovascular disorder and many other (Valko et al., 2007). Antioxidant activity is attributed by the changes in the metabolizing key enzymes and thereby controlling the unnecessary quick ageing process in the living systems (Finley et al., 2011; Nzaramba et al., 2009). Living cells possess antioxidant defense system mainly comprising of glutathione, ascorbic acid, vitamin E, superoxide dismutase, and glutathione peroxidase to protect themselves against harmful oxidative stress (Kaplowitz and Tsukamoto, 1996).

Oxidative reactions lead to formation of free-radicals. The most common compounds which are attacked by oxidation are unsaturated fats, which generally turn rancid as a consequence. These reactions are often enhanced with ferrus or copper ions. Degradation due to oxidative reactions can cause adverse effects on all biomolecules. The oils like okra seed oil, ground nut oil, linseed oil, olive oil, and sesamum oil (Tables 1 and 2), which are native to North-East India, possess antioxidant activity. These oils are capable of preventing oxidative stress by detoxifying various harmful chemical agents entering the human body. Antioxidants present in the seed oils include mainly tocopherols, flavonoids, carotenoids, and bioactive plant phenols (Table 5) (Dimitrios, 2006; Shukla et al., 1997). Oil producing seeds contain various types of phenolic compounds, such as flavonoids, lignans, lignins, phenolic acids, and tannins. Flavonoids can exert their antioxidant activity via a series of mechanisms, e.g., by chelating metal ions, by scavenging or quenching free-radicals or by inhibiting enzymetic systems responsible for free-radical generation (Dias et al., 2005; Islam, 2009). Flavonoids are the most widely present polyphenolic compounds in many oil seeds (Saikia et al., 2006).

Lignans are dimeric phenyl propanoids and often possess one or more phenol (Ar-OH) functionality. These compounds are considered to be protective against colon, breast, and prostate cancers (Kocchar, 2002). Tocopherols are another important antioxidant present in seed oils. α-Tocopherol exhibits vitamin E activity and prevents oxidation of lipids. The antioxidant activity of tocopherol is based on the tocopherol-tocopheryl quinone redox system (Shukla et al., 1997). Tocopherol acts as free radical scavenger and thus can be used in the presservation of animal products. Sunflower oil contains high γ-tocopherol making this plant resistant to autoxidation (Arnao et al., 2001). The flax plant Linum usitatissimum possesses various tocopherols and carotenoids and some sterols, thus making its oil high in antioxidants. Rapeseed oil and soyabean oil contain high percentage of tocopherols

Table 7. Application of various seed-oil Plants of North east India (1)

Name of the Plant	Bioactivity of the plant	Diseases treated	Mode of action of the plant	Reference
Abelmoschus esculentus L. Moench	Anticancer	Intestinal cancer	Cancer is prevented by its ability to bind bile acids	Yogesh et al., 2011
	Antidiabetic activity	Diabetes mellitus	It stabilizes blood sugar by regulating the rate at which sugar is absorbed from the intestinal tract	Sabitha et al., 2011
Anisomeles indica (L.) Kuntze	Anti-inflammatory activy	Bacterial inflammation	inhibit DNA replication of pathogen by inhibiting NO, TNF-α without affecting cell viability	Baranwal et al., 2012
	Antimicrobial activity	Gastric cancer, Malignancy	Inhibition of NF-B activation, as well as IL-8 secretion, in H. pylori might be a useful strategy for the management of chronic gastritis	Rao et al., 2012
		Food poisoning	The seed oil kills the pathogen by interfering with the formation of hyphae	Kundu et al., 2013
Arachis hypogaea L.	Antifungal activity	Conjunctives, Eye injuries Cataract	Oil works by disrupting the cell wall of the fungal hypae	Sobolev et al., 2011
	Anti-inflammatory and Anticancer activity	Scarring of chorioretina Corneal cancer	inhibits NF-κB signaling in treatment of cancer and inflammatory diseases	Kochert et al., 1996
Brassica juncea (L.) Czern	Antidiabetic activity	Diabetes mellitus, Obesity	It involves processes controlling both glucose metabolism and depressive states by decreasing the effects of monoamine levels on the brain	Anand et al., 2009
	Antifungal activty	Oral candidiasis, Dermatophytosis, Nail and skin spoilage	It containing broad antifungal spectrum thereby controlling various fungal diseases	Thakur et al., 2014
	Anticancer activity	Breast Cancer	inhibiting tumor formation in breast	Thakur et al., 2014
Brassica rapa L.	Antioxidant, anticancer, and Anti-inflammatory activities	HIV Cancer	Glucosinolates, component of Brassica rapa L., rapidly hydroliysed yielding glucose and instable aglycons and then break-down to isothiocyanates, having free radical scavenging, anticancer and anti-inflammatory properties	Jafarian-Dehkordi et al., 2013; Cartea et al., 2011; Tawfiq et al., 1995; Tannin-Spitz., 2007
Capsella bursa-pastoris (L.) Medik.	Antioxidant activity	Oxidative stress related various disorder	They can prevent the formation of deleterious radicals, like peroxynitrite,	Bekker et al., 2002
	Antimicrobial activity	Tinea capitis, Tinea pedis, Tinea corporis, Oxycomycosis	phenolic components of the oil affects the cell wall and membrane permeability of the pathogen,	Goun et al., 2002; Grosso et al., 2011

Table 7. Application of various seed-oil Plants of North east India (2)

Carthamus tinctorius L.	Anticoagulant effects	Thrombosis, Bleeding, Thrombopenia	Anticoagulant activity is accomplished by inhibition of platelet aggregation and prolong prothrombin time	Hiramatsu et al., 2009; Yue et al., 2013
	Cardiovascular function	Ischemia	This seed oil can provide protection to H9c2 cardiomyocytes against ischemia by up-regulating HO-1 expression through the PI3K/Akt/Nrf2 signaling pathway	Asgarpanah et al., 2013; Jun et al., 2009; Yue at al., 2013.
	Hepatoprotective activity	Hepatic fibrosis	attenuate oxidative stress mediated injury	Yue et al., 2013; Zang et al., 2011
	Antioxidant activity	Cell apoptisis, Oxidative stress mediated diseases	reducing cell proliferation and suppressing extracellular matrix (ECM) synthesis in the living system	Wang et al., 2013
Cocos nucifera L.	Antineoplastic activities	Cancer	Inhibition of the proliferation of neoplastic cells	Figueira et al., 2013
	Antitumor activity	Malignancy, Myeloid Leukemia	Termination of proliferation of K562 cells, responsible for the occurrence of Myeloid Leukemia	Figueira et al., 2013
	Leishmanicide potential	Leishmaniansis	Termination of cell divison	Figueira et al., 2013; Singla, 2012
Croton tiglium L.	Antitumor activity	Melanoma	Induces apoptosis	Nath et al., 2013; Yumnamcha et al., 2014
	Antioxidant activity	Parkinson's diseases, Alzheimer's diseases	Modify the activity of one or more protein kinase involved in cell cycle control	Nath et al., 2013
Dysphania ambrosioides (L.) Mosyakin & Clemants	Amoebicidal activity	Amebiasis	Attacks the protozoan parasite cell wall and induces the release of the intracellular constituents thereby affecting permeability	Ávila-Blanco et al., 2014
	Anticancer activity	Colon cancer Cervical cancer and hepatocarcinoma	It works by inhibiting the cell proliferation and cell division by arresting cell cycle	Barros et al., 2013
Gaultheria fragrantissima Wall.	Anti-inflammatory activities	Edema, Acute Pain	Inhibiting the production of pro-inflammatory cytokines responsible for inflammation	Liu et al., 2013; Padmavathy et al., 2014
	Analgesic activities	Rheumatoid Arthritis, Joint pain, Constricting Chest Pain, Transient Ischemic Attack	It is done through significantly inhibiting murine peritoneal capillary permeability	Liu et al., 2013
Glycine max L.	Immunity booster	Immunity deficiency diseases	The omega -3-fatty acid reacts with the immune cell nurturing them producing enhancement in immnunity	Mujić et al., 2011
Gossypium arboreum L.	Antioxidant activity	Alzheimer's diseases	Direct interaction of the extracts and the hydrogen peroxide rather than the extracts alter the cell membranes, limiting the damage induced by the hydrogen peroxide	Annan et al., 2008

Table 7. Application of various seed-oil Plants of North east India (3)

Helianthus annuus L.	Anticancer activity	Skin cancer	the oil forms a protective layer on your skin and acts as a shield against the harmful UV rays of the sun	Dwivedi and Sharma, 2014
	Anti-ageing activity	Premature aging	the oil helps to protect the elastin and collagen content in our skin	
Juglans regia L.	Antiproliferative activity	Cancer	cell growth inhibition	Carvalho et al., 2010
	Antioxidant activity	Oxidative stress mediated diseases	inhbiting the production of free radicals	Pereira et al., 2007
Linum usitatissimum L.	Anti-inflammatory activity	Arachidonic acid-induced inflammation	The oil inhibits both cyclooxygenase and lipoxygenase pathways of arachidonate metabolism by blocking estrogen receptors	Kaithwas et al., 2011
	Anticancer activity	Breast cancer		Kaithwas et al., 2011
	Antiulcer	Ulceration	oil exhibit significant inhibitory effect on gastric secretion/total acidity	Kaithwas and Mazumder., 2010
	Anti-neuropathy condition	Carpal tunnel syndrome	This oil has a noteworthy recovery rate in this complication, Further mechanism is still unrevealed	Hasempur et al., 2014
Mesua ferrea L.	Antifungal activities	nosocomial infections, tooth decay and dental caries, eye infections	Inhibition of the hyphal protein synthesis	Chahar et al., 2013
Ricinus communis L.	Antiasthmatic activity	Asthma, Broncitits, hypersensititvity	It significantly decreases milk induced leukocytosis and eosinophilia and protect degranulations of mast cells	Rana et al., 2012
	Cytotoxic activity	Cancer	Ricin, bioactive molecule in the oil targets the cell leaking its vital content out of the cell membrane	
Sesamum indicum L.	Anti-hyperlipidemic effects	Cardiovascular and cerebrovascular diseases	downregulating the activity of lipogenic enzymes	Asgary et al., 2013
	Hepatoprotective activity	Jaundice, Hepatitis A, Liver sclerosis	circulating concentrations of endothelial function biomarkers	
Syzygium aromaticum (L.) Merr. & L.M.Perry	Anti-infective activity	Food poisoning, Botulism	Inhibits cell wall synthesis of the pathogen.	Kamatou et al., 2012
	Analgesic activity	Rheumatoid Arthritis, Joint pain, Constricting Chest Pain	The oil activates the transient receptor potential vanilloid 1 (TRPV1) receptors which are involved in the transmission and modulation of pain channels in the peripheral nervous system	
	Anticancer activity	Cancer	It induces growth inhibition and apoptosis	

that render antioxidant activities. Coconut oil contains low amount of tocol (tocopherols and toc otrienols) (Valko et al., 2007).

Sterols are steroidal alcohols present in the oil which serve as an important antioxidant. Rapeseed oil contains sterol in free form as well as in esterified form (Raad et al., 2013; Kareru et al., 2010). A group of derivatives of hydroxytyrosol is present in olive and castor oils (Horn et al., 1999). Carotenoids have also been reported to possess high antioxidant activity, especially in the exposure to the light. Phenols present in the seed oils contribute to the antioxidant properties. Common phenolic antioxidants include butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate (PG) and tertiary butyl hydroquinone (TBHQ) (Dutta and Sharma, 2011; Leung et al., 1999). Lipophilic antioxidants are more active in emulsions, while polar antioxidants are more active in bulk fats and oils.

Characteristics of edible oils can be compared through the smoke point because it reflects the molecular structure of the oil (Hunt, 1953). The smoke point of a fat or oil is the point of the temperature at which the lipid begins to disintegrate into fatty acids and glycerol to produce bluish smoke (Table 3). It marks the point from where flavour and nutrition degradation begins, and thus is an important consideration for characteri-

zing the quality of edible oils. Oils having high smoke point are used for deep frying. Antioxidants can have influence on the features of smoke points of oils. It has been observed that the smoke point of soybean oil and lard was increased BHA, BHT or TBHQ and removing cholesterol (Yen et al., 1997). Various biofunction and probable mechanism of action of other notable seed oil plants are summarized in table 7 given below.

CONCLUSION

Seed oil yielding plants may provide an avenue for developing a new set of drugs for controlling wide range of ailments associated with oxidative stress, as well as several types of contagionus and pathogenic diseases. The northeastern states of India, being one of the largest repositories of the plant kingdom, offers various seed oil yielding plants, which could be explored further for their antioxidant activity and antimicrobial properties. Seed oils can be used to increase the self-life of the industrial food products. Thus antioxidant property present in the seed oils can be explored for wide range of applications ranging from preservation of food products to prevention of the oxidative stress related diseases, e.g. cancers and cardio-vascular disorders. The antimicrobial property of the seed oil producing plants and various bioactive compounds isolated from them may lead to the discovery of new antimicrobial compounds to fight against MDR microbial strains and various forms of infections in general.

ACKNOWLEDGEMENTS

Authors would like to thank Bioinformatics Centre (BIF), DBT Govt of India. Assam University, Silchar, Assam for providing facilities in literature search. First author acknowledge the UGC-BSR fellowship.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Abano EE, Amoah KK. Effect of moisture content on the phys ical properties of tiger nut (Cyperus esculentus). Asian J Agric Sci. 2011;5:56-66.

Adelakun OE, Oyelade OJ, Ade-Omowaye BIO, Adeyemi IA, Van de Venter M. Chemical composition and the antioxidative properties of Nigerian Okra Seed (Abelmoschus esculentus Mo ench) Flour. Food Chem Toxicol. 2009;47:1123-1126.

Afolabi IS, Marcus GD, Olanrewaju TO, Chizea V. Biochemic al effect of some food processing methods on the health promo ting properties of under-utilized Carica papaya seed. J Nat Prod. 2011;4:17-24.

Ahmad A, Abdin MZ. Interactive Effect of Sulphur and Nitro gen on the Oil and Protein Contents and on the Fatty Acid Pro files of Oil in the Seeds of Rapeseed (Brassica campestris L.) and Mustard (Brassica juncea L. Czern. and Coss.). J Agron Crop Sci. 2002;185:49-54.

Al-Khalifa A, Maddaford TG, Chahine MN. Effect of dietary hempseed intake on cardiac ischemia-reperfusion injury. Am J Physiol Regul Integr Comp Physiol. 2007;292:1198-1203.

Aluyor EO, Ori-Jesu M. The use of antioxidants in vegetable oils - A review. Afr J Biotechnol. 2008;7:4836-4842.

Amaral JS, Casal S, Pereira JA, Seabra RM, Oliveira BP. Det ermination of Sterol and Fatty Acid Compositions, Oxidative Stability, and Nutritional Value of Six Walnut (Juglans regia L.) Cultivars Grown in Portugal. J Agric Food Chem. 2003;51:7698-7702.

Amarowicz R, Naczk M, Shahidi F. Antioxidant activity of crude tannins of canola and rapeseed hulls. J Am Oil Chem Soc. 2000;77:957-961.

Amarowicz R, Wanasundara P, Shahidi F. Chromatographic separation of flaxseed phenolics. Die Nahrung. 1994;38:520-526.

Amarowicz R, Wanasundara UN, Karamać M, Shahidi F. Antio xidant activity of ethanolic extract of mustard seed. Nahrung. 1996;40:261-263.

Anand P, Murali YK, Tandon V, Murthy PS, Chandra R. Ins ulinotropic effect of aqueous extract of Brassica nigra improves glucose homeostasis in streptozotocin induced diabetic rats. Exp Clin Endocrinol Diabetes. 2009;117:251-256.

Anilakumar RK, Pal A. Nutritional, Medicinal and Industrial Uses of Sesame (Sesamum indicum L.) Seeds-An Overview. Agriculturae Conspectus Scientificus. 2010;75:159-168.

Anjum F, Shahid M, Bukhari S. Study of Quality Characteristic s and Efficacy of Extraction Solvent/ Technique on the Antiox idant Activity of Bitter Gourd Seed. J Food Process Technol. 2013;4:132-138.

Annan K, Houghton PJ. Antibacterial, antioxidant and fibroblast growth stimulation of aqueous extracts of Ficus asperifolia Miq. and Gossypium arboreum L., wound-healing plants of Ghana. J Ethnopharmacol. 2008;119:141-144.

Applewhite TH. Fats and Fatty Oils. In: Grayson M, Kirk-Oth mer Encyclopedia of Chemical Technology, Volume 9. (New York, USA: John Wiley and Sons Inc), pp. 123-129,1978.

Arafat S, Gaafar A, Basuny A, Nassef L. Chufa Tubers (Cyperus esculentus L.): As a New Source of Food. World Appl Sci J. 2009;7:151-156.

Ardabili G, Farhoosh R, Khodaparast H. Chemical composition and physicochemical properties of pumpkin seeds (Cucurbita pepo subsp. pepo var. styriaka) grown in Iran. J Agric Sci Tech. 2011;13:1053-1063.

Aremu MO, Olaofe O, Akintayo TE. A comparative study on the chemical and amino acid composition of some Nigerian under utilized legume flours. Pak J Nutr. 2006;5:34-38.

Armstrong JS. Mitochondrial membrane permeabilization: the sine qua non for cell death. Bioessays. 2006;28:253-260.

Arnao MB, Cano A, Acosta M. The hydrophilic and lipophilic contribution to total antioxidant activity. Food Chem. 2001;73:239-244.

Asgarpanah J, Kazemivash N. Phytochemistry, pharmacology and medicinal properties of Carthamus tinctorius L. Chin J Integr Med. 2013;19:153-159.

Avancini CAM, Wiest JM, Mundstock EA. Bacteriostatic and bactericidal activity of the Baccharis trimera (Less.) D.C. Compositae decocto, as disinfectant or antiseptic. Arq Bras Med Vet Zootec. 2000;52:230-234.

Averbeck D, Averbeck S, Dubertret L, Young AR, Morlie`re P. Genotoxicity of bergapten and bergamot oil in Saccharomyces cerevisiae. J Photochem Photobiol B. 1990;7:209-229.

Ávila-Blanco ME, Rodríguez MG, Moreno Duque JL, Muñoz-Ortega M, Ventura-Juárez J. Amoebicidal Activity of Essential Oil of Dysphania ambrosioides (L.) Mosyakin & Clemants in an Amoebic Liver Abscess Hamster Model. Evid Based Complement Alternat Med. 2014;2014:930208.

Ayoola GA, Lawore FM, Adelowotan T, Aibinu IE, Adenipe kun E, Coker HAB, Odugbemi TO. Chemical analysis and antimicrobial activity of the essential oil of Syzigium aromaticum (clove). Afr J Microbiol Res. 2008;2:162-166.

Bakkali F, Averbeck S, Averbeck D, Idaomar M. Biological effects of essential oils--a review. Food Chem Toxicol. 2008;2:446-475.

Bankar GR, Nayak PG, Bansal P, Paul P, Pai KS, Singla RK, Bhat VG. Vasorelaxant and antihypertensive effect of Cocos nucifera Linn. endocarp on isolated rat thoracic aorta and DOCA salt induced hypertensive rats. J Ethnopharmacol. 2011;134:50-54.

Baranwal VK, Irchhaiya R, Singh S. Anisomeles indica: An overview. Int Res J Pharm. 2012;3:84-86.

Barros L, Pereira E, Dueñas M, Carvalho AM, Santos-Buelga C. Ferreira ICFR. Bioactivity of Chenopodium ambrosioides L.: antioxidant and antitumour potential and detailed characterization in bioactive compounds. In 1st Symposium on Medicinal Chemistry. Braga, 2013. Available at: https://bibliotecadigital.ipb.pt/handle/10198/8678 (accessed on 10th February 2014).

Bekker NP, UI'chenko NT, Glushenkova AI. Lipids of the aerial part of Capsella bursa-pastoris. Chem Nat Compd. 2002;38:610-611.

Bennion M. Introductory Foods. 10th Edition. (New Jersey, USA: Prentice-Hall Inc), 1995.

Bhuvaneshwar U, Singh KP, Ashwani K. Ethno-Medicinal, Phytochemical And Antimicrobial Studies of Euphorbia tirucalli L. J Phytol. 2010;2:65-77.

Bisignano C, Saija A, Dugo P, Cross KL, Parker ML, Waldron KW, Wickham MS J. Characterization of polyphenols, lipids and dietary fibre from almond skins (Amygdalus communis L.). J Food Compos Anal. 2010;23:166-174.

Boutkhila S, Idrissib ME, Amechrouqb A, Chbichebc A, Chakira S, Badaoui KE. Chemical composition and antimi crobial activity of crude, aqueous, ethanol extracts and essential oil s of Dysphania ambrosioides (L.) Mosyakin & Clemants. Acta Botanica Gallica: Botany Letters. 2009:156:201-209.

Braca A, Siciliano T, Arrigo M. Chemical composition and antimicrobial activity of Momordica charantia seed essential oil. Fitoterapia. 2008;79:123-125.

Burkill IH. A Dictionary of Economic Products of the Malay Peninsula. (Kuala Lampur, Malaysia : Ministry of Agriculture & Co-operatives), 1996.

Burt S. Essential oils: their antibacterial properties and potential applications in foods - a review. Int J Food Microbiol. 2004;94:233-253.

Burton W, Salisbury P, Potts D. The Potential of canola quality Brassica juncea as an oilseed crop for Australia. In Edwards J. 13th Australian Research Assembly on Brassicas - Conference Proceedings, Perth: Tamworth, NSW, pp. 84-87, 2008. Available at : http://www.cabdirect.org/abstracts/20043006910.html;jsessionid=6E3EEE2D7CEA398C85D6A1C77936DD70. (accessed 10th August 2015).

Canella M, Castriotta G. Protein composition and solubility of tomato seed meal. Lebensm Wiss Technol. 1980;13:342-358.

Cartea ME, Francisco M, Soengas P, Velasco P. Phenolic compounds in Brassica vegetables. Molecules. 2011;16:251-280.

Carvalho CC, Cruz PA, Fonseca MMR, Filho LX. Antibacterial properties of the extract of Abelmoschus esculentus, Biotechnol Bioprocess Engineer. 2011;16:971-977.

Carvalho M, Ferreira PJ, Mendes VS, Silva R, Pereira JA, Jerónimo C, Silva BM. Human cancer cell antiproliferative and antioxidant activities of Juglans regia L. Food Chem Toxicol. 2010;48:441-447.

Chahar MK, Kumar S, Geetha L, Lokesh T, Manohara KP. M esua ferrea L.: A review of the medical evidence for its phytochemistry and pharmacological actions. Afr J Pharm Pharmacol. 2013;7:211-219.

Chopra RN, Nayar SL, Chopra IC. Glossary of Indian medicinal plants. (New Delhi, India; National Institute of Science Communication and Information Resources), 2002.

Choudhury S, Riyazuddin A, André Barthel Plet A. Volatile Oils of Mesua ferrea (L.) from Assam, India. J Essent Oil Res . 1998;10:497-501.

Chowdhury K, Banu LA, Khan S, Latif A. Studies on the fatty acid composition of edible oil. Bangladesh J Sci Ind Res. 2007;42:311-316.

Clara KW, Sze-Tao M, Shridhar KS. Walnuts (Juglans regia L): proximate composition, protein solubility, protein amino acid composition and protein in vitro digestibility. J Sci Food Agr 2000;80:1393-1401.

Concha J, Soto C, Chamy R, Zúñiga ME. Effect of rosehip extraction process on oil and defatted meal physicochemical properties. J Am Oil Chem Soc. 2006;83:771-775.

Copping LG. The neem tree: source of unique natural products for integrated pest management, medicine, industry and other

purposes. Schmutterer H ed. (Weinheim, Germany: Wiley VCH), 1995.

Craker LE. A proceedings of the XXVI international horticultural congress: The future for medicinal and aromatic plants. Acta Hortic. 2004;629:135-137.

Dahanukar SA, Thatte UM. Therapeutic approaches in ayur veda revisited. (Mumbai, India: Popular Prakashan), 1989.

Decorde K, Teissèdre PL, Sutra T, Ventura E, Cristol JP, Rouanet JM. Chardonnay grape seed procyanidin extract supplementation prevents high-fat diet-induced obesity in hamsters by improving adipokine imbalance and oxidative stress markers. Mol Nutr Food Res. 2009;53:659-666.

Deka DC, Basumatary S. High quality biodiesel from yellow oleander (Thevetia peruviana) seed oil. Biomass Bioenerg. 2011;35:1797-1803.

Deorani SC, Sharma GD. Medicinal Plants of Nagaland. (Dehra Dun, India: Mahendra Pal Singh), 2007.

Dias AS, Porawski M, Alonso M, Marroni N, Collado PS, González-Gallego J. Quercetin decreases oxidative stress, NF-kappaB activation, and iNOS overexpression in the liver of streptozotocin-induced diabetic rats. J Nutr. 2005;135:2299-2304.

Dimitrios B. Sources of natural phenolic antioxidants. Trends Food Sci Technol. 2006;17:505-512.

Dunn RO. Effect of Antioxidants on the Oxidative Stability of Methyl Soyate (Biodiesel). Fuel Proc Technol. 2005;86:1071-1085.

Dutta U, Sarma GC. Koch-Rajbansi's and Their Traditional Phyto-therapy, A Case Study in the Chirang District Of Western Assam. Int J Sci Adv Technol. 2011;1:139-141.

Dwivedi A, Sharma GN. A Review on Heliotropism Plant: Helianthus annuus L. Phytopharmacology. 2014;3:149-155.

Dwivedi C, Muller LA, Goetz-Parten DE, Kasperson K, Mistry VV. Chemopreventive effects of dietary mustard oil on colon tumor development. Cancer Lett. 2003;196:29-34.

Dwivedi D, Ram R. Chemical Composition of bitter apricot kernals form Ladakh, India. Acta Hort. 2008;765:335-338.

Edgar B, Cahoon K, Ripp G, Sarah EH, Brian MG. Transgenic Production of Epoxy Fatty Acids by Expression of a Cytochro me P450 Enzyme from Euphorbia lagascae Seed. Plant Physiol. 2002;128:615-624.

Eka HD, Tajul Aris Y, WanNadiah WA. Potential use of Malaysian rubber (Hevea brasiliensis) seed as food, feed and biofuel. Int Food Res J. 2010;17:527-534.

Elmatbaea E. Effect of Pumpkin Seed (Cucurbita pepo L.) Diets on Benign Prostatic Hyperplasia (BPH): Chemical and Morphometric Evaluation in Rats. World J Chem. 2006;1:33-40.

Eromosele CO, Paschal NH. Characterization and viscosity parameters of seed oil from wild plants. Bioresource Technol. 2002;86:203-205.

Faiza I, Wahiba K, Nassira G, Chahrazed B, Fawzia BA. Antibacterial and antifungal activities of olive (Olea europaea L.) from Algeria. J Microbiol Biotechn Res. 2011;1:69-73.

FAO. Project document for a regional standard for Pomegranate. Rome: FAO, 2009. Available at: ftp://ftp.fao.org/codex/Meetings/CCNEA/ccnea5/ne05_09e.pdf (accessed on 10th August 2015).

FAO/WHO. Protein quality evaluation. Reports of a joint FAO/WHO expert Consultation. Rome: Food and Agriculture Organization of the United Nations, 2006. Available at: https://books.google.co.kr/books/about/Protein_Quality_Evaluation.html?id=ieEEPqffcxEC&redir_esc=y (accessed on 10th August 2015).

Fennema OR. Food Chemistry. (New York, USA: Marcel Dekker Inc.), 1985.

Figueira CN, Santos RM, Campesatto EA, Lúcio IML, Araújo EC, Bastos MLA. Biological activity of the Cocos nucifera L.. and its profile in the treatment of diseases: A review. J of Chem and Pharmaceutical Res. 2013;5:297-302.

Finley JW, Kong AN, Hintze KJ, Jeffery EH, Ji LL, Lei XG. Antioxidants in foods: state of the science important to the food industry. J Agric Food Chem. 2011;59:6837-6846.

Fokou E,Achu MB, Kansci G, Ponka R, Fotso M, Tchiégang C, Tchouanguep FM. Chemical properties of some cucurbitaceae oils from Cameroon. Pak J Nutr. 2009;8:1325-1334.

Frega NF, Bocci L, Conte, Testa F. Chemical composition of Tobacco Seeds (Nicotiana tabacum L.). J Am Oil Chem Soc. 1991;68:29-33.

Fukuda Y, Nagata M, Osawa T, Namiki M. Chemical aspects of the antioxidative activity of roasted sesame seed oil, and the effect of using the oil for frying. Agric Biol Chem. 1986;50:857-862.

Fukuda Y, Nagata M, Osawa T, Namiki M. Contribution of lig nan analogues to antioxidative activity of refined unroasted sesame seed oil. J Am Oil Chem Soc. 1986;63:1027-1031.

Gardner G, Craker LE. ISHS Acta Horticulturae 765: XXVII International Horticultural Congress - IHC International Symposium on Plants as Food and Medicine. Seoul, Acta Hort, 2006. Available at: https://library.plantandfood.co.nz/cgi-bin/koha/opac-detail.pl?biblionumber=17797&query_desc=au%3A%22Craker%2C%20Lyle%20E.%22 (accessed on 10th August 2015).

Gogoi TK, Talukdar S, Baruah DC. Comparative analysis of performance and combustion of koroch seed oil and jatropha methyl ester blends in a diesel engine. (Linköping, Sweden: Linköping University Electronic Press), pp. 3533-3540, 2011.

Gopala Krishna AG, Hemakumar KH, Khatoon S. Study on the composition of rice bran oil and its higher free fatty acids value. J Am Oil Chem Soc. 2006;83:117-120.

Goun EA, Petrichenko VM, Solodnikov SU, Suhinina TV, Kline MA, Cunningham G, Nguyen C, Miles H. Anticancer and antithrombin activity of Russian plants. J Ethnopharmacol

2002;81:337-342.

Grimm DT, Sanders TH, Pattee HE, Williams, DE, Sanchez-Dominguez S. Chemical Composition of Arachis hypogaea L. subsp. hypogaea var. hirsuta Peanuts. Pean Sci. 1996;23:111-116.

Gunstone FD. Vegetable Oils in Food Technology: Composition, Properties and Uses. 2nd ed. (West Sussex, UK: Wiley-Blackwell), pp.137-167, 2011.

Gross NR, Guzman CA. Chemical Composition of Aboriginal Peanut (Arachis hypogaea L.) Seeds from Peru. J Agric Food Chem. 1995;43:102-105.

Hashempur MH, Homayouni K, Ashraf A, Salehi A, Taghizadeh M, Heydari M. Effect of Linum usitatissimum L. (linseed) oil on mild and moderate carpal tunnel syndrome: a randomized, double-blind, placebo-controlled clinical trial. Daru. 2014;22:43.

Hiramatsu M, Takahashi T, Komatsu T, Kido T, Kasahara Y. Antioxidant and neuroprotective activities of mogami-benibana (Safflower, Carthamus tinctorius Linne). Neurochem Res. 2009;34:795-805.

Honary LAT. Biodegradable/Biobased Lubricants and Greases. Machinery Lubrication, Issue No. 200109 (Noria Corporation), 2004.

Hopkins CY, Chisholm MJ. Fatty acids of kenaf seed oil. J Am Oil Chem Soc. 1959;36:95-96.

Hoppe MB, Jha HC, Egge H. Structure of an antioxidant from fermented soybeans (tempeh). J Am Oil Chem Soc. 1997;74:477-479.

Howell S. Promising Industrial Applications for Soybean Oil in the US. (St. Louis, Missouri, USA: American Soybean Assosiation), 2007.

Hron Sr RJ, Kim HL, Calhoun MC, Fisher GS. Determination of (+)-, (−)-, and total gossypol in cottonseed by high-perform ance liquid chromatography. J Am Oil Chem Soc. 1999;76:1351-1355.

Huda SN, Grantham-McGregor SM, Tomkins A. Cognitive and motor functions of iodine-deficient but euthyroid children in Bangladesh do not benefit from iodized poppy seed oil (Lipiodol). J Nutr. 2001;131:72-77.

Hunt RA. Relation of Smoke Point to Molecular Structure. Ind Eng Chem. 1953;45:602-606.

Ingale S, Shrivastava SK. Chemical studies of new varieties of sunflower (Helianthus annuus) LSF-11 and LSF-8 seeds. Agri Biol J N Am. 2011;2:1171-1181.

Islam M. Medicinal Plants of North-East India. (Jaipur, India: Avishkar Publishers), 2009.

Islam SN, Ferdous AJ, Ahsan M, Faroque AB. Antibacterial activity of clove extracts against pathogenic strains including clinically resistant isolates of Shigella and Vibrio cholera. Pak J Pharm Sci. 1990;3:1-5.

Jafarian-Dehkordi A, Zolfaghari B, Mirdamadi M. The effects of chloroform, ethyl acetate and methanolic extracts of Brassica rapa L. on cell-mediated immune response in mice. Res Pharm Sci. 2013;8:159-165.

Jarret RL, Wang ML, Levy IJ. Seed oil and fatty acid content in okra (Abelmoschus esculentus) and related species. J Agric Food Chem. 2011;59:4019-4024.

Jeet K, Devi N, Narender T, Sunil T, Lalit S, Raneev T. Trachy spermum ammi (Ajwain): A Comprehensive Review. Int Res J Pharm. 2007;3:133-138.

Jenkins DJ1, Kendall CW, Marchie A, Parker TL, Connelly PW, Qian W, Haight JS, Faulkner D, Vidgen E, Lapsley KG, Spiller GA. Dose response of almonds on coronary heart disease risk factors: blood lipids, oxidized low-density lipoproteins, lipoprotein(a), homocysteine, and pulmonary nitric oxide: a randomize ed, controlled, crossover trial. Circulation. 2002;106:1327-1332.

Johnson LA, Lusas EW. Comparison of alternative solvents for oils extraction. J Am Oil Chem Soc. 1983;60:229-242.

Jun MS, Ha YM, Kim HS, Jang HJ, Kim YM, Lee YS, Kim HJ, Seo HG, Lee JH, Lee SH, Chang KC. Anti-inflammatory action of methanol extract of Carthamus tinctorius involves in hemeoxygenase-1 induction. J Ethnopharmacol. 2011;133:524-530.

Kaithwas G, Majumdar DK. Effect of L. usitatissimum (Flaxs eed/Linseed) Fixed Oil against Distinct Phases of Inflammation. ISRN Inflamm. 2013:735158.

Kaithwas G, Majumdar DK. Evaluation of antiulcer and ant isecretory potential of Linum usitatissimum fixed oil and possible mechanism of action. Inflammopharmacology. 2010;18:137-145.

Kaithwas G, Mukherjee A, Chaurasia AK, Majumdar DK. Anti-inflammatory, analgesic and antipyretic activities of Linum usitatissimum L. (flaxseed/linseed) fixed oil. Indian J Exp Biol. 2011;49:932-938.

Kalaivani M, Jegadeesan M. Antimicrobial Activity of Alcoh olic Extract Extract of Leaves and Flowers of Madhuca longifolia. Int J Sci Res Publ. 2013;3:1-3.

Kamatou GP, Vermaak I, Viljoen AM. Eugenol-From the Remote Maluku Islands to the International Market Place: A Review of a Remarkable and Versatile Molecule. Molecules. 2012;17:6953-6981.

Kaplowitz N, Tsukamoto H. Oxidative stress and liver disease. Prog Liver Dis. 1996;14:131-159.

Kareru PG, Keriko JM, Kenji GM, Gachanja AN. Anti-termite and antimicrobial properties of paint made from Thevetia peruviana (Pers.) Schum. oil extract. Afr J Pharmacy Pharmacol. 2010;4:87-89.

Kaushik N, Agnihotri A. GLC analysis of Indian rapeseed-mustard to study the variability of fatty acid composition. Biochem Soc Trans. 2000;28:581-583.

Kazeem MI, Abimbola SG, Ashafa AOT. Inhibitory potential of

Gossypium arboreum leaf extracts on diabetes key enzymes, α-amylase and α-glucosidase. Bangladesh J Pharmacol. 2013;8:149-155.

Khanka MS, Tewari L, Kumar S, Singh L, Nailwal TK. Extraction Of High Quality Dna From Diploknema butyracea. Food Chem. 2009;1:33-35.

Kim JY, Kim DN, Lee SH, Yoo SH, Lee SY. Correlation of fat ty acid composition of vegetable oils with rheological behavior and oil uptake. Food Chem. 2010;118:398-402.

Kochert G, Stalker HT, Gimenes M, Galgaro L, Romero Lopes C. RFLP and cytogenetic evidence on the origin and evolution of allotetraploid domesticated peanut, Arachis hypogaea (Leguminosae). Am J of Bot. 1996;83:1282-1291.

Kochhar SP. Sesame, rice-brans and flaxseed oils. In Gunstone, FD, ed. Vegetable oils in Food Technology: Composition, Properties and uses. (United Kingdom, Oxford: CRC Press), pp.308-315, 2002.

Kundu A, Saha S, Walia S, Kour C. Antioxidant and antifungal properties of the essential oil of Anisomeles indica from India. J of Med Plants Res. 2013;7:1774-1779.

Kwon KH, Kim KI, Jun WJ, Shinn DH, Cho HY, Hong BS. In vitro and in vivo effects of macrophage - stimulatory polysaccharide from leaves of Perilla frutescens var. crispa. Biol Pharm Bull. 2002;25:367-371.

Kyralan M, Golukcu M, Tokgoz H. Oil and conjugated linole nic acid contents of seeds from important pomegranate cultivars (Punica granatum L.) grown in Turkey. J Am Oil Chem Soc. 2009;86:985-990.

Lampi A, Hopia A, Piironen V. Antioxidant activity of minor amounts of tocopherol in natural triacylglycerols. J Am Oil Chem Soc. 1997;74:549-555.

Lazzeri L, Errani M, Leoni O, Venturi G. Eruca sativa spp. Oleifera: A new non-food crop. Ind Crop Prod. 2004;20:67-73.

Lee JW, Lee KW, Lee SW, Kim IH, Rhee C. Selective increase in pinolenic acid (all-cis-5,9,12-18:3) in Korean pine nut oil by crystallization and its effect on LDL-receptor activity. Lipids. 2004;39:383-387.

Leung J, Fenton T, Clandinin D. Phenolic components of sunflower flour. J Food Sci. 1981;46:1386-1388.

Li L, Tsao R, Yang R, Kramer JK, Hernandez M. Fatty Acid Profiles, Tocopherol Contents, and Antioxidant Activities of Heartnut (Juglans ailanthifolia Var. cordiformis) and Persian Walnut (Juglans regia L.). J Agric Food Chem. 2007;55:1164-1169.

Liny P, Divya TK, Barasa M, Nagaraj B, Krishnamurty N, Dinesh R. Preparation Of Gold Nanoparticles From Helianthus annuus (Sunflower) Flowers and Evaluation of Their Antimicrobial Activities. Int J Pharma Bio Sci. 2012;3:440-446.

Liu WR, Qiao WL, Liu ZZ, Wang XH, Jiang R, Li SY, Shi RB, She GM. Gaultheria: Phytochemical and Pharmacological Characteristics. Molecules. 2013;18:12071-12108.

Luitel DR, Maan B, Timsina B, Münzbergová Z. Medicinal plants used by the Tamang community in the Makawanpur district of central Nepal. J Ethnobiol Ethnomed. 2014;10:1-11.

Mabaleha MB, Mitei YC, Yeboah SO. A comparative study of the properties of selected melon seed oils as potential candidates for development into commercial edible vegetable oils. J Am Oil Chem Soc. 2007;84:31-36.

Mahale SM, Goswami AS. Composition and Characterization of Refined Oil Compared with Its Crude Oil from Waste Obtained from Mangifera indica. Asian J Res Chem. 2011;4:1415-1419.

Majumdar K, Datta B, Shankar U. Establishing continuity in distribution of Diploknema butyracea (Roxb.) H J Lam in Indian subcontinent. J Res Biol. 2012;2:660-666.

Marikkar JM, Ghazali HM, Long K. Composition and thermal characteristics of Madhuca longifolia seed fat and its solid and liquid fractions. J Oleo Sci. 2010;59:7-14.

Milovanović M, Jovanović K. Characterization and composite on of melon seed oil. Journal of Agricultural Sciences. 2005;50:41-47.

Mishra A, Dash P, Murthy P, Siddique HH, Kushwaha P. A Classical Review on Rajika (Brassica juncea). J Bot Sci. 2012;1:18-23.

Miyazawa M, Nishiguchi T, Yamafuji C. Volatile components of the leaves of Brassica rapa L. var. perviridis Bailey. Flavour Frag J. 2005;20:158-160.

Moghaddam MN. In vitro Inhibition of Helicobacter pylori by Some Spices and Medicinal Plants Used in Iran. Glob J Pharmacol. 2011;5:176-180.

Mohamed A, Bhardwaj H, Hamama A, Webber C. Chemical composition of kenaf (Hibiscus cannabinus L.) seed oil. Ind Crop Prod. 1995;4:157-165.

Mujić I, Šertović E, Jokić S, Sarić Z, Alibabić V, Vidović S, Živković J. Isoflavone content and antioxidant properties of soybean seeds. Croat. J. Food Sci. Technol. 2011;3:16-20.

Murakami H, Asakawa A, Terao J, Matsushita S. Antioxidative stability of tempeh and liberation of isoflavones by fermentation. Agric Biol Chem. 1984;48:2971-2975.

Nash DT. Cardiovascular risk beyond LDL-C levels: Other lipids are performers in cholesterol story. Postgrad Med. 2004;116:11-15.

Nath R, Roy S, De B, Choudhury MD. Anticancer and antioxidant activity of croton: A Review. Int J Pharm Pharm Sci. 2013;5:63-70.

Naz R, Bano A. Antimicrobial potential of Ricinus communis L. leaf extracts in different solvents against pathogenic bacterial and fungal strains. Asian Pac J Trop Biomed. 2012;2:944-947.

Nuzhat T, Vidyasagar GM. Antifungal Investigation on Plant Essential Oils. A Review. Int J Pharma Pharm Sci. 2013;5:19-28.

Nzaramba MN, Reddivari L, Bamberg JB, Miller Jr JC. Antiproliferative activity and cytotoxicity of Solanum jamesii tuber extracts on human colon and prostate cancer cells in vitro. J Agric Food Chem. 2009;57:8308-8315.

Oh K, Hu FB, Manson JE, Stampfer MJ, Willett WC. Dietary fat intake and risk of coronary heart disease in women: 20 years of follow-up of the nurses' health study. Am J Epidemiol. 2005;161:672-679.

Oliveira I, Sousa A, Ferreira IC, Bento A, Estevinho L, Pereira JA. Total phenols, antioxidant potential and antimicrobial activity of walnut (Juglans regia L.) green husks. Food Chem Toxi col. 2008;46:2326-2331.

Olorunnipa TA, Igbokwe CC, Lawal TO, Adeniyi BA, Mahady GB. Anti-Helicobacter pylori activity of Abelmoschus esculentus L. Moench (okra): An in vitro study. Clin Microbiol. 2013;2:132.

Özcan MM. Some Nutritional Characteristics of Fruit and Oil of Walnut (Juglans regia L.) Growing in Turkey. Iran J Chem Chem Eng. 2009;28:322-341.

Padmavathy S, Nair DN, Shanthi T. GC-MS analysis of bioactive componen in Gautheria Fragratissima WALL. Asian J Pharm Clin Res. 2014;7:83-85.

Paiva-Martins F, Rodrigues V, Calheiros R, Marques MP. Characterization of antioxidant olive oil biophenols by spectroscopic methods. J Sci Food Agric. 2011;91:309-314.

Pandey DP, Rather MA. Isolation and Identification of Phytoc hemicals from Xanthium strumarium. Int J Chemtech Res. 2012;4:266-271.

Pantzaris TP, Basiron Y. The lauric (coconut and palmkernel) oils. In Vegetable Oils in Food Technology: Composition, Properties and uses. Gunstone F ed. 2nd ed. (Oxford, UK: CRC Press), pp. 412-420, 2002.

Parekh J, Chanda SV. Antibacterial Activity of Aqueous and Alcoholic Extracts of 34 Indian Medicinal Plants against Some Staphylococcus Species. Turk J Biol. 2008;32:63-71.

Pereira AP, Isabel CFR. Ferreira A, Marcelino F, Valentão P, Andrade PB, Seabra R, Estevinho L, Bento A, Pereira JA. Phenolic Compounds and Antimicrobial Activity of Olive (Olea europaea L. C. Cobrançosa) Leaves. Molecules. 2007;12:1153-1162.

Pereira JA, Oliveira I, Sousa A, Valentão P, Andrade PB, Ferreira IC, Ferreres F, Bento A, Seabra R, Estevinho L. Walnut (Juglans regia L.) leaves: Phenolic compounds, antibacterial activity and antioxidant potential of different cultivars. Food Chem Toxicol. 2007;45:2287-2295.

Phippen Winthrop B, Isbell Terry A, Phippen Mary E. Total seed oil and fatty acid methyl ester contents of Cuphea access ions. Ind Crop Prod. 2006;24:52-59.

Pholen J, Pohtee F. The chemical composition of Tea seed oil variety. In Automating calculation for rapid seed oil quality control and authentication. Lee PJ, Ichikawa Y, Menard RR, Gioia AJD ed. (Milford, United States: Waters), pp. 345-351, 2011.

Ponnusha BS, Subramaniyam S, Pasupathi P, Subramaniyam B, Virumandy R. Antioxidant and Antimicrobial properties of Glycine Max-A review. Int J Curr Biomed Sci. 2011;1:49-62.

Qayum M, Nisar M, Shah MR, Zia-ul-Haq M, Kaleem AW, Marwat IK. Biological Screening of oils from Impatiens bicolor Royle. Pak J Bot. 2012;44:355-359.

Raad NH, Mun'im RA, Sinna MS, Anfal MK, Moayad SH, Yasamin AK, Ali M, Ahmaed AA. Antibacterial Activity of Aqueous and Alcoholic Extracts of Capsella Bursa against Selected Pathogenic Bacteria, Am J BioSci. 2013;1:6-10.

Rabia N, Asghari B. Antimicrobial potential of Ricinus communis leaf extracts in different solvents against pathogenic bacterial and fungal strains. Asian Pac J Trop Biomed. 2012;2:944-947.

Rajakannu S, Veezhinathan M, Anandan K, Balasubramaniam G, Sritharan UR. Comparative evaluation of antimicrobial activity of selected three herbal plants extract with digital image processing technique. EJBI. 2013;9:14-26.

Ramadhas AS, Jayaraj S, Muraleedharan C. Biodiesel production from high FFA rubber seed oil. Fuel. 2005;84:335-340.

Rana M, Dhamija H, Prashar B, Sharma S. Ricinus communis L. - A Review. Int J PharmTech Res. 2012;4:1706-1711.

Rao YK, Lien HM, Lin YH, Hsu YM, Yeh CT, Chen CC, Lai CH, Tzeng YM. Antibacterial activities of Anisomeles indica constituents and their inhibition effect on Helicobacter pylori-induced inflammation in human gastric epithelial cells. Food Chem. 2012;132:780-787.

Ratzka A, Vogel H, Kliebenstein DJ, Mitchell-Olds T, Kroyma nn J. Disarming the mustard oil bomb. Proc Natl Acad Sci. 2002;99:11223-11228.

Reni ML. The Chemical Composition of Tender Coconut (Cocos nucifera L.) Water and Coconut Meat and Their Biological Effect in Human Body. Int J Green Herb Chem. 2013;2:723-729.

Rios JL, Recio MC. Medicinal plants and antimicrobial activity. J Ethnopharmacol. 2005;100:80-84.

Rodriguez RJ, Low C, Bottema CD, Parks LW. Multiple functions for sterols in Saccharomyces cerevisiae. Biochim Biophys Acta. 1985;837:336-343.

Sabitha V, Ramachandran S, Naveen KR, Panneerselvam K. Antidiabetic and antihyperlipidemic potential of Abelmoschus esculentus (L.) Moench. in streptozotocin-induced diabetic rats. J Pharm Bioallied Sci. 2011;3:397-402.

Saidu TB, Abdullahi M. Phytochemical Determination and Antibacterial Activities of The Leaf Extracts of Combretum molle And Gossypium arboreum. Bayero J Pure Appl Sci. 2011;4:132-136.

Saikia AP, Ryakala VK, Sharma P, Goswami P, Bora U. Ethnobotany of medicinal plants used by Assamese people for various skin ailments and cosmetics. J Ethnopharmacol.

2006;106:149-157.

Sakagami Y, Kajimura K. Bactericidal activities of disinfectants against vancomycin-resistant enterococci. J Hosp Infect. 2002;50:140-144.

Sankaranarayanan S, Bama P, Deccaraman M, Vijayalakshimi M, Murugesan K, Kalaichelvan PT, Arumugam P. Isolation and characterization of bioactive and antibacterial compound from Helianthus annuus linn. Indian J Exp Biol. 2008;46:831-835.

Sarma SK, Reddy SK, Akhil MCH, Sankar S. Phytochemical And Antimicrobial Activty of whole plant of Madhuca indica. Int J Res Pharma Chem. 2013;3:15-19.

Sayeed M, Sohel G, Khan A. Physico-chemical characteristics of Mesua ferrea seed oil and nutritional composition of its seed and leaves. B Chem Soc Ethiopia. 2004;18:157-166.

Scherer R, Godoy HT. Antioxidant activity index (AAI) by 2,2-diphenyl-1-picrylhydrazyl method. Food Chem. 2009;112:654-658.

Schmidt S, Pokorný J. Potential application of oilseeds as sources of antioxidants for food lipids-a review. Czech J Food Sci. 2005;23:93-102.

Schubert SY, Lansky EP, Neeman I. Antioxidant and eicosanoid enzyme inhibition properties of pomegranate seed oil and ferm ented juice flavonoids. J Ethnopharmacol. 1999;66:11-17.

Scott PT, Pregelj L, Chen N, Hadler JS, Djordjevic MA, Gresshoff PM. Pongamia pinnata: An Untapped Resource for the Biofuels Industry of the Future. Bioenerg Res. 2008;1:21-29.

Shin SW, Kang CA. Studies on compositions and antifungal activities of essential oils from cultivars of Brassica juncea L. Kor J Pharmacogn. 2001;32:140-144.

Shobolev V , Khan SI, Tabanca N, Wedge DE, Manly SP, Cutler SJ, Coy MR, Becnel JJ, Neff SA, Gloer JB. Biological Activity of Peanut (Arachis hypogaea L.) Phytoalexins and Selected Natural and Synthetic Stilbenoids. J Agric Food Chem. 2012;59:1673-1682.

Shrestha KA, Tiwari RD. Antifungal activity of the crude extracts of some medicinal plants against Fusarium solani (MART.) SACC. Ecoprint. 2009;16:75-78.

Shukla V, Wanasundara P, Shahidi F. Natural antioxidants from oilseeds. In Shahidi, F., ed. Natural Antioxidants, Chemistry, Health Effects, and Applications. Illinois: The American Oil Chemists Society. Champaign. 1997;34:14-19.

Silva Riveriro Rafaela, Silva Davi Oliveira, Fontes Humberto Rollemberg, Alviano Celuta Sales, Fernandes Patricia Dias, Alviano Daniela Sales. Anti-inflammatory, antioxidant, and antimicrobial activities of Cocos nucifera var. typica. BMC Complement Altern Med. 2013;13:107.

Singla RK. Review on the Pharmacological Properties of Cocos Nucifera Endocarp. Webmed Central Pharmaceutical Sciences. 2012;3: WMC003413.

Sobolev VS, Khan SI, Tabanca N. Biological Activity of Peanut (Arachis hypogaea) Phytoalexins and Selected Natural and Syn thetic Stilbenoids. J Agric Food Chem. 2011;59:1673-1682.

Soleimanpour S, Sedighinia FS, Afshar AS, Zarif R, Asili J, Ghazvini K. Synergistic antibacterial activity of Capsella bursa-pastoris and Glycyrrhiza glabra against oral pathogens. Jundi shapur J Microbiol. 2013;6:e7262.

Sowemimo AA, Fakoya FA, Awopetu I, Omobuwajo OR, Adesanya SA. Toxicity and mutagenic activity of some selected Nigerian plants. J Ethnopharmacol. 2007;113:427-432.

Spino C, Dodier M, Sotheeswaran S. Anti-HIV coumarins from Calophyllum seed oil. Bioorg Med Chem Lett. 1998;8:3475-3478.

Tabassum W, Kullu AR, Sinha MP. Effects of leaf extracts of Moringa oleifera on regulation of hypothyroidism and lipid profile. The Bioscan. 2013;8:665-669.

Tambe Y, Tsujiuchi H, Honda G, Ikeshiro Y, Tanaka S. Gastric cytoprotection of the non-steroidal anti-inflammatory sesquiterpene, beta-caryophyllene. Planta Med. 1996;62:469-470.

Tambekar DH, Dahikar SB. Exploring antibacterial potential of some Ayurvedic preparations to control bacterial enteric infections. J Chem Pharm Res. 2010;2:494-501.

Tannin-Spitz T, Bergman M, Grossman S. Cucurbitacin glucosides: Antioxidant and free-radical scavenging activities. Biochem Biophys Res Commun. 2007;364:181-186.

Taveira M, Fernandes F, Pinho P Guedes de, Andrade PB, Pereira JA, Valentão P. Evolution of Brassica rapa var. rapa L. volatile composition by HS-SPME and GC/IT-MS. Microchem J. 2009;93:140-146.

Tawfiq N, Heaney RK, Plumb JA. Dietary glucosinolates as blocking agents against carcinogenesis-Breakdown products assessed by induction quinine reductase activity in murine heap cell. Carcinogenesis. 1995;16:1191-1196.

Tenore GC, Troisi J, Di Fiore R, Basile A, Novellinno E. Chemical composition, antioxidant and antimicrobial properties of Rapa Catozza Napoletana (Brassica rapa L. var. rapa DC.) seed meal, a promising protein source of Campania region (southern Italy) horticultural germplasm. J Sci Food Agric. 2012;92:1716-1724.

Thakur AK, Chatterjee SS, Kumar V. Antidepressent like effect of Brassica juncea L. leaves in diabetic rodents. Indian J Exp Biol. 2014;52:613-622.

Thapa LB, Dhakal TM, Chaudhary R, Thapa H. Medicinal Plants Used by Raji Ethnic Tribe of Nepal in Treatment of Gas trointestinal Disorders. Our Nat. 2013;11:177-186.

Teh SS, Ee GC, Mah SH, Yong YK, Lim YM, Rahmani M, Ahmad Z. In vitro cytotoxic, antioxidant, and antimicrobial activities of Mesua beccariana (Baill.) Kosterm., Mesua ferrea Linn., and Mesua congestiflora extracts. BioMed Research International. 2013;2013:1-9.

Upadhyay B, Singh KP, Kumar A. Ethnomedicinal , phytochem ical and antimicrobial studies of Euphorbia tirucalli L.. J

Phytol. 2010;2:65-77.

Usta N. Use of tobacco seed oil methyl ester in a turbocharged indirect injection diesel engine. Biomass Bionerg. 2005;28:77-86.

Valko M, Leibfritz D, Moncol J, Cronin MT, Mazur M, Telser J. Free radicals and antioxidants in normal physiological functions and human disease. Int J Biochem Cell Biol. 2007;39:44-84.

Vosoughkia M, Ghareaghag LH, Ghavami M, Gharachorloo M, Delkhosh B. Evaluation of Oil Content and Fatty Acid Composition in Seeds of Different Genotypes of Safflower (Carthamus tinctorius L.). Int J Agric Sci Res. 2011;2:59-66.

Walia A, Malan R, Saini S, Saini V, Gupta S. Hepatoprotective effects from the leaf extracts of Brassica juncea in CCl4 induced rat model. Der Pharma Sinica. 2011;2:274-285.

Wang CY, Liu Q, Huang QX, Liu JT, He YH, Lu JJ, Bai XY. Activation of PPARγ is required for hydroxysafflor yellow A of Carthamus tinctorius to attenuate hepatic fibrosis induced by oxidative stress. Phytomedicine. 2013;20:592-599.

Wang YC, Huang TL. Screening of anti-Helicobacter pylori herbs deriving from Taiwanese folk medicinal plants. FEMS Immunol Med Microbiol. 2005;43:295-300.

Wang T. Soybean Oil. In Vegetable oils in Food Technology: Composition, Properties and uses. Gunstone F ed. (West Sussex, UK: Blackwell Publishing), pp.312-326, 2002.

Willcox ML, Graz B, Falquet J, Sidib´e Oumar, Forsterd Mathieu, Diallo Drissa. Argemone mexicana Decoction for the Treatment of Uncomplicated Falciparum malaria. T Roy Soc Trop Med H. 2007;101:1190-1198.

Yen GC, Shao CH, Chen CJ, Duh PD. Effects of Antioxidant and Cholesterol on Smoke Point of Oils. LWT - Food Sci Technol. 1997;30:648-652.

Yu JC. Jiang ZT, Li R, Chan SM. Chemical Composition of the Essential Oils of Brassica juncea (L.) Coss. Grown in Different Regions, Hebei, Shaanxi and Shandong, of China. J Food Drug Analysis. 2003;11:22-26.

Yogesh C, Kumar EP, Manisha B, Hardik RM, Vamshikrishna BA. An Evaluation of Antibacterial Activity of Abelmoschus esculentus on Clinically Isolated Infectious Disease Causing Bacterial Pathogen from Hospital. Int J Pharm Phytopharmacol Res. 2011;1:107-111.

Yong JW, Ge L, Ng YF, Tan SN. The Chemical Composition and Biological Properties of Coconut (Cocos nucifera L.) Water. Molecules. 2009;14:5144-5164.

Yue S, Tang Y, Li S, Duan JA. Chemical and Biological Properties of Quinochalcone C-Glycosides from the Florets of Carthamus tinctorius. Molecules. 2013;18:15220-15254.

Zhang YB, Guo J, Dong HY, Zhao XM, Zhou L, Li XY, Liu JC, Niu YC. Hydroxysafflor yellow A protects against chronic carbon tetrachloride-induced liver fibrosis. Eur J Pharmacol. 2011;660:438-444.