SUDAN UNIVERSITY OF SCIENCE AND TECHNOLOG

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Effect of Black Cumin *(Nigella sativa L.)* Seeds Oil on the Stability of Peanut Oil During Frying Process

تأثير زيت الحبة السوداء علي ثباتية زيت الفول السوداني أثناء عملية القلي

A dissertation Submitted to Sudan University of Science and Technology in Fulfillment for the Requirements of Master Science Degree in Food Science and Technology, Department of Food Science and Technology, College of Agricultural Studies.

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DEDICATION

To my lovely father and mother

To my dear sisters and brothers

To my best friends

To any human who respect science

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I am indebted to "Allah" who granted me everything including the mind, health and patience to accomplish this work.

I owe and grateful acknowledge an immeasurable debt to my supervisor Mahdi Abbas Saad whoes influence pervaded my work and my study.

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ABSTRACT

This study was conducted to evaluate the effect of black cumin (*Nigella sativa* L.) seeds oil (BCSO) on crude and refined peanut oil stability during frying periods. Crude and refined peanut oil was blended with 5%, 10% and 15% BCSO and commercial antioxidant (CA). The blends were used to fry potato chips for up to 60 min.

Black cumin seeds collected from the local market, were analyzed for protein, moisture, fats, fibers and carbohydrates contents then physical properties (colour, refractive index (RI), viscosity, density) and chemical properties (free fatty acid (FFA), peroxide value (PV), saponification value (SV), iodine value (IV), fatty acids composition and tocopherols). The physicochemical properties of the blends were monitored during frying potato chips at 0, 15, 30, 45 and 60 min.

Black cumin seeds had 52% oil content and total tocopherols 36.171 mg/100g. The blend of 5% BCSO with crude and refined peanut oil were significantly decreased ($P<0.05$) in colour, viscosity, FFA, PV when were compared with all other blends and control after 60 min frying potato chips.
The blend of 5% BCSO with refined peanut oil was significantly decreased ($P<0.05$) in RI when was compared with all other blends and control after 60 min frying potato chips, while the blend of same ratio of BCSO with crude peanut oil there was insignificant difference ($P<0.05$) in RI when was compared with all other blends and control after 60 min frying potato chips.

The blend of 5% BCSO with crude and refined peanut oil was significantly different ($P>0.05$) in IV when was compared with all other blends and control after 60 min of frying potato chips. Also the general acceptability showed significant difference for fried potato with the blend of crude and refined peanut oil with 5% BCSO compared with fried potato with all other blends and control.

Among all blending ratios (5%, 10% and 15%) of BCSO with peanut oil 5% was found to be the best blending ratio during frying potato chip till 60 min.

ملخص البحث

أجريت الدراسة لتقدير تاثير زيت حبة الكمون الأسود علي ثباتية زيت الفول السوداني الخام والمكرر اثناء التحمير , خلط زيت الفول السوداني الخام والمكرر مع (5%, 10%, 15%) من زيت حبة الكمون الاسود وايضا تم خلطه مع مضادات الاكسدة التجارية, ثم أستخدم زيت الفول السوداني المخلوط بكل الاضافات المختلفة في تحمير شرائح البطاطس حتي 60 دقيقة.

تم جمع حبة الكمون الاسود من الاسواق المحلية , تم قياس التحليل التقريبي لحبة الكمون الأسود لتقدير محتوي كل من (بروتين, رطوبة, دهون,الياف والكربوهيدريتات) وأيضا تم قياس الخصائص الفيزيائية(درجة اللون, معامل الانكسار , اللزوجة و الكثافة) وايضا الخصائص الكيميائية (الاحماض الدهنية الحرة, وقيمة البيروكسيدات, قيمة التصبن ,الرقم اليودي ومجموع التوكوفيرولات وتركيب الاحماض الدهنية) ثم الخصائص الفيزوكيميائية لكل انواع الخليط المختلفة اثناء تحمير شرائح البطاطس بعد 0, 15, 30 ,45, 60 دقيقة.

وجد ان نسبة الزيت في حبة الكمون الاسود 52% ومحتوي التكوفيرولات (31.6 ملجم/100جم). اوضحت النتائج انخفاض معنوي في اللون, اللزوجة, وقيمة الاحماض الدهنية الحرة وقيمة البيروكسيدات لخليط زيت الفول السوداني الخام والمكرر المضاف اليه زيت الكمون الاسود بنسبة 5% عند مقارنته مع كل انواع الخلط الاخري, وايضا وجد ان خليط زيت الفول السوداني المكرر المضاف اليه 5% زيت حبة الكمون الاسود كان هنالك انخفاض معنوي في معامل الانكسار عند مقارنته بكل انواع الخلط الاخري بعد 60 دقيقة تحمير بينما هنالك فرق معنوي في معامل الانكسار لخليط زيت الفول السوداني الخام المضاف اليه 5% زيت حبة الكمون الاسود مقارنة مع زيت الفول السوداني الخام المخلوط بكل الاضافات الاخري وزيت الفول السوداني الخام بدون خلط , ولكن هنالك فروق معنوية في قيمة اليود لخليط الفول السوداني الخام والمكرر المضاف اليه زيت الكمون الاسود بنسبة 5% عند مقارنته مع كل انواع زيت الفول السوداني المخلوط بالنسب الاخري وزيت الفول السوداني عديم الخلط .

وأيضا وجد ان التقييم الحسي للقبول العام لزيت الفول السوداني المضاف اليه زيت حبة الكمون الاسود بنسبة 5% ذات زيادة معنوية عند مقارنته مع زيت الفول السوداني الخام المخلوط بالمضافات الاخري والزيت عديم الخلط .

من بين كل نسب خلط زيت حبة الكمون الاسود (5% , 10%, 15%) مع زيت الفول السوداني وجد ان 5% كانت افضل نسبة خلط اثناء تحمير شرائح البطاطس حتي 60 دقيقة.

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CHAPTER ONE

INTRODUCTION

Nigella sativa L. is a vegetal spice belongs to the Ranunculaceae family, commonly known as black cumin seed. The seeds of *Nigella sativa* L have several therapeutic effects such as prevention of cancer, antihypertensive effect antia-inflammatory, analgesic and antihistaminic action. *N. sativa* seeds are used for edible and medicinal purposes. They are used in the preparation of traditional sweet dish, composed of black cumin paste, which is sweetened with honey or syrup, and in flavoring of foods, especially bakery products and cheese (Salma *et al*. 2007).

Black cumin seeds contain appreciable quantities of unsaturated especially poly unsaturated fatty acids (48 to 70%), while mono unsaturated (18to 29%), and saturated fatty acids (12to 25%), are in lesser proportions. Besides a better fatty acid profile, it contains considerable quantities of tocopherols and allied bioactive compounds. Moreover, the presence of phytosterols in amounts of 0.33 to 0.36% (Sultan *et al*., 2009).

Peanut is very important oil seed in sudan beside cotton, sunflower and sesame seeds. Peanut oil had odour and golden colour. Most of Sudanese people prefer the crude form, which were used in many forms like butter (dakoa). Roasting in the shell, in confections, cooking oil and the residue as animal feed (Balla, 2001).

A consumer friendly way of improving oxidative stability of edible oils is the addition of natural antioxidants. Therefore, search for finding useful source of natural antioxidants is highly desirable, because synthetic antioxidant has been questioned (Bera *et al*., 2004). Blending of vegetable oils emerged as an economical way of modifying the physicochemical characteristics of vegetable oils and fats besides enhancement in oxidative stability (Chu and Kung, 1998).

-The commercial antioxidants have caused health problems, for some people according to Taghvaei and Jafari (2015).

-Addition of cumin oil to peanut oil to improve its stability characteristics cumin oil is very rich in natural antioxidant 45.066 mg/100g oil (Sultan *et al*., 2009).

-Make it possible to replace commercial antioxidant with natural one.

Objectives

1- To improve the stability of peanut oil during frying process.

2- To determine the suitable amount of black cumin seeds oil needed to be added to crude and refined peanut oil.

3- To carry out the physicochemical properties of black cumin seeds oil.

4- To compare black cumin seeds oil with a commercial antioxidant and to study their effect on the stability of crude and refined peanut oil during frying process.

CHAPTER TWO

LITERATURE REVIEW

2.1 Botanical description of black seed *Nigella sativa:*

Nigella sativa is a spice plant belonging to the family Ranunculaceae (Aqel and Shaheen, 1996); its seed oil contains thymoquinone and many monoterpenes such as r-cymene, and apinene, and it has bronchodilator (El-Thair *et al*., 1999), antibacterial (Hanfy and Hatem, 1991) hypotensive (Zaoui *et al*., 2000), and immune potentiating (El-Kadi and Kandil, 1987) activities, and commonly grows in Europe, Middle East, and Western Asia.

Coequal names of it's used in Arab countries are Al-Habbah Al-Sawada, Habbet El-baraka, Kamoun Aswad, Schuniz and Khodria. In Pakistan, India and Sri Lanka it is called a Kalvanji, Azmut, Gurat, Aof and Aosetta; and in English language is known as black seed, black cumin and black caraway, *Nigella sativa* is a pretty herb, seed which are commonly known as Kalonji (Blatter *et al*., 1984) there are three species in this group *Nigella sativa* L., *Nigella damascene* and *Nigella arrensis* L. (Goutb, 1981), it is approximately 60 cm tall, erect herbaceous annual with blue-white flowers. The fruit has a capsule with numerous, angular, black seed, about 1-5 mm long. The important producing countries are: India, Pakistan, Iran, Syria, Egypt and United States (Abu-Zeid, 1986).

The crop is successfully grown under low temperature and high humidity climates, in Northern Africa and Mediterranean known as winter crop and cultivated in October and November (Gutb, 1980).

Black cumin seed (*Nigella sativa*) volatile oil has recently been shown topossess 67 constituents, many of which are capable of inducing beneficial pharmacological effect in humans (Aboutabl *et al*., 1986).

2.2 Chemical composition:

Black cumin seed (*Nigella sativa*) seed are rich in nutrients, organic compounds and minerals. The seed content of these compounds was investigated by Baboyan *et al*. (1978); Osman (1996) and Elshiekh (1999) they reported the protein content is 18-21%, also Baboyan *et al.* (1978) showed that the seed component of amino acids were arginine, glutamic acid, leucine, lysine, methionine, tyrosine, prolineand threonine, etc. The unsaturated fatty acid represents linoleic, linolenic, arachidonic, eicosadienoic, oleic and almitoleic acid (Gad *et al*., 1963; Babayan *et*

al., 1978). While saturated fatty acid represent plamitic, stearic and myristic acid (Gad *et al*., 1963; Menounos *et al*., 1986). Minerals (1.79 - 3.74%) calcium, phosphorus, potassium, sodium and iron (El-Zawahry, 1997; Babayan, 1978), moisture 7.43, ash 4.14%, fixed oil 37%, volatile oil 1.64, albumin 8.2%, mucilage 1.9%, organic acid precipitated by copper 0.38%, metarabin 1.36%, melanthin 1.4%, cellulose 8.32%, sugar 2.75% and other substance dissolved by soda 9.38% (Saeed, 1972).

Chemical analysis of black seed (*Nigella sativa*) showed that potassium, phosphorus, sodium and iron are the predominant elements present, zinc, calcium, magnesium, manganese and copper are found at lower level, cadmium and arsenic are not detected in the seeds (Al- Jasser, 1992) The seed also contains triterpenes components of alpha-hedrin (Kumarass and Haut, 2001).

2.3 The oil extract:

Gad *et al*. (1963) investigated chemical and physical properties of the oil extract from black seed (*Nigella sativa*) cultivated in Egypt. They found that specific gravity was about 0.92, acid value 30.30, and oleic acid represents about 43.76. Seeds of *Nigella sativa* are frequently used in flock medicine in the Middle East and some Asian countries for the promotion of good health and treatment of many ailments including fever, common cold, headache, asthma, rheumatic disease, various microbial infections and to expel worms from the intestines.

2.4 Uses of black cumin (*Nigella sativa*)

2.4.1- Medicine

In the traditional system of medicine practiced in the Arabian Gulf region, Black Seed is recommended for a wide range of ailments, including fever, cough, bronchitis, asthma, chronic headache, migraine, dizziness, chest congestion, dysmenorrheal, obesity, diabetes, paralysis, hemiplegic, back pain, infection, inflammation, rheumatism, hypertension, and gastrointestinal problems such as dyspepsia, flatulence, dysentery, and diarrhea. It has been used as a stimulant, diuretic, emmenagogue, lactagogue, anthelmintic, and carminative. Black Seed has also been used externally where it is applied directly to abscesses, nasal ulcers, orchitis, eczema, and swollen joints. The results of extensive pharmacological studies justify the broad, traditional therapeutic value of Black Seeds. These studies found Black Seed to have analgesic, anti-lipemic, post coital contraceptive, diuretic and antihypertensive, bronchodilator and calcium antagonist, histamine

release inhibitor, hepatoprotective, anthelmintic, antifungal, antimicrobial (against a wide range of organisms), anticancer, and anti-inflammatory activities (Ansari and Satish, 2013).

2.4.2- Foods

Nigella sativa L. used as a condiment in bread and other dishes and in the preparation of a traditional sweet dish, composed of black cumin paste, which is sweetened with honey or syrup and in flavouring of foods, especially bakery products and cheese. Nigella seed oil or extract has protective and curative actions and is considered as one among newer sources of edible oils (Hamadi, 2007).

2.4.3 – Cosmetics

Nigella Sativa L. can affect skin by causing an allergic reaction. Simply touching black seed may cause a red rash along the skin. This rash is often accompanied by an itching sensation (Alherz, 2012).

2.5 Vegetable oils and fats:

Oils and fats are water insoluble organic compounds, chemically they are esters of the tri, di and mono glycerides in which only two or one hydroxyl group of the glycerol is ester fied with fatty acids are only formed in small amounts (0.1_0.4%) reported by Elkhattab, (2011)..

2.6 Peanut oil

Peanut *Archis hypogaea*is grown annually out the Sudan and larger scale cultivation is contemplated in the Gezira and in the sandy soil of Kordofan in west central Sudan Elkhattab, (2011). It is now an important oil seed crop of the world in production after soybean and cotton. it is high in oil content (52.5%) and rich source in protein 26.17% , however it has small seeds (28-29 gm/100 seed) and spherical shape. (Balla, 2001). The major peanut producing countries in the world are India, China, USA, Indonesia, Burma, Nigeria, Senegal, Zaire, Brazil and Argentina (FAO, 1988).

Peanut is very important oil seed in Sudan beside cotton, sunflower and sesame seeds. Peanut oil had odour and golden colour. Most of Sudanese people prefer the crude form, which were used in many forms like butter (Dakoa). Roasting in the shell, in confections, cooking oil and the residue as animal feed (Balla, 2001). Peanut oil is easily refined to give a pale yellow oil of pleasant, mild or bland flavor.

Peanut oil contains up to 30% linoleic acid, the essential fatty acid which plays a major part in human diet (Ihekoronye and Ngobby, 1985). Peanut seed are rich in oil 38-50%. Which is used for cooking, salad manufacture of margarine, soap and as lubricant. The high quality oil is used as well in pharmaceutical industry (Hitiggins, 1951).

2.7 Physical properties of groundnut seed

2.7.1 Moisture content

Khalil and Chughtai (1983) reported that the moisture content in the range 4.7 % to 5.1% for the four high yielding imported groundnut cultivars grown in Pakistan. Cobb and Johnson (1973) reported that the moisture content of the whole kernel of peanut varied between 3.9 and 13.2%. The moisture content of the seed of three cultivars of groundnut varied between 4.8 and 5.1% as reported by Balla (2001).

2.7.2 Oil content

Misra *et al*, (1992) reported that the oil content for groundnut range between 42.5% and 54.5% while Nigam *et al*, (1994) stated that the average oil content of groundnut was 51%. Sanders *et al*. (1982) reported that the oil content in peanut seed ranged from 36% to 56%. Ahmed (2001) reported that total oil content of three cultivars of groundnut seeds varied from 49.7% to 52.2% by Balla (2001). Berry (1982) reported that the groundnuts from 16% *Arachis hypogaea* L. cultivars were found to contain oil in the range of 43 to 50%.

2.7.3 Protein content

Khalil and Chiughtai (1983) reported that there were significant differences in protein content of five peanut cultivars grown in Pakistan which ranged between 24.5 to 28.55. Kumari and Reddy (1993) pointed that the crude protein content of peanut was 23.4%. Freeman , *et al* ., (1954) and Balla (2001) noticed that protein content of three cultivars of groundnut seed was between 20.1% and 26.1 %.

2.7.4 Crude fiber

Khalid and Chughtai (1983) reported that the crude fiber of four groundnut cultivars varied between 4.6 to 4.8% where as Cobb and Johnson (1973) reported that peanut kernel contains 1.2- 4.3% crude fiber . Balla (2001) reported that the crude fiber of three groundnut cultivars ranged from 1.3% to 1.5%.

2.7.5 Ash content

Ash content of groundnut cake ranged between 1.8% and 3.1% (Cobb and Johnson 1973), while values between 1.2% and 4.3% were reported by Freeman *et al. (*1954). Khalil and Chugati (1983) found that the ash content of four ground cultivars grown in Pakistan varied from 2.3% to 2.5%. Balla (2001) reported that ash content of three cultivars of groundnut ranged from 2.2% to 2.5%.

2.8 Physical analysis of groundnut oil

2.8.1 Refractive index

Refractive index is a basic value that relates to molecular weight, fatty acid, chain length, degree of un saturation, and degree of conjugation, refractive index is the degree of deflection of a beam of light occurs when it passes from one transparent medium to another a refractometer with temperature control is used for fat and oils with measurement usually at $25C^0$. Jacob and Krishnamurthy (1990) marked that the refractive index of groundnut oil at 40 C^o ranged from 1.4620 to 1.4640. Allen and Robert (1975) showed that the refractive index of groundnut oil varied between 1.4605 to 1.4645 at 40 C^oin Codex Alimentarius Commission (1993) the refractive index of peanut oil was mentioned as 1.4600 to 1.4650 at 40 C^o Balla (2001) reported that the refractive index of groundnut Cultivars varied between 1.4638 to 1.4666 at 40 C^o.

2.8.2 The density

Elkhattab, (2011) found that the density of groundnut oil at 21 C^o was 0.9150, while the relative density of groundnut oil was reported by Codex Alimentarius Commission (1993) to vary from 0.9140 to 0.9170 at 20C^o.

2.8.3 The viscosity

Viscosity is a measure of internal resistance of the liquid flow and is an essential index in the study of oils and their intermolecular forces; viscosity is also a useful criterion on desegregation or depolymerization such as that which occurs in initial stages of hydrolysis of fats and oils during storage (Joslyn, 1970).

Viscosity is an important parameter for the design of industrial process; for example, it determines the rate at which oil drain from fried food In general saturated fatty acids because their molecular structure enable close proximity of the carbon chains, which allow intermolecular interactions (Nichos and Sanderson

2003). The increase in viscosity of frying oils is due to polymerization, the length of the fatty acids or to the type of oil (Mariod, 2005).

Viscosity is considered an important parameter in the overall assessment of the quality of the quality of edible oils since it can have a significant effect on frying performance and fried food acceptability. It controls the amount of oil absorbed by fried materials and thus the total sum of oxidative products within the food (Alim and Morton 1978). Moreover it is looked upon as a major determinant of heat transfer or cooking rate of the oil and it is believed that the heat transfer rate decreases with increasing viscosity (Elkhattab, 2011).

Balla (2001) reported that the viscosity of oil increased with rise in temperature, while saturation and larger molecules such as long chain fatty acids or polymerized oil increased the viscosity. Elkhattab, (2011). Reported that the viscosity of groundnut oil at 21C^{o} was 70.7 cp. Balla (2001) found that the viscosity of three groundnut cultivars to range between 46.0 and 52.43 centipoises at 30 C^{o}. Parasad and Dutt (1989) reported that the viscosity of groundnut ranged from 16.22 to 76.67 cp.

2.8.4 The colour

Changes in the colour of fats and oils finished products are perceived as indicating poor – quality product, regardless of the reason or effect upon performance consumers may not consciously notice the color of a bottled oil unless it appears different from other products on the shelf marketing has unsuccessfully promoted lighter or whiter oil as being better for most salad oils and shortenings. Food processors usually have ingredient specifications that identify the allowable colour parameters because the fats and oils products may have the ability to enhance or diminish the appearance of the prepared food product colors of fats and oils must be monitored as they are received to maintain both real and perceived product quality. Allen and Robert, (1975) reported that the yellow colour appeared in crude oil of peanut is due to presence of β-carotene pigments , while in Codex Alimentarius Commission (1993) mentioned that the colour of groundnut oil was to depend on the characteristics of the designated products . Cobb and Johnson (1973) indicated that the colour of groundnuts oil using lovibond as maximum yellow 16.0 and 2.0 for red colour.

2.9 Chemical analysis of groundnut oil

2.9.1 Peroxide value

Oxidation of lipids is a major cause of their deterioration, and hydro peroxides formed by the reaction between oxygen and unsaturated fatty acids are the primary products of this reaction hydro peroxide have no flavor or odor but breakdown rapidly to form aldehydes, which have a strong, disagreeable flavor and odor. The peroxide concentration, usually expressed as peroxide value is a measure of oxidation or rancidity, in its early stages, peroxide value (PV) measures the concentration of substances. Therefore, high peroxide values usually mean poor flavor ratings, but a low peroxide value is not always an indication of a good flavor (Elkhattab, 2011).

Balla (2001) reported that the peroxide value of crude groundnut oil ranged from 0.7 to 1.2 milli .equiv O_2/Kg of oil for the refined oil. Applewhite (1982) pointed out that the effects of atmospheric oxidation apply to all fats and oils, regardless of their stage of processing.

2.9.2 Free fatty acids

Hydrolytic rancidity occurs as a result of a splitting of triglyceride molecule at the ester linkage with the formation of free fatty acid. Jacob and Krishnamurthy (1990) reported that the free fatty acids as oleic acid, of groundnut oil should be less than 3%. Elkhattab, (2011) claimed that the free fatty acids, as oleic acid of peanut oil should have a maximum value of 0.05%.

2.9.3 Iodine value

The iodine value is a chemical constant for a fat or oil. It is a valuable characteristic in fat analysis that measures unsaturation , but does not define the specific fatty acids iodine value analyses are very accurate and provide nearly theoretical values, except in the case of conjugated double bonds or when the double bond in near a carboxyl group. However unless the history of the fat or the type of fat in the product is known, an iodine value may be somewhat meaningless by itself for example; a product prepared with a meat fat with consistency and performance characteristics similar to a vegetable oil. Based product will have a considerably different iodine value. Further, even vegetable oil products with comparable functionality, different source oils. With not have like iodine values, iodine value is a useful tool for process control and product specification. Iodine is

measure of the unsaturation of fat and oils and is expressed as the number of centigrams of iodine absorbed per gram of sample (Elkhattab, 2011).

Ali (2002) reported that the measurement of iodine value (IV) was found to be one of the most convenient methods to determine saturation and unsaturation oil. The initial iodine value for groundnut oils was reported to be 97.5 cmg /iodine/100g/fat. Jacob and Krishnamurthy (1990) found that the iodine value of groundnut oil ranged between 85 and 95. Cobb and Johnson (1973) value of peanut oil ranged from 82 to 107. Codex Alimentarius Commission (1993) reported that the iodine value for groundnut oil ranged from 80 to 106.

2.9.4 Saponification value

Ramsden (1995) define the saponification value of oil as milligrams of potassium hydroxide needed to neutralize the fatty acids formed by the complete hydrolysis of one gram of the lipid. Jacob and Krishnamurthy (1990) found that the saponification value of groundnut oil varied from 188 to 196. Codex Alimentarius Commission (1993) mentioned that the saponification value as mg KOH/g oil should range from 187 to 196.

2.9.5 Fatty acids composition

Gas-liquid chromatographic analysis of the oil fatty acid methyl esters revealed the occurrence of oleic (37.94 to 41.90%) linoleic (34.59 to 37.51%) , palmitic (12.22 to 13.30), stearic (3.17 to 3.67%) arachidic (1.63 to 1.85%) eicosaenoic (0.99 to 1.22%), behenic (3.24 to 4.36%), and lignoceric (1.08 to 1.44%) as the major fatty acids showed by (Elkhattab, 2011).

2.10 Blending of edible vegetable oil

Blending technology of reset oil is a well known produce for different purposes such as nutrition, medicine, pharmacy, cosmetic and for energy as fuel blends (Luna and Michelena, 1986). It had been mono saturated that stable of poly unsaturated vegetable oils were improved by blending oils with different portion of high oleic sunflower oil. Elkhattab, (2011).studied the improvement of oxidative stability of groundnut oil, he concluded that the oxidative stability of those oils improved by blending with olein. Prakash *et al*. (2001) studied binary blends of 80% base oil (mustard, groundnut and sunflower oil) and 20% blending oil (sesame, refine palm and rice bran oil). The blending was carried out for the sake sensory odour profiling of base oils, namely sesame blending oil and their blends.

Mariod *et al*. (2005) studied the improvement of the oxidation stability of sunflower kernel oil (SKO) blending with highly stable unconventional melon bug

oil (MBO). They found that the stability of SKO and MBO were 43 and 48 respectively. The blending of KSO with the usual Sudanese oils resulted in remarkable increase in their oxidative stability.

2.11 Frying technology

Frying is one of the oldest methods known to human kind for preparing food. Fried foods are among the favorites for people around the world. The Latin and Greek words for frying originate from those used for roasting, suggesting that frying may have developed from roasting (Elkhattab, 2011). The simplest deep-fat frying is conducted in a kettle of oil heated on a stove or over an open fire. Small batches of food are immersed in hot oil and removed when fried as determined by the experience of the cook. The first real technological advance in frying was the introduction of continuous cookers. The development of continuous fryers provided a boost for the commercial development of frying (Elkhattab, (2011).

Deep-fat frying is the most complex edible fat and oil application. Frying fat influences many qualities of the finished product such as flavor, texture, shelf life and nutritional attributes (Perkins and Erickson, 1996).

In Africa and some parts of Asia, particularly India, the oil has been reportedly used for cooking purposes (Elkhattab, 2011). Oleic acid is the most abundant monounsaturated fatty acid in all the common edible oils (Gunstone, 2000). Compared with polyunsaturated fatty acids, oleic acid is more stable towards oxidation both at ambient storage temperatures and at the high temperatures that prevail during the cooking and frying of food. therefore , oils with high amounts of oleic acids are slower to develop oxidative rancidity during shelf life or undergo oxidative decomposition during frying than those oils that contain high oleic acid, low – linoleic and low-linolenic acids produced by various methods including genetic modification (Anon, 1998), and have been shown to be more stable to deterioration during deep-frying than regular oils.

The physical and chemical changes occurring in frying oils and the many compounds formed in deterioration during deep-frying oils have been extensively reported. Although these compounds often are used to measuring nonspecific compounds that may or may not relate to oil degradation or fried –food quality .in fact, the frying industry is still searching for the ultimate criteria to evaluate frying stability of oils and fried –food flavour quality and stability (Warner, 2002).

From a practical point of view, commercial and industrial frying oil operators want to know the answer to one question: when should frying oil is discarded or

how does one know when the frying oil needs to be dumped? Unfortunately, there is no simple answer. A specific method may be ideal for one operation but completely useless in another. The determination of the end point of frying oil is therefore dependent on good judgment and knowledge of the particular frying operation, as well as on type of frying oil and the analytical measurements used (Fritsch, 1981).

Quality evaluation of frying fats may be carried out in many ways. Although a sensory evaluation of foods is the most important quality assessment, taste evaluations are not practical for routine quality control. It is always preferred to have a quantitative method for which rejection point could be established by sensory means (Fritsch, 1981). Due to the complexity of the problem, there is no single procedure that will yield reliable results in all situations. Determination of total polar materials in a frying fat provides the most reliable measure of the extent of deterioration in most cases. About 80% of lipid in groundnut is unsaturated with about50% monounsaturated fatty acid and 30% polyunsaturated fatty acid and consequently groundnut oil has a longer shelf life.

Ground oil is excellent oil for deep frying pastries shortening, oleo margarine, mayonnaise, salad dressing and other food product obtained by (Elkhattab, 2011).

2.12 Mechanism of frying

Frying is a combined process of mass and heat transfer and chemical reaction between oil and air, oil and moisture (from the food), and oil and various food constituents, such as proteins. Carbohydrates or chemical additive the combined reactions between the proteins and carbohydrates in the food and the hot oil in the fryer generate fried flavor and surface color via the Millard reaction and some oxidative reaction in the oil itself.

Most frying operations are conducted at oil temperature of 300-365 °F. Extruded products and pellets are typically fried at 380- 420 °F. Heat from the frying oil penetrates the products and vaporizes its internal moisture. The water vapor migrates to the surface of food and escapes as steam .as the moisture content drops, the product turns from a golden yellow to light- or medium brown color is a pictorial representation of these physical phenomena that take place during frying. The oil also undergoes a series of chemical reactions during frying. These include hydrolysis, oxidation (autoxidation, photosensitize oxidation and photochemical, oxidation and thermal decomposition (polymerization).

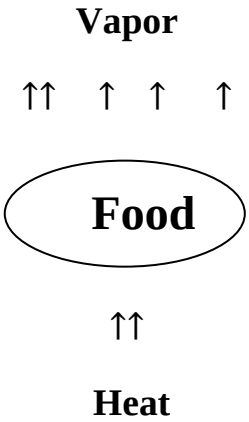

Fig. 1: Heat and mass transfer in frying

2.12.1 Oxidation

The oxygen in deep-fat frying reacts with oil (Peers and Swoboda 1982; Cuesta *et al*., 1993; Sanchez-Muniz *et al.*, 1993; Houhoula *et al*., 2003). The chemical mechanism of thermal oxidation is principally the same as the autoxidation mechanism. The thermal oxidation rate is faster than the autoxidation, but specific and detailed scientific information and comparisons of oxidation rates between thermal oxidation and autoxidation are not available. The mechanism of thermal oxidation involves the initiation, propagation, and termination of the reaction.

2.12.2 Hydrolysis

Hydrolysis is the reaction between a water molecule and triglyceride molecule, the reaction can be described hydrolysis produces and molecule of free fatty acids (FFA) and a molecule of diglyceride. The reaction can continue between a diglyceride molecule and another molecule of water to produce a molecule of monoglycride and another of (FFA) ultimately, the reaction can yield a molecule of glycerol and three molecules of (FFA); however, the occurrence of this complete reaction in a fryer is rare. The hydrolysis of oil can occur only when oil and water are in perfect solution. Oil and water do not mix, but they do become soluble when subjected to very high pressure. Hydrolysis can occur at normal frying temperatures in the presence of a small amount of surfactant. A surfactant (emulsifier) can come from various sources.

2.13 Antioxidants

Antioxidants are used widely in fats and oils products to delay oxidative processes. Some foods like fats and oils, when heated, suffer thermal oxidation and

produce compounds such as peroxides. The peroxides turn into aldehydes, ketones, epoxides, dimers and polymers, undermining the quality of food. Inorder to minimize such effects, the food industry makes use the antioxidants (Litwinienko *et al*., 1999).

Antioxidants are additives that delay the onset of oxidative changes in food (Brasil, 1997). Thus, they contribute to food preservation; prevent changes in flavor, and slow rancidity and discoloration processes (Bitar 2008). Several antioxidants, such as citric acid, BHA, TBHQ (tertiary butyl hydroquinone), BHT (3.5-di-tert-butyl-4-hydroxytoluene) and propyl gallate - PG -(3.4.5-trihydroxybenzoate propyl), are used in food preservation as stocked vegetable oils (Kim *et al*., 2009). The following antioxidants: BHA, TBHQ, BHT, PG, as well as ascorbic acid, sorbic acid and citric acid, are listed in the FDA, (2009) as authorized food additives. Also, ascorbic acid, sodium ascorbate, calcium ascorbate, potassium ascorbate, erythorbicacid, isoascorbic acid, sodium erythorbate, isoascorbate sodium, lecithin, sodium lactate, citric acid, calcium citrate, calciumcitrate tri-acid, citric acid esters, fatty acids with glycerol and glucose oxidase (*Aspergillusniger*), are allowed as antioxidants in food by ANVISA (Brasil, 1999). Phytic acid, due to its ability to chelate iron and inhibit the emergence of hydroxyl radicals, is used as antioxidant and to prevent discoloration and extend the average life of foods (Filgueiras, 2009).

The knowledge of thermal stability of antioxidants is very important in food preservation. In edible oils, the choice of antioxidant must be aimed at the preservation of unsaturated fatty acids to increase the stability to thermal degradation, which usually happens between 150 and 220 °C. However, the presence of high concentrations of unsaturated fatty acids in vegetable oils requires greater thermal stability of the antioxidant (Yilmaz and Karakaya, 2009).

Oxidation increases at higher ambient temperatures and is catalyzed by the presence of heavy metal ions, especially copper. The degree of unsaturation of the oil also influences shelf life, for example oils with a high level of linolenic fatty acid are more prone than those with a higher saturated fatty acid content. Oxidation can be minimized by the presence of anti-oxidants, which inactivate free radicals. Dosages of antioxidants are generally up to 200 mg/kg, based on total fat content. The largest application of antioxidants is found in the processing of oil seeds into oils and fats where refining removes impurities from vegetable oils. With these impurities natural antioxidants can also be removed from the oils, making the products susceptible to oxidation. A range of synthetic antioxidants are available to

restore or even improve the oils natural protection against oxidative degradation and thus increasing their shelf life considerably. Other use of antioxidants are found in the rendering of animal fats, the meat industry, in baked goods and practically all foods with a high oil content such as mayonnaise and margarine.

2.14 Organoleptical quality of foods

The quality of food products may be understood just as a measure of desirability in a product and as such must be closely related to consumer acceptance for he is the final key to understanding quality. Although advances were being made in the development of objective tests that measure individual quality factors, most aspects of quality can be measured by sensory panels, more tightly, food quality and acceptance can indicate by correlating the quantitative measurement of various sensory characteristics contributing to the overall appreciation of food, with the consumer assessment or preference rating (Mahgoub, 2010).

People chosen for sensory evolution maybe classified as follow;

* Well trained persons
* Laboratory staff
* Public consumers

Food scientists and technologists are frequently faced with having to make judgments about quality of oils or fats which they handle, or products in which oil or fat contents are significant. There are two distinct closely forms of judgment. The first form concerns the quality of the products as it already become rancid? Accepting that product or received is of more or less satisfactory quality, how long , under defined storage condition, is it likely to remain? The answer to the first question can be directly from a single sensory test, it is accepted for most oils and fats that completely bland, tasteless product is ideal. There is exceptions butter fat, olive oil, sesame oil, but the problem for taster is the detection of very small amounts of objectionable oxidation end products. These are mainly aldehydes, but alcohols, ketones, carboxylic acids and lactones also play a part in off-flavors (Mahgoub, 2010).

Rancid flavors are chemically very complex, since they are derived from any or all of the unsaturated fatty acids originally present in the oil and each of these can oxidize through several different mechanisms. Descriptive terms such as rancid, paity beany, green, stable and so on are attempts to describe sensation

arising from the presences of very small quantities of oxidation end products in an oil or fat. Some specific, recognized aldehydes are having distinctive characters, these aldehydes are ultimately derived from linoleic or linolenic acids, and most of them sare disliked (Mahgoub, 2010)

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

3.1.1 Sampling materials

The seeds of cumin seed were collected from Khartoum state; crude, refined peanut oil and potatoes were brought from Khartoum state.

3.1.2 Chemicals and reagents

All chemicals and reagents used in this study were collected from the National Food Research Centre (NFRC).

3.2 Methods

3.2.1 Sample preparation

Sample of black cumin seeds were cleaned by removing foreign particles, and then kept in polyethylene bags for further analysis away from light at room temperature.

3.2.2 Proximate analysis of cumin seeds

3.2.2.1 Determination of moisture content

Moisture was determined by the AOAC (2000). Two gm of sample were dried in an oven at 103 ± 2 C^{o} for 24 hrs; the test repeated three times, then the average was taken.

$$\text{Moisture content } \% = \frac{\text{Weight loss (gm)}}{\text{Weight of sample (gm)}} \times 100$$

3.2.2.2 Extraction of cumin oil

3.2.2.2.1 Mechanical pressing

The extraction of the oil from cumin seeds was done in the manner described by Balla (2001) with minor modification. About one kilo-gram seeds were weighed after removal of impurities, using mortar the size of the seeds was reduced to increase the surface area for oil extraction. The sample was transferred to cloth bag, and then the oil was extracted from the seeds using cold press.

3.2.2.3 Determination of oil content

Oil content was determined according to the AOAC (2000). Two gm of sample were extracted with hexane for 8hrs in soxhlet apparatus;

$$\text{Oil content} = \frac{\text{Weight of extracted oil}}{\text{Weight of sample (gm)}} \times 100$$

3.2.2.4 Determination of protein content

Nitrogen content determinations were made in fat free meals by micro-Kjeldal technique following the AOAC (2000). About 0.2gm of sample was weighed accurately into Kjeldal flask, 0.4 gm of catalyst mixture and 3.5 ml of concentrated sulphuric acid were added, the flask was placed in the digestion equipment for 2hrs. the digested sample was then placed in the distillation apparatus, 20 ml of 40% NaOH were added and the ammonia evolved was received in 8ml of 2% boric acid solution.

The trapped ammonia was titrated against 0.02 N/HCL using universal indicator (Methyl red+ bromocresol green);

$$\text{N} = \frac{\text{Volume of HCL x 0.02N/HCL x 14}}{\text{Weight of sample}} \times 100$$

Protein content = N ×6.25

3.2.2.5 Determination of crude fiber

Crude fiber was determined according to the AOAC (2000). Two gm of fat free(Meals was treated successively with a boiling solution of H_2SO_4 and KOH (0.26N and 0.23N, respectively). The residue was separated by filtration, washed, dried, weighed and ashed at 500 C^o. the loss of weight resulting from ashing corresponded the crude fiber in the sample.

3.2.2.6 Determination of ash content

Ash content was determined according to the AOAC (2000). One gm of defatted sample was ignited at 500 C^o in a muffle furnace for 24hrs.

$$\text{Ash content} = \frac{\text{weight of ash}}{\text{Weight of sample}} \times 100$$

3.2.3 Physical analysis of black cumin seeds oil

The physical analysis of black cumin seeds oil was conducted from the National Food Research Centre (NFRC).

3.2.3.1 The colour

The color intensity of oils was recorded using a Lovibond Tintometer as units of red, yellow and blue) in the manner described by Balla (2001).

Samples of oils were filtered through filter paper immediately before testing. An appropriate 5.25 inches was filled with oil and placed in the tintometer in specific place. The instrument was switched on and looked through the eyepiece, and then slides were adjusted until a color match was obtained. The values obtained by matching were recorded as red, yellow and blue.

3.2.3.2 The density

The density of oil was determined using density bottle method. A clean and dry density bottle of 25ml capacity at 30℃ was weighed in gram (W0). Then the bottle was filled with water and reweighed at 30℃ (W1). Melted oil was brought to 300C and the water was substituted with this oil after drying the density bottle and weighted again (W2) and the specific gravity was determined (AOAC, 2000).

The density = (W1-W0) / (W2-W0) = $\frac{\text{mass of substance}}{\text{Mass of an equal volume of water}}$

3.2.3.3 Refractive index (RI)

The refractive Index (RI) was determined by Abbe 60 refractometer as described by the AOAC (2000). A double prism was opened by means of screw head, few drops of oil were placed in prism. The prism was closed firmly by tightening the screw head and the instrument was then left to stand for few minutes before reading in order to equilibrate the sample temperature with that of the instrument ($32\pm2C^{o}$).the prisms were cleaned between readings by wiping of the oil with soft cloth, and then with cotton moister with petroleum ether and left to dry, test was repeated three times.

3.2.3.4 Viscosity (cp)

The viscosity of the oil samples was detected using an Oswald-U-tube viscometer according to Cocks and Van Rede (1966) the viscometer was suspended in a constant temperature bath ($32 \pm 2C^{o}$). So that capillary was vertical. The instrument was filled to the mark at the top of the lower reservoir with the oil by means of pipette inserted into the side arm , so that the tube above the mark was not wetted. The instrument was then left to stand for few minutes before reading in order to equilibrate the sample temperature with that of the instrument ($32+2C^{o}$). By means of the pressure on the respective arm of the tube, the oil was moved into the other arm so that the meniscus was 1cm above the mark at the top of the upper reservoir. The liquid was then allowed to flow freely through the rube and the time required for the meniscus to pass from the mark above the upper reservoir to that at the bottom of the upper reservoir was recorded.

Calculation

$$\text{Viscosity of the oil } = \frac{T - To}{TO}$$

Where
T= Flow-time of the oil.
To = Flow-time of the distilled water.

3.2.4 Chemical analysis of oil

The chemical analysis of black cumin seeds oil was conducted from the National Food Research Centre (NFRC).

3.2.4.1 Iodine value (IV)

The iodine value of the oils, which quantifies their unsaturation level, was determined according to the AOAC (2000). Approximately, 0.2 gm of oil as accurately weighed and placed in a dry and clean flask specially offered for the test. A 25ml of pyridine sulphate dibromide solution was added to the content of the flask. The flask was then stoppered and the mixture was allowed to stand for 10 minutes in a dark place. The stopper and the side of the flask were rinsed with enough amount of distilled water; the contents of the flask were shaken and titrated against 0.1N sodium thiosulphate solution using starch liquid as an indicator. A blank determination was carried out simultaneously.

Calculation

$$\text{iodine value} = \frac{12.69 \times (B - S) \times N}{w}$$

Where;
B = volume in ml of standard sodium thiosulphate solution required for the blank.
S = volume in ml of standard sodium thiosulphate solution required for the sample.
N = normality of standard sodium thiosulphate solution.
W = weight in g of the sample.

3.2.4.2 Peroxide value (PV)

The peroxide value (PV) of the oil samples was determined according to the AOAC (2000). About 5gm of the sample were weighed into a 250 ml stopper conical flask. 30 ml of acetic acid chloroform solvent mixtures were added and swirled to dissolve. 0.5 ml saturated potassium iodide solution was added with a Mohr pipette stood for 1 min in dark with occasional shaking, and then about 30 ml of water was added. Slowly the liberated iodine was titrated with 0.1 N sodium thiosulphate solutions, with vigorous shaking until yellow colour was almost gone. About 0.5 ml starch solution as indicator was added and was continued titration shaking vigorously to release all iodine gas from CHCL layer until blue colour disappeared. If less than 0.5 ml of 0.1 N $Na_2S_2O_3$ was used 0.01 N $Na_2S_2O_3$ was repeated. Blank determination (must be less than 0.1 ml 0.1N $Na_2S_2O_3$) was conducted. Peroxide value expressed as mille equivalent of peroxide oxygen per Kg sample (Meq per Kg oil).
Calculation

$$\text{Peroxide value} = \frac{\text{Titer x N x 1000}}{\text{Weight of the sample}}$$

Where:
Titer = ml of sodium Thiosulphate used (blank corrected)
N = Normality of sodium thiosulphate solution.

3.2.4.3 Free fatty acids (FFA)

Free fatty acid was determined according to the AOAC (2000). About 5to 10 g of cooled oil sample was weighed in a 250 ml conical flask and 50 ml to 100 ml of freshly neutralized hot ethyl alcohol was added and about 1 ml of phenolphthalein indicator solution, the mixture was warmed about 5 minutes and was titrated while hot against standard alkali solution shaking vigorously during the titration. The weight of the oil was taken for the estimation and the strength of the alkali used for titration shall be such that the volume of alkali required for alkali required for the titration must not exceed 10 ml.

Calculation

$$\text{Free fatty acids as oleic acid } \frac{28.2 \times \text{V} \times \text{N}}{w}$$

Where:
V = Volume in ml of standard sodium hydroxide used.
N = Normality of the sodium hydroxide solution.
W = Weight in g of the sample

3.2.4.4 Fatty acid composition

Fatty acid composition of oil was determined by gas chromatography apparatus (Py E-UNICAM model GCD) according to acid catalyzed as follow:
About one ml of oil was taken in 100ml rounded bottomed flask 100ml , 6 ml of 0.5 ml namethanolic and was well shaken , 6ml 1% methanolic Hs50 was well shaken, the mixture was left over night at 50 C^{O}, then 2 ml hexane was added and shaken, enough saturated sodium chloride was added to bring level to the neck of the flask , 1 ml of the upper layer was taken into stoppared tube and some anhydrous sodium sulphate was added to remove the moisture , then Sample now was ready for injection in GC.

About 0.5 Oil was injected in GC with column (PEGA) poly ethylene Glycoladipate 16%. 1.5 m nitrogen was used as carrier gas at flow rate 1 ml/sec 1 ml per second the temperature of the detector and to column were set at 220 and 203 C^{o} with attenuation 16X10 and chart speed 1 cm/minute the analysis was allowed to proceed until the last peak had emerged.

The area of each peak was calculated by the triangulation method, the ratio of the constituents was determined by measuring the area of all the peaks and the percentage represented by each peak was calculated.

3.2.4.5 Tocopherols

For the determination of tocopherols, a solution of 250 mg of oil in 25 ml of n-heptane was directly used for the HPLC. The HPLC analysis was conducted using a Merck-Hitachi low-pressure gradient system, fitted with a L-6000 pump, a Merck-Hitachi F-1000 fluorescence spectrophotometer (detector wavelengths for excitation 295 nm, for emission 330 nm), and a D-2500 integration system. The samples in the amount of 20 µl were injected with a Merck 655-A40 autosampler onto a Diol phase HPLC column 25 cm × 4.6 mm ID (Merck, Darmstadt, Germany) using a flow rate of 1.3 ml/min. The mobile phase used was n-heptane/tert-butyl methyl ether (99 + 1, v/v) (Balz *et al*., 1992).

3.3 Blending operation

3.3.1 Crude peanut oil

Crude peanut oil blended with (5, 10 and 15% BCSO) oil and commercial antioxidant (CA) for both. The blends were well shaken and then used for frying potatoes.

3.3.2 Refined peanut oil

Refined peanut oil blended with (5, 10 and 15% BCSO) oil and commercial antioxidant (CA) for both. The blends were well shaken and then used for frying potatoes.

3.4 Frying operation:

3.4.1 Crude peanut oil

Were carried out in tefal fryer, 10 kg of potatoes were used for frying potatoes were cut into slices and were divided to 3 parts every part fried in crude peanut oil (control), blend of crude peanut oil with 5, 10 and 15% black cumin seed oil (BCSO) and crude peanut oil with commercial Antioxidant (CA) form zero time and every 15 minutes until 60 minutes thermostat control was used for measuring temperature at 160C^{o}, sample was cooled and stored until required for analysis.

3.4.2 Refined peanut oil

Were carried out in tefal fryer, 10 kg of potatoes were used for frying potatoes were cut into slices and were divided to 3 parts every part fried in refined peanut oil (control), blend of refined peanut oil with 5,10 and 15% black cumin seed oil (BCSO) and refined peanut oil with commercial Antioxidant (CA) form zero time and every 15 minutes until 60 minutes thermostat control was used for measuring temperature at 160C^{o} , sample was cooled and stored until required for analysis.

3.5 Sensory evaluation

Fried potatoes were assessed organoleptically by the ranking test according to the procedure described by Ihekoronye and Ngoddy (1985). 15 panelists from the National Food Research Centre (NFRC) staff were asked to evaluate taste, colour, odour, texture and acceptability.

The ranking test depended on the range (a) as excellent, (b) as very good(c) as good (d) as bad and (e) as very bad.

3.6 Statistical analysis

Data were analyzed as complete randomized design with three replicates using statistical analysis system program SAS. Means were separated using Duncan's multiple range test according to Steel *et al*, (1997).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Proximate composition:

Table (1) shows the proximate composition of black cumin seeds which includes: moisture, oil, protein, crude fiber, carbohydrates and ash contents.

The moisture content of black cumin seeds was found to be 3.5%. This percentage was lower than the values obtained by Gharby *et al*., (2015); Ali *et al*., (2012); Javed *et al*., (2012); Sultan *et al*., (2009) and Cheikh-Rouhou *et al*. (2007).Their readings were 8.10, 4.20, 5.40, 6.46 and 11.60% respectively.

Black cumin seeds had an oil content which was 52%. It was higher than all readings of previous works (Javed *et al*., 2012; Matthaus and Oscan 2011; Sultan *et al*., 2009; Cheikh-Rouhou *et al*., 2007 and Akram, 1999) which was 21.67, 30.40, 31.16, 40.00 and 30.00% respectively.

The protein content of black cumin seeds was 18%, which was lower than the values reported by Gharby *et al*., (2015); Ali *et al*., (2012); Javed *et al*., (2012); Sultan *et al*., (2009); Atta., (2003) and Takruri and Dameh, (1998). Their readings were 26.50, 19.80, 24.05, 22.80, 20.00 and 20.00% respectively.

The crude fiber of black cumin seeds was 10%, this value was higher than the values reported by Gharby *et al*., (2015); Ali *et al*., (2012); Javed *et al*. (2012); Sultan *et al*., (2009); Cheikh-Rouhouh *et al*., (2007) and Ataa, (2003), which was 6.80, 5.10, 5.50, 6.03, 5.10 and 5.10%, respectively.

The ash content of black cumin seeds was 8.75% this value was lower than the value reported by Gharby *et al*., (2015) which was 9.6%, but it was higher than the values obtained by Ali *et al*., (2012); Javed *et al*., (2012); Padmas, (2010) and Sultan *et al*., (2009). Their readings were 4.00, 4.34, 6.00 and 4.20% respectively.

4.2 Physical properties of black cumin seeds oil

Table (2) shows that the physical properties of black cumin seeds oil, which covers: Refractive index which was 1.472; it was higher than those brought by Gharby *et al*.,(2015); Ali *et al*., (2012); Salma *et al*., (2007) and Cheickh-Rouhou *et al*. (2007). Their readings were: 1.4680, 1.4683, 1.4680 and 1.4600- 1.4700, respectively. It was lower than the value obtained by Sultan *et al*., (2009) which was 1.4730.

Table (1) proximate composition of black cumin seeds

Constituent	Mean values %
Moisture content	3.50
Oil content	52.00
Protein content	18.00
Crude fiber	10.00
*Carbohydrates (soluble)	7.75
Ash content	8.75

*Calculated by difference

The density of BCSO was 0.918 at 24 ºC. This value was lower than those values reported by Zzaman *et al*.,(2014) and Sultan *et al*., (2009), which were 0.930 and 0.923 respectively. It was higher than that reported by Ali *et al*., (2012) which was 0.907 at 25ºC.The viscosity of BCSO was 27.2 centipoises. It was observed that the BCSO viscosity value was higher than the value reported by Hamadi *et al*., (2007) which was 11.23 cp. but it was lower than the value reported by Zzaman *et al*. (2014) which was 64.53 c.p.

The colour of BCSO was Yellow = 32.2; Red =12.1 and Blue = 0.5 at 24 Cº. This value of yellow lower than yellow = 33.98 while higher than red =0.86 and blue = 0.48 which were reported by Sultan *et al*. (2009) and 28.59 yellow, 4.5 red and lower than 9.41 blue were reported by Zzaman *et al*, (2014)**.**

4.3 Chemical properties of black cumin seeds oil

Table (2) shows the chemical properties of BCSO which cover: Peroxide value which was found to be 5.00 (meq O_2/ kg of oil). This value was lower than that obtained by Ali *et al*., (2012); Bourgou *et al*., (2010); Sultan *et al*., (2009); Cheickh-Rouhou *et al*. (2007). Their records were 12.70, 10.00, 5.703, 5.65 (meq O_2/kg of oil), respectively, but it was higher than that obtained by Gharby *et al*., (2015) which was 3.4 (meq O_2/ kg of oil). Free fatty acid as oleic acids was found to be 0.570% which was lower than the values reported by Gharby *et al*., (2015); Ali *et al*., (2012); Sultan *et al*. (2009). Their findings were 0.9, 1.2 and 0.67% respectively. But it was higher than that found by Zzaman *et al*.,(2014) which was 0.20%. Saponification value of BCSO was 175.25 (MgKOH/g), it was higher than both readings 172.56 and 172.44 which were mentioned by Zzaman *et al*.,(2014) and Sultan *et al*. (2009), but it was lower than 204.00 which was obtained by Ali *et al*.,(2012).

Iodine value of BCSO, as Iodine /100 oil, was 110.20 which was lower than all values reported by Gharby *et al*., (2015); Ali *et al*., (2012) and Sultan *et al*., (2009). Their readings was 128, 115 and 112.3 (iodine/100 oil), respectively. Tocopherol of BCSO was 36.171 (mg/100g), it was higher than the range of readings 9.15 to 19.93 which were obtained by (Matthaus and Ozcan 2011).

Table (2) Physio-Chemical properties of black cumin seeds oil

Colour	Mean values
Red	12.1
Yellow	32.2
Blue	0.5
Refractive index	1.4720
Density	0.9180
Viscosity	27.2
Peroxide value	5.00 (meq O_2/ kg of oil)
Free fatty acids	0.570 %
Saponification value	175.25 (MgKOH/g)
Iodine value	110.20 (iodine/100 oil)
Total of tocopherols	36.171 (mg/100g),

4.3.1 Fatty acids types and amounts of black cumin seeds oil

Fig (1) shows the fatty acid profile of BCSO. The percentage of unsaturated fatty acids was found in this study 82.64 which was nearly similar to 82.9 that reported by Gharby *et al*., (2015) and higher than 78.4 which was recorded by Ali *et al*., (2012).The essential fatty acid linoleic (omega 6) was 57.38% being the major fatty acid. This result was higher than those found by Ali *et al*., (2012) and Padmaa, (2010) which was 52.6 and 55.6 %, respectively.

Oleic acid (19.65%) was lower than 23.4% which was reported by Padmaa, (2010). Linolenic acid was found to be asmall amount (1.13%) which was higher than 0.25% that showed by Argon and Gokyer, (2016). The percentage of palmitic acids was 12.07% which was lower than those obtained by (Gharby *et al*., 2015, Ali *et al*., 2012 and Padmaa, 2010) which was 13.1, 12.5 and16.0% respectively.

The percentage of myristic acids was 2.49 which was higher than that obtained by Gharby *et al*. (2015); which was (1%) by cold press extract and (0.2%) by solvent extracted. The percentage of stearic acids was 2.49 which was higher than that obtained by Gharby *et al*. (2015) which was (0.2%) by cold press extract and (0.2%) by solvent extract.

4.4 Changes of physical properties of peanut oil blended with different ratios (5, 10 and 15%) of black cumin seeds oil and with recommended percentage of commercial antioxidant during frying potato chips.

4.4.1 Colour:

Table (3) shows changes in red colour of crude peanut oil blended with both of BCSO at different ratios (5, 10 and 15%) and recommended percentage of CA then used for frying potato chips at different frequent time (zero, 15, 30, 45 and 60 min). It was pointed that there was significantly decreased in colour at zero and 15min of frying potato chips with the blend of crude peanut oil with 5% BCSO (0.20) and (0.20) when was compared to the blends of same peanut oil mixed with (CA, 10% BCSO, 15% BCSO) 2.00, 2.00, 2.00 and 2.00, 2.00, 2.00, respectively., while there was significantly increased when was compared with control 0.10 and 0.10.

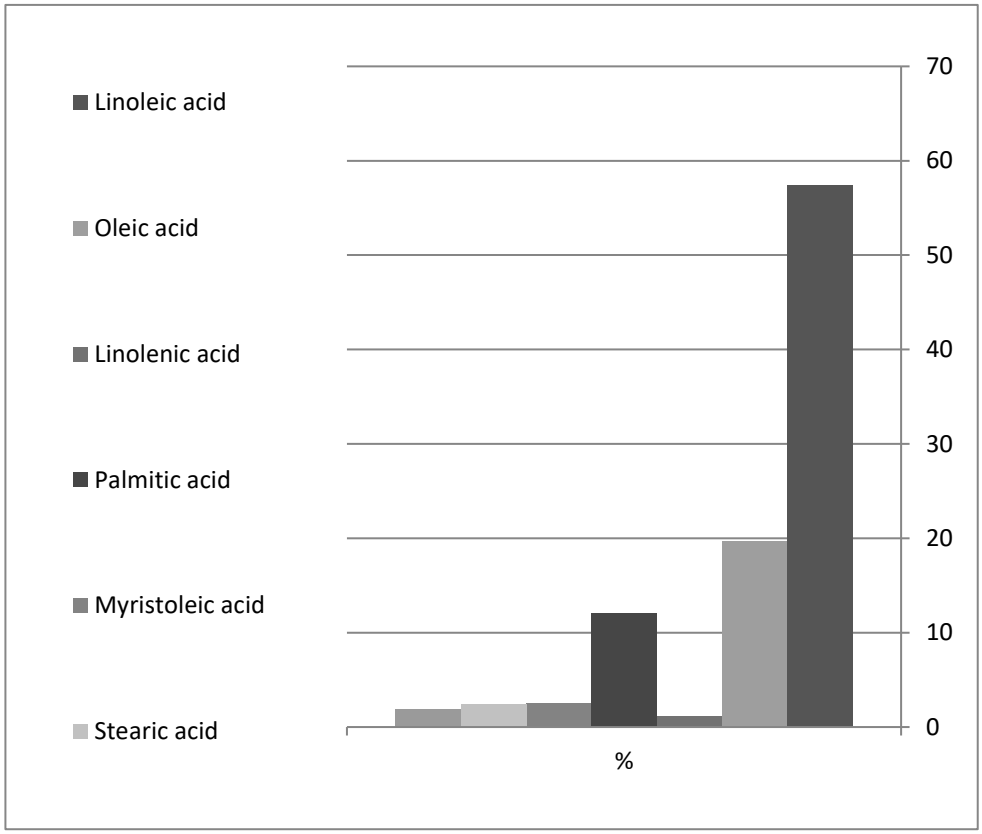

Fig (2): Fatty acids types and amounts of black cumin seeds oil

After 30, 45 and 60 min of frying potato chips it was showed that there was significant decrease in colour of crude peanut oil mixed with 5% BCSO 0.20, 0.20 and 0.20 when was compared with the blends of same peanut oil mixed with (CA, 10% BCSO, 15% BCSO) and control (2.00, 2.00, 2.00, 0.25), (4.00, 3.00, 4.00, 0.30) and (4.00, 2.00, 4.00, 0.30), respectively. The result of blend 5% of BCSO agreed with Shakak *et al*. (2015) who found that there was significant decrease in colour of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips. So it is advisable to add less than 5% concentration of BCSO to increase its stability.

4.4.2 Refractive index

Table (4) shows changes in refractive index of peanut oil mixed with different ratios of BCSO and CA and then used for potato chips frying at different frequent time (zero, 15, 30, 45 and 60 min). It was registered that there was no significant difference in the refractive index at zero, 15, 30, 45 and 60 min of frying potato chips with the blend of crude peanut oil with 5% of BCSO (1.4660, 1.4650, 1.4660, 1.4650, 1.4650) when was compared with the blends of same peanut oil mixed with CA, 10% BCSO and 15% BCSO., and control at the same frequent frying time of potato chips (1.4660, 1.4660, 1.4650, 1.4650, 1.4650), (1.4670, 1.4670, 1.4670, 1.4670, 1.4670), (1.4670, 1.4670, 1.4670, 1.4670, 1.4670) and (1.4700, 1.4700, 1.4690, 1.4690, 1.4690), respectively. This result of blend 5% percentage of BCSO disagreed with Khattab and Shakak (2012) who found that there was no significant difference in RI of the blend of moringa oil with groundnut oil (1:1) compared with groundnut oil after frying potato chips and Shakak, *et al*. (2015) who showed that there was no significant difference in RI of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips.

Table (3): Changes in red colour of crude peanut oil mixed with (5% BCSO, 10% BCSO and 15% BCSO) and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	0.10^{s}	0.20^{f}	2.00^{l}	2.00^{l}	2.00^{l}	1.2
15	0.10^{s}	0.20^{f}	2.00^{l}	2.00^{l}	2.00^{l}	1.2
30	0.25^{m}	0.20^{f}	2.00^{l}	2.00^{l}	2.00^{l}	1.29
45	0.30^{q}	0.20^{f}	3.00^{i}	4.00^{h}	4.00^{h}	2.3
60	0.30^{q}	0.20^{f}	2.00^{l}	4.00^{h}	4.00^{h}	2.1
Treatment means	0.21	0.20	2.2	2.8	2.8	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

Table (4): Changes in refractive index of crude peanut oil mixed with (5% BCSO, 10% BCSO and 15% BCSO) and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	1.4700[a]	1.4660[a]	1.4670[a]	1.4670[a]	1.4660[a]	1.4672
15	1.4700[a]	1.4650[a]	1.4670[a]	1.4670[a]	1.4660[a]	1.4670
30	1.4690[a]	1.4660[a]	1.4670[a]	1.4670[a]	1.4650[a]	1.4668
45	1.4690[a]	1.4650[a]	1.4670[a]	1.4670[a]	1.4650[a]	1.4652
60	1.4690[a]	1.4650[a]	1.4670[a]	1.4670[a]	1.4650[a]	1.4666
Treatment means	1.4694	1.4654	1.4670	1.4670	1.4654	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

4.4.3 Viscosity:

Table (5) shows changes in viscosity (c.p) of peanut oil blended with both of BCSO at different ratios (5, 10 and 15%) and recommended percentage of CA then used for frying potato chips at different frequent time (zero, 15, 30, 45 and 60 min). It was showed that there was significant decrease in viscosity index at zero, 15, 30, 45 and 60 min of frying potato chips with the blend of crude peanut oil mixed with 5% BCSO (20.54, 20.71, 20.42, 20.41, 20.48) when was compared to the blends of same peanut oil mixed with CA, 10% BCSO and 15% BCSO., and control at the same frequent frying time of potato chips (23.50, 23.09, 24.57, 24.10, 23.66), (30.17, 29.23, 29.35, 28.19, 26.72), (30.35, 26.73, 30.78, 25.61, 22.26) and (21.09, 20.97, 21.44, 20.99, 21.06), respectively. So it is advisable to add less than 5% concentration of BCSO to increase its stability. The result of blend 5% percentage of BCSO agreed with Khattab and Shakak (2012) who found that there was no significantly difference in viscosity of the blend of moringa oil with groundnut (1:1) oil compared with groundnut oil after frying potato and Shakak *et al*. (2015) who found that there was significant decrease in viscosity of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips.

4.5 Changes of chemical properties of crude peanut oil blended with different ratios (5, 10 and 15%) of black cumin seeds oil and recommended percentage of commercial antioxidant during potato chips frying

4.5.1 Free fatty acids

Table (6) shows changes in free fatty acids (%) of crude peanut oil mixed with different ratios (5, 10 and 15%) of BCSO and recommended percentage of CA during frying potato chips at frequent time zero, 15, 30, 45 and 60 min.

It was registered that there was no significant change in FFA at zero and 15 min of frying potato chips with the blend of crude peanut oil mixed with 5% BCSO (0.226) and (0.226) when was compared with the same peanut oil mixed with CA and control (0.226, 0.226) and (0.226, 0.226), but there was significant decrease when was compared with the blends of same peanut oil with (10%, 15% of BCSO for both) (0.423, 0.507) and (0.367, 0.423), respectively.

Table (5) Changes in viscosity (cp) of crude peanut oil mixed with (5% BCSO, 10% BCSO and 15% BCSO) and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	21.09^{st}	20.54^{w}	30.17^{bc}	30.35^{bc}	23.50^{o}	25.13
15	20.97^{u}	20.71^{uv}	29.23^{de}	26.73^{j}	23.09^{op}	24.14
30	21.44^{s}	20.42^{wx}	29.35^{de}	30.78^{b}	24.57^{m}	25.12
45	20.99^{u}	20.41^{wxy}	28.19^{fgh}	25.61^{l}	24.10^{mn}	23.86
60	21.06^{st}	20.48^{w}	26.72^{j}	22.26^{qr}	23.66^{o}	22.84
Treatment means	21.11	20.51	28.73	28.77	23.69	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

After 30 and 45 min there was no significant change in FFA of the blend of crude peanut oil with 5% concentration of BCSO (0.226) and (0.226) when was compared with same peanut oil mixed with CA (0.226 and 0.226) but there was significant decrease when was compared with the blends of same peanut oil with (10%, 15% BCSO for both) and control (0.507, 0.507), (0.423, 0.423) and (0.254, 0.254), respectively. Also after 60 min there was significant decrease in FFA of the blend of crude peanut oil with 5% concentration of BCSO (0.226) when was compared with the blends of same peanut oil mixed with CA, 10% BCSO, 15% BCSO and control (0.254, 0.507, 0.423 and 0.282), respectively. So it is advisable to add less than 5% concentration of BCSO with peanut oil to increase its stability. This result of blend 5% percentage of BCSO was disagreed with Khattab and Shakak (2012) who found that there was no significant difference in FFA of the blend of moringa oil with groundnut (1:1) oil compared with groundnut oil after frying potato chips., Shakak *et al*. (2015) showed that there was significant increase in FFA of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips.

4.5.2 Peroxide value:

Table (7) shows changes in peroxide value (meq O_2/kg oil) of crude peanut oil mixed with BCSO at different ratios (5, 10 and 15%) and CA then was used for frying potato chips at frequent time zero, 15, 30, 45 and 60 min. It was pointed that there was significant increase in PV at zero, 15 and 30 min of frying potato chips with the blend of crude peanut oil mixed with 5% BCSO (4.67, 5.00, 6.00) when was compared with the same peanut oil mixed with CA and control (4.00, 4.00, 4.33) and (4.33, 4.67, 5.00), respectively**.**, but there was significant decrease when was compared with the blends of same peanut oil with 10% and 15% BCSO (7.33, 7.33, 7.33) and (6.00, 6.00, 9.00), respectively. After 45 min there was no significant difference in PV of the blend of crude peanut oil with 5% concentration of BCSO (6.00) when was compared with same peanut oil mixed with CA (5.67) and control (6.00) but there was significant decrease when was compared with the blends of same peanut oil with 10% and 15% BCSO (10.33 and 9.00) respectively.

Also after 60 min there was significant decrease in PV of the blend of crude peanut oil with 5% concentration of BCSO (6.00) when compared with same the blends of same peanut oil mixed with (CA, 10% BCSO, 15% BCSO) and control (6.67, 6.33, 15.00 and 12.00), respectively.

Table (6): Changes in free fatty acids (%) of crude peanut oil mixed with different ratios (5% BCSO, 10% BCSO and 15% BCSO) and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	0.226^{j}	0.226^{j}	0.423^{e}	0.367^{f}	0.226^{j}	0.294
15	0.226^{j}	0.226^{j}	0.507^{c}	0.423^{e}	0.226^{j}	0.322
30	0.254^{I}	0.226^{j}	0.507^{c}	0.423^{e}	0.226^{j}	0.327
45	0.254^{I}	0.226^{j}	0.507^{c}	0.423^{e}	0.226^{j} 0	0.327
60	0.282^{h}	0.226^{j}	0.507^{c}	0.423^{e}	0.254^{i}	0.389
Treatment means	0.248	0.226	0.490	0.412	0.232	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

So it is advisable to add less than 5% concentration of BCSO to increase its stability. The result of blend 5% percentage of BCSO agreed with Khattab and Shakak (2012) who found that there was no significant decrease in PV of the blend of moringa oil with groundnut (1:1) oil compared with groundnut oil after frying potato chips, while disagreed with Shakak *et al*. (2015) who showed that there was significant increase in PV of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips.

4.5.3 Iodine value:

Table (8) shows changes in iodine value (iodine /100g oil) of peanut oil mixed with BCSO at different ratios (5, 10 and 15%) and CA then was used for frying potato chips at frequent time zero, 15, 30, 45 and 60 min. It was pointed that there was no significant difference in PV at zero and 15 min of frying potato chips with the blend of crude peanut oil mixed with 5% BCSO (92.33) and (91.00) when was compared with the same peanut oil mixed with CA (92.33) and (91.33), but there was significant decrease when was compared with the blends of same peanut oil with (10%, 15% of BCSO for both) and control (102.00, 100.00), (107.00, 106.00) and (105.30, 105.00), respectively.

After 30, 45 and 60 min there was significant increase in IV of the blend of crude peanut oil with 5% concentration of BCSO (91.33, 85.00, 85.00) when was compared with same peanut oil mixed with CA (83.67, 83.67, 83.00) but there was significant decrease when compared with the blends of same peanut oil with 10%, 15% BCSO for both and control (100.00, 98.00, 98.00), (104.00, 100.00, 98.00) and (98.00, 97.00, 97.00), respectively. So it is advisable to add less than 5% concentration of BCSO to increase its stability. The result of blend 5% percentage of BCSO disagreed with (Shakak *et al*. (2015) who showed that there was significant increase in IV of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips.

4.6 Sensory evaluation of fried potato with crude peanut oil mixed with different concentration (5, 10 and 15%) of (BCSO) and with recommended percentage of (CA)

Table (9) shows that there was no significant difference in colour of fried potato with the blend of 5% concentration of black cumin seeds oil with peanut oil (4.15) when was compared with the blends of peanut oil with CA, 10% of BCSO for both and control (4.31, 4.23, 4.62) respectively, while there was significantly increased when was compared with the blend of 15% BCSO with peanut oil (2.46).

Table (7): Changes in peroxide value (meq/kg) of crude peanut oil mixed with different ratios (5, 10 and 15%) of BCSO and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	4.33^{mn}	4.67^{lmn}	7.33^{g}	6.00^{ijk}	4.00^{n}	5.27
15	4.67^{lmn}	5.00^{klmn}	7.33^{g}	6.00^{ijk}	4.00^{n}	5.40
30	5.00^{klmn}	6.00^{ijk}	7.33^{g}	9.00^{f}	4.33^{mn}	6.33
45	6.00^{ijk}	6.00^{ijk}	10.33^{e}	9.00^{f}	5.67^{ijk}	7.40
60	6.33^{hij}	6.00^{ijk}	15.00^{b}	12.00^{d}	6.67^{ghi}	11.33
Treatment means	5.27	5.53	9.46	8.40	4.93	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

Table (8) Changes in iodine value (iodine/100g) of crude peanut oil mixed with different ratios (5, 10 and 15%) of BCSO and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	105.30^{ab}	92.33^{gh}	102.00^{c}	107.00^{a}	92.33^{gh}	99.79
15	105.00^{b}	91.00^{hi}	100.00^{d}	106.00^{ab}	91.33^{hi}	98.67
30	98.00^{def}	91.33^{hi}	100.00^{d}	104.00^{b}	83.67^{kl}	95.40
45	97.00^{ef}	85.00^{k}	98.00^{def}	100.00^{d}	83.67^{kl}	92.73
60	97.00^{ef}	85.00^{k}	98.00^{def}	98.00^{def}	83.00^{l}	92.20
Treatment means	100.46	88.93	90.87	103.00	86.80	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

Also the Table (9) shows that there was no significant difference in odour of fried potato with 5% concentration of BCSO mixed with peanut oil (3.85) when was compared with the blends of peanut oil with (CA , 10% and 15% BCSO) and control (4.23, 4.15, 3.85, 4.31), respectively.

Table (9) shows there was significant difference in texture of fried potato with the blend 5% concentration of BCSO with peanut oil (3.69) when was compared with the blends of peanut oil with CA , 10% and 15% BCSO and control (4.23, 4.15, 2.69, 4.23), respectively. Also the same table shows there was significant increase in taste of fried potato with the blend 5% concentration of BCSO with peanut oil (4.39) when was compared with the blend of peanut oil with CA (3.31) and the blend of peanut oil with 15% BCSO (3.54), but there was no significant difference when was compared with the blend of 10% BCSO with peanut oil (4.39) and control (4.23). The same Table shows that there was significant increase in general acceptability of fried potato with the blend 5% concentration of BCSO with peanut oil (4.15) when was compared with the blends of peanut oil with 10%, 15% BCSO for both and control (3.54, 3.39, 3.77) respectively, while there was no significant difference when was compared with the blend of CA with peanut oil which was (3.85).

4.7 Changes in physical properties of refined peanut oil blended with different ratios (5, 10 and 15%) of BCSO and recommended percentage of CA during potato chips frying

4.7.1 Colour

Table (10) shows changes in red colour of refined peanut oil blended with both of BCSO at different ratios (5, 10 and 15%) and recommended percentage of CA then used for frying potato chips at different frequent time (zero, 15, 30, 45 and 60 min). It was pointed that there was significant decrease in red colour at zero, 15, 30, 45 and 60min of frying potato chips with the blend of refined peanut oil with 5% BCSO (0.40, 0.40, 0.40, 0.40, 0.40) when was compared to the blends of same peanut oil mixed with (CA, 10% BCSO, 15% BCSO) (4.30, 4.30, 4.40, 7.30, 10.00), (2.10, 5.00, 5.30, 6.00, 7.30) and (4.30, 4.30, 4.30, 6.00, 10.00), respectively., while there was significantly increased when was compared with control (0.10, 0.20, 0.20, 0.20, 0.30). The result of blend 5% percentage of BCSO agreed with Shakak *et al.* (2015) who found that there was significant decrease in colour of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips.

Table (9) changes in sensory evaluation of fried potato with crude peanut oil mixed with different ratios (5, 10 and 15%) of BCSO and CA.

Parameters	Samples				
	Control	A	B	C	D
Colour	4.15^{a}	4.15^{a}	4.23^{a}	2.46^{b}	4.31^{a}
Odour	4.31^{a}	3.85^{a}	4.15^{a}	3.85^{a}	4.23^{a}
Texture	4.23^{a}	3.69^{ab}	4.15^{a}	2.69^{c}	4.23^{a}
Taste	4.23^{a}	4.39^{a}	4.39^{a}	3.54^{b}	3.31^{b}
G.A	3.77^{ab}	4.15^{a}	3.54^{b}	3.39^{b}	3.85^{a}

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

Table (10): Changes in red colour of refined peanut oil mixed with different ratios (5, 10 and 15% of BCSO) and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	0.10^{y}	0.40^{w}	2.10^{s}	4.30^{n}	4.30^{n}	2.44
15	0.20^{x}	0.40^{w}	5.00^{k}	4.30^{n}	4.30^{n}	2.84
30	0.20^{x}	0.40^{w}	5.00^{i}	4.30^{n}	4.40^{m}	2.86
45	0.20^{x}	0.40^{w}	6.30^{j}	6.10^{h}	7.30^{f}	4.06
60	0.30^{v}	0.40^{w}	7.30^{f}	10.00^{b}	10.00^{b}	5.60
Treatment means	0.20	0.40	5.14	5.80	6.06	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

4.7.2 Refractive index

Table (11) shows changes in refractive index of refined peanut oil mixed with different ratios of BCSO and CA and then used for potato chips frying at different times (zero, 15, 30, 45 and 60 min). It was registered that there was significant decrease in the refractive index at zero, 15, 30, 45 and 60 min of frying potato chips with the blend of refined peanut oil with 5% of BCSO (1.4650, 1.4650, 1.4650, 1.4650, 1.4650) when was compared with the blends of same peanut oil mixed with (CA, 10% BCSO, 15% BCSO) and control at the same frequent frying time of potato chips (1.4750, 1.4750, 1.4750, 1.4750, 1.4750), (1.4690, 1.4690, 1.4690, 1.4690, 1.4690), (1.4750, 1.4750, 1.4750, 1.4750, 1.4750) and (1.4690, 1.4690, 1.4690, 1.4690, 1.4690) respectively. This result of blend 5% percentage of BCSO disagreed with Khattab and Shakak (2012) who found that there was no significant difference in RI of the blend of moringa oil with groundnut oil (1:1) compared with groundnut oil after frying potato chips and Shakak, *et al*. (2015) who showed that there was no significant difference in RI of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips.

4.7.3 Viscosity

Table (12) shows changes in viscosity (c.p) of refined peanut oil blended with both of BCSO at different ratios (5, 10 and 15%) and recommended percentage of CA then used for frying potato chips at different frequent time (zero, 15, 30, 45 and 60 min). It was pointed that there was significant decrease in viscosity at zero, 15, 30, 45 and 60 min of frying potato chips with the blend of refined peanut oil with 5% BCSO (19.16, 18.60, 18.76, 19.31, 19.12) when was compared to the blends of same peanut oil mixed with CA, 10% BCSO, 15% BCSO at same frequent frying time of potato chips (22.96, 23.94, 21.23, 24.46, 25.30), (27.15, 28.17, 22.92, 28.32, 23.30), (23.95, 22.48, 23.29, 22.10, 25.20), respectively., while there was significant increase when was compared with control(17.56, 18.27, 18.28, 17.96, 17.88). So it is advisable to add less than 5% concentration of BCSO to increase its stability. The result of blend 5% percentage of BCSO agreed with Khattab and Shakak (2012) who found that there was no significantly difference in viscosity of the blend of moringa oil with groundnut (1:1) oil compared with groundnut oil after frying potato and Shakak *et al*. (2015) who found that there was significant decrease in viscosity of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips.

4.8 Changes in chemical properties of refined peanut oil blended with different ratios (5, 10 and 15%) of black cumin seeds oil and recommended percentage of commercial antioxidant during potato chips frying

4.8.1 Free fatty acids

Table (13) shows changes in free fatty acids of refined peanut oil mixed with different ratios of BCSO and CA and then used for potato chips frying at different times (zero, 15, 30, 45 and 60 min). It was registered that there was significant decrease in FFA at zero, 15, 30, 45 and 60 min of frying potato chips with the blend of refined peanut oil with 5% of BCSO (0.141, 0.141, 0.141, 0.141, 0.141) when was compared with the blends of same peanut oil mixed with (CA, 10% BCSO, 15% BCSO) and control at the same frequent frying time of potato chips (0.220, 0.220, 0.220, 0.220, 0.220), (0.367, 0.367, 0.423, 0.423, 0.451), (0.367, 0.423, 0.423, 0.423, 0.423) and (0.197, 0.197, 0.197, 0.197, 0.226), respectively. This result of blend 5% percentage of BCSO disagreed with Khattab and Shakak (2012) who found that there was no significant difference in FFA of the blend of moringa oil with groundnut oil (1:1) compared with groundnut oil after frying potato chips and Shakak *et al*. (2015) who showed that there was no significant difference in FFA of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips.

4.8.2 Peroxide value

Table (14) shows changes in peroxide value (meq O_2/kg oil) of refined peanut mixed with different ratios (5, 10 and 15%) of BCSO and recommended percentage of CA during frying potato chips at frequent time zero, 15, 30, 45 and 60 min. It was noticed that there was no significant difference in PV of refined peanut oil mixed with 5% BCSO at zero min of frying potato chips (3.00) when compared with the blends of same peanut oil mixed with (CA, 10% BCSO, 15% BCSO) and control (3.00, 4.00, 3.00 and 2.00), respectively.

Table (11): Changes in refractive index of refined peanut oil mixed with different ratios (5, 10 and 15%) of BCSO and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	1.4690^{d}	1.4650^{h}	1.4690^{d}	1.4750^{a}	1.4750^{a}	1.466
15	1.4690^{d}	1.4650^{h}	1.4690^{d}	1.4750^{a}	1.4750^{a}	1.4706
30	1.4690^{d}	1.4650^{h}	1.4690^{d}	1.4750^{a}	1.4750^{a}	1.4706
45	1.4680^{de}	1.4650^{h}	1.4690^{d}	1.4740^{c}	1.4750^{a}	1.4702
60	1.4680^{de}	1.4650^{h}	1.4690^{d}	1.4720^{c}	1.4750^{a}	1.4698
Treatment means	1.4686	1.4650	1.440	1.4742	1.4750	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

Table (12): Changes in viscosity (cp) of refined peanut oil mixed with different ratios (5, 10 and 15%) of BCSO and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	17.56^{tu}	19.16^{pq}	27.15^{b}	23.95^{j}	22.96^{m}	27.96
15	18.27^{s}	18.60^{r}	28.17^{a}	22.48^{mn}	23.94^{j}	22.29
30	18.28^{s}	18.76^{r}	22.92^{m}	23.29^{jkl}	21.23^{o}	20.90
45	17.96^{t}	19.31^{pq}	28.32^{a}	22.10^{mn}	24.46^{h}	22.43
60	17.88^{t}	19.12^{pq}	23.30^{jkl}	25.20^{fg}	25.30^{ef}	22.16
Treatment means	17.98	18.99	25.97	23.40	23.58	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

Table (13): Changes in free fatty acids (%) of refined peanut oil mixed with different ratios (5, 10 and 15%) of BCSO and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	0.197^{i}	0.141^{l}	0.367^{d}	0.367^{d}	0.220^{h}	0.258
15	0.197^{i}	0.141^{l}	0.367^{d}	0.423^{c}	0.220^{h}	0.270
30	0.197^{i}	0.141^{l}	0.423^{c}	0.423^{c}	0.254^{f}	0.288
45	0.197^{i}	0.141^{l}	0.423^{c}	0.423^{c}	0.254^{f}	0.288
60	0.226^{g}	0.141^{l}	0.451^{b}	0.423^{c}	0.220^{h}	0.292
Treatment means	0.203	0.141	0.406	0.412	0.234	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

After 15 and 30 min of frying potato chips it was showed that there was no significant difference in PV of refined peanut oil mixed with 5% BCSO (3.33, 4.67) when was compared with the blends of same peanut oil mixed with CA, 10% BCSO, 15% BCSO (4.00, 4.00), (4.00, 4.00) and (3.00, 3.00), respectively., while there was significant decrease when was compared with control (9.00, 12.00).
Also after 45 min of frying potato chips there was significant decrease in PV of refined peanut oil mixed with 5% BCSO (6.00) when was compared with the blends of same peanut oil mixed with CA, 10% BCSO, 15% BCSO and control 14.00, 8.00, 9.00 and 15.00, respectively.

Also after 60 min of frying potato chips showed that there was significant decrease in PV of refined peanut oil mixed with 5% BCSO (9.00) when was compared with the same refined peanut oil mixed with CA (20.00) and control (18.33), but there was no significant difference when was compared with the blends of same peanut oil with 10% and 15% BCSO (10.00 and 10.00), respectively. So it is advisable to add less than 5% concentration of BCSO to increase its stability. The result of blend 5% percentage of BCSO agreed with Khattab and Shakak (2012) who found that there was no significant decrease in PV of the blend of moringa oil with groundnut (1:1) oil compared with groundnut oil after frying potato chips, while disagreed with Shakak *et al*. (2015) who showed that there was significantly increased in PV of blend of palm olein with groundnut oil (1:1) compared with palm olein oil after 5 hours frying potato chips.

4.8.3 Iodine value

Table (15) shows changes in iodine value (iodine /100 oil) of refined peanut mixed with different ratios (5, 10 and 15%) of BCSO and recommended percentage of CA during frying potato chips at frequent time zero, 15, 30, 45 and 60 min. It was noticed that there was significantly increased in IV at frying time zero, 15, 30, 45 and 60 min of refined peanut oil mixed with 5% BCSO (103.30, 103.00, 100.70, 98.00, 97.33) when was compared with the refined peanut oil mixed with the recommended percentage of CA and control (, (93.00, 93.00, 90.00, 90.00, 89.00) and (102.15, 100.70, 97.67, 90.00, 89.33), respectively., while there was significant decrease when was compared to high concentration of the blends of refined peanut oil with 10% and 15% of BCSO (106.00, 106.00, 106.00, 102.00, 102.00) and (108.00, 106.00, 100.00, 10.00, 98.00) respectively. So it is advisable to add less than 5% concentration of BCSO to increase its stability.

Table (14): Changes in peroxide value (meq/kg) of refined peanut oil mixed with different ratios (5, 10 and 15%) of BCSO and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	2.00^{d}	3.00^{d}	4.00^{d}	3.00^{d}	3.00^{d}	3.00
15	9.00^{bcd}	3.33^{d}	4.00^{d}	3.00^{d}	4.00^{d}	4.67
30	12.00^{bcd}	4.67^{d}	4.00^{d}	3.00^{d}	4.00^{d}	5.53
45	15.00^{bcd}	6.00^{cd}	8.00^{bcd}	9.00^{bcd}	14.00^{bcd}	10.40
60	18.33^{bc}	9.00^{bcd}	10.00^{bcd}	10.00^{bcd}	20.00^{b}	13.47
Treatment means	11.27	5.13	6.00	5.60	9.00	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

Table (15): Changes in iodine value (iodine/100g) of refined peanut oil mixed with different ratios (5, 10 and 15%) of BCSO and CA during frying chips at frequent time

Frying time (min)	Samples					Frying time Means
	Control	A	B	C	D	
0	102.10^{cd}	103.30^{c}	106.00^{b}	108.00^{a}	93.00^{j}	102.00
15	100.70^{de}	103.00^{c}	106.00^{b}	106.00^{b}	93.00^{j}	101.74
30	97.67^{gh}	100.70^{de}	106.00^{b}	100.00^{ef}	90.00^{kl}	98.87
45	90.00^{kl}	98.00^{gh}	102.00^{cd}	100.00^{ef}	90.00^{kl}	96.00
60	89.33^{klm}	97.33^{h}	102.00^{cd}	98.00^{gh}	89.00^{lm}	95.13
Treatment means	95.86	100.466	104.04	102.40	91.00	

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

4.9 Sensory evaluation of fried potato with refined peanut oil mixed with different concentration (5, 10 and 15%) of black cumin seeds oil and with recommended percentage of commercial antioxidant

Table (16) shows that there was no significant difference in colour of fried potato with the blend of 5% concentration of black cumin seeds oil with refined peanut oil (4.15) when was compared with the blend of CA with refined peanut oil and control (4.46 and 4.62), and also there was no significant change in colour of fried potato with the blend of 5% concentration of BCSO with refined peanut oil when was compared with the blend of 10% BCSO with peanut oil (4.46) while there was significantly increased when was compared with the blend of 15% BCSO with peanut oil (2.46).

Also the Table (16) shows that there was no significant difference in odour of fried potato with 5% concentration of BCSO mixed with peanut oil (3.85) when was compared with the blend of CA, 10% BCSO, 15% BCSO with refined peanut oil and control (4.23, 431, 4.15, 3.85) respectively.

Also Table (16) shows there was no significant difference in taste of fried potato with the blend 5% concentration of BCSO with peanut oil (4.23) when was compared with the blend of CA and 10% of BCSO with peanut oil and control (3.92, 3.92, 4.39) respectively, but there was significantly increased when was compared with the blend of 15% BCSO with peanut oil (3.31).

Also Table (16) shows that there was significant difference in general acceptability of fried potato with the blend 5% concentration of BCSO with peanut oil (3.77) when was compared with the blends of (CA, 10% BCSO, 15% BCSO) with peanut oil and control (3.39, 4.08, 3.39, 4.86), respectively.

Table (16) changes in sensory evaluation of fried potato with peanut oil mixed with different ratios (5, 10 and 15%) of BCSO and CA.

Parameters	Samples				
	Control	**A**	**B**	**C**	**D**
Colour	4.62^{a}	4.15^{a}	4.46^{a}	2.46^{c}	4.46^{a}
Odour	4.31^{a}	3.85^{a}	4.15^{a}	3.85^{a}	4.23^{a}
Texture	4.62^{a}	4.23^{ab}	4.23^{ab}	2.69^{c}	4.23^{ab}
Taste	4.39^{a}	4.23^{a}	3.92^{a}	3.31^{b}	3.92^{a}
G.A	4.46^{a}	3.77^{bc}	4.08^{ab}	3.39^{c}	3.39^{c}

Values are mean±SD.

Mean(s) sharing same superscript(s) letters in rows and columns are not differ significantly (P>0.05) according to DMRT.

Key:

Control

A: blend of 5% black cumin seeds oil mixed with peanut oil

B: blend of 10% black cumin seeds oil mixed with peanut oil

C: blend of 15% black cumin seeds oil mixed with peanut oil

D: commercial antioxidant mixed with peanut oil

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

1- Oil content of black cumin seeds was found to be high 52%.

2- Its physicochemical properties were found to be of good quality.

3- Among all blending ratios(5,10 and 15%) of BCSO with crude and refined peanut oil 5% was found to be the best blending ratio when tested for increased stability of crude and refined peanut oil during frying period at frequent times (zero,15,30,45 and 60 minutes) and also when was compared with the recommended percentage of CA.

5.2 RECOMMENDATIONS

More studies are needed to determine the suitable quantity of BCSO required, which should be less than 5% according to the results obtained.

REFERENCE

Aboutabl, E.A. ; El Ezzouny, A.A. and Hammerschimidt, F.J. (1986). Aroma volatiles of Nigella sativa seeds. In: Brunkel, E.J. editor, Progress in Essential Oil Research. *Proceeding of the International Symposium on Essential Oils*. 44-55.

Abu Zeid, S.N. (1986). Medicinal plant and herbs. Arabic Ed., Elhilal Library and House, Beirut, Lebanon.

Ahmed. A.M.A.(2001). Effect of storage and packaging sunflower oil oxidative stability. M.Sc. Thesis University of Khartoum. Sudan.

Akram Khan, M., (1999). Chemical Composition And Medicinal Properties of *Nigella sativa* Linn. *Inflammopharmacology*. 7,15–35.

AL Herz, H. (2012). A methodology for discovering *Nigella Sativa,* international recipes, and its benefits: cooking with *Nigella sativa*, MSc thesis, Ball State University Muncie, Indiana

Al Jasser, (1992). Chemical Composition and Micro Flora of Black Cumin (*Nigella sativa* L.) Seeds Growing in Saudi Arabia *Food Chemistry*, 45:239.

Ali, D.O.M.(2002). Effect of level of palm olien on the frying quality and stability of groundnut oil M.Sc. Thesis, University of Khartoum, Sudan.

Ali, M.A., Sayeed, M.A., Alam, M.S., Yeasmin, M.S., Khan, A.M., and Muhamad, I.I., (2012). Characteristics Of Oils And Nutrient Contents of *Nigella sativa* Linn. And *Trigonellafoenum-graecum* seeds.Bull. Bulletin of the Chemical Society of Ethiopia. 26; 55–64.

Alim, H. and Morton, I. D. (1978). Deep fat frying oil and absorption.

Allen, J.S.A and Robert, L. (1975). Effect of Lipperoxide on proteins in raw and processed peanut. *Agriculture Food Chemistry*.23:141-145.

Anon, (1998). US grown plant mid- Oliec sunflower in from, 9- 92.

Ansari, Z. and Satish, T. (2013). Traditional uses of Nigella sativa, in Malegaon region of Nashik - A Review. Int. *J. Pure App. Biosci*. 1 (2): 19-23.

AOAC **(**2000). "*Association of Official Analysis Chemist" Official Methods of Anaysis of The Association Of Official Analytical Chemist*. William Horwtiz Editor, 17th ed.

Applewhite, T. (1982). Baileys industrial oil and fat products. 1(3): 127-295.

Aqel, M. and Shaheen, R. (1996). Effect of volatile oil of *Nigella sativa* seeds on the uterine smooth muscle of rat and guinea pig. *Journal of Ethnopharmacology*, 52: 23-26.

Argon, Z. U. and Gokey, A. (2016) Determination of Physicochemical Properties of Nigella sativa Seed Oil from Balıkesir Region, Turkey. *Chemical and Process Engineering Research*. (41): 2224-7467

Atta, B. (2003). Some Characteristics of Nigella (*Nigella Sativa* L.) Seed Cultivated in Egypt and Its Lipid Profile. *Food Chemistry*, **83**: 63-68.

Baboyan, V.K.; Kootungal, D. and Halaby,J.A. (1978). Proximate analysis, fatty acid and amino acid composition of *Nigella sativa* seed. *J. Food. Sci*., 43: 1314.

Balla, S.O.A. (2001). Studies on The Effect Of Chemical Refining On Oil Quality Of Three Groundnut Cultivars Grown In Sudan.

Balz, M.; Schulte, E. and Their, H.-P. (1992): Trennung von Tocopherolen und Tocotrienolen durch HPLC. *European Journal of Lipid Science and Technology*, 94: 209–213.

Bera, D., Lahiri, D. and Nag, A. (2004). Novel Natural Antioxidant for Stabilization of Edible Oil: The Ajowan (*Carumcopticum*) Extract Case. *Journal of the American Oil Chemists' Society*., 81: 169-172.

Berry, S. K. (1982). Fatty acid composition of16 groundnut (*Arachis hypogaea L.*) cultivars grown under Malaysian conditions. *Pertanika* 5(1): 20-24.

Bitar, A. (2008). Sensory Thresholds of Selected Phenolic Constituents from Thyme and their Antioxidant Potential in Sunflower Oil. *Journal of American Oil Chemists Society*, **V**. 85; 641-646.

Blatter, E.; Caius J, F. and Mhaskarks.M (1984). Indian Medicinal Plant. 2nd ed. Allahabad, India: Lalit Mohan Basu, 11-12.

Bourgou, S.; Bettaieb, I.; Saidani, M.; Marzouk, B (2010). Fatty Acids, Essential Oil, And Phenolics Modifications Of Black Cumin Fruit Under Nacl Stress Conditions. *Journal of Agricultural and Food Chemistry*. 58, 12399–12406.

Brazil. (1997) Ministry, S. *National Health Surveillance Agency - ANVISA.* Ordinance No. 540, of October 27, Approves the Technical Regulation: Food Additives - Definitions, Classification and Employment. Official Gazette of the Federative Republic of Brazil.

Brazil. (1999). Ministry of Health. *National Agency of Sanitary Surveillance - ANVISA.* Resolution nº 386 of August 5, Technical regalement on additives

used according to good manufacturing practices and their functions. Official Gazette of the Federative Republic of Brazil.

Cheikh-Rouhou, S.; Besbes, S.; Hentati, B.; Blecker, C.; Deroanne, C. and Attia, H. (2007). N. sativa L.: Chemical composition and physicochemical characteristics of lipid fraction. *Food Chem*., 101(2): 673-681.

Chu, Y.H. and Kung, Y.H. (1998). A Study On Vegetable Oil Blends. *Food Chemistry*, **62**(1): 191-195.

Cobb, W.Y. and Johnson, B.R.(1973). Physiochemical properties of peanut U.S.A Peanut Research and Education Association.

Cocks, L.V. and Van Rede**,** C. (1966).Laboratory Handbook for Oil and Fat Analysis.Academic Press, London and New York.

Codex Allimentarius Commission (1993). Codex standard for edible A. rachis oil. Joint FAO/WHO. Food standards programs, fat, oils are related products 8. 2nd ed.

Cuesta, C; Sanchez-Muniz, F. J; Garrido-Polonio, C.; Lopez-Varela, S and Arroyo R. (1993). Thermooxidative and hydrolytic changes in sunflower oil used in frying with a fast turnover of fresh oil. *Journal American Oil Chemistry Society* 70:1069–73.

Elkabashi, T.A.(2000). Effect of frequent Frying and Storage on Quality of Sudanese Edible Oils. M.Sc. Thesis, Department of Food Science and Technology, Faculty of Agriculture, University of Khartoum, Sudan.

El-Kadi, A. and Kandil, O. (1987). The black seed (*Nigella sativa*) and immunity: Its effect on human T cell subset. *Federation Proceeding*, 46: 1222.

Elkhattab, M. A. (2011) Effect of Frying on the Physiochemical Properties of *Moringa Oleifera*, Groundnut (*Arachis hypogaea*) Oil and their Blends. Thesis, Sudan University of Science and Technology, Sudan.

El-Shiekh, A.A. (1999). Use of herbal *Nigella sativa* seeds for laying hens. M.Sc. Thesis, University of Khartoum, Sudan.

El-tahir, K.E.; Al-tahir, A.Y. and Ageel, A.M. (1999). Pharmacological studies on sesame and Nigella sativa fixed oils: Effect on the sensitivities of the adrenoceptors, baroreceptors, platelets and the uterus of the rat. *Saudi Pharmaceutical J*. 7 (9): 205-15.

El-Zawahry, B.H. (1997). Chemical composition of Nigella sativa linn seed: In: Effect of *Nigella sativa* on certain aspects of metabolism after feeding normal and hyperlipedemic diet in adult and old animals (MD Thesis in medical basic sciences). Cairo, Egypt: Al-Azhar University, 16-28.

FAO (1988). FAO Economic and social development series No. 45. Rome: food and Agriculture organization.

FDA (2009) *"FOOD AND DRUG ADMINISTRATION* –". Everything Added to Food in the United States. FDA U. S. Washington:.

Filgueiras, C. T. (2009). Evaluation of phytic acid antioxidant activity of corn germ. *New Chemistry*, 32 (7): 1787-1791.

Freeman, A.F; Morris, N,J. and willich, R. K.(1954).Peanut butter. U.S department agriculture A I C 370.

Fritsch C.W.(1981). Measurement of frying fat deterioration, a brief review. *Journal of the Amirican oil chemists Sosity*, 58: 272.274.

Gad, A.M.; El-Dakhakhany, M. and Hassan, M.M. (1963). Studies on the chemical constitution of Egyptian *Nigella sativa* oil. *Plant med*. 11 (2): 134-8.

Gharby, S.; Harhar, H.; Guillaume, D.; Roudani, A.; Boulbaroud, S., Ibrahimi, M.; Ahmad, M.; Sultana, S.; Hadda, H.; Chafchaouni-Moussaoui, I. and Charrouf, Z., (2015) Chemical Investigation Of *Nigella Sativa L.* Seed Oil Produced In Morocco. *Journal of the Saudi Society of Agricultural Sciences* **14**, 172–177

Goutb, H.T. (1981). Agricultural and constituents of medical plants, Dar Elmerikh.

Gunstone , F. D(2000). Composition and properties of Edible oils, in w.Hamm and R.J. Hamilton (Eds). Edible oil processing (PP.3-5). England; Sheffield Academic press.

Gutb, F.T. (1980). Medical plants, cultural practices and chemical constituents. Emarikh House, Saudi, Elriyad.

Hamadi, A.; Christophe, B. and Claude, D. (2007).:Chemical composition and physicochemical characteristics of *Nigella sativa* L lipid fraction. *Food Chem*. 101:673–81. 5.

Hanafy, M.S.M. and Hatem, M.E. (1991). Studies on the antimicrobial activity of Nigella sativa seed (black cumin). *Journal of Ethonopharmacology*, 34 (2-3): 275-8.

Hitiggins, B.B.(1951). Origin and Early history of peanut. The peanut the Un predictable legume, Washington: National fertilizer Assocission.

Houhoula, D. P; Oreopoulou, V. and Tzia, C. (2003). The effect of process time and temperature on the accumulation of polar compounds in cottonseed oil during deep-fat frying. *Journal Science Food Agricalture*. 83:314–9

Ihekoronye, A.I. and Ngoddy, P.O.(1985). Integrated Food Science and Technology For The Tropics. Macmillan Science and Education and Macmillan Publishers, London.

Jacob, Z. and Krishnamurthy, M.N,(1990).Studies on physiochemical characteristics and fatty acid composition of lipids produced by a strain of Rhodotorula gracilis CFR *Journal American oil Chemistry society* 67(10): 642-645.

Javed, S., Shahid, A. A., Haider, M. S., Umeera, A., Ahmad, R. and Mushtaq, S. (2012). Nutritional, Phytochemical Potential And Pharmacological Evaluation Of Nigella Sativa (Kalonji) And Trachyspermum Ammi (Ajwain). *Journal of Medicinal Plants Research*. **6**(5), pp. 768-775**.**

Joslyn, M. N. (1970) Methods in Food Analysis. Academic Press, New York, pp 20-23.

Khalil. J.K. and Chug htai (1983). Chemical composition and Nutritional quality of five peanut cultivars growin in Pakistan. *Qualities Plantarum plant food human nutrition* . 63-70.

Khattab, M.A. and Shakak, M.A.S.(2012) Effect of Frying on the Physiochemical Properties of *Moringa Oleifera*, Groundnut (*Arachishypogaea*) Oil and their Blends. Journal of Science and Technology. JAVS **13(**2).

Kim, J. I. (2009). Kinetic Study of the Quenching Reaction of Singlet Oxygen by Common Synthetic Antioxidants (tert-Butylhydroxyanisol, tert-di-Butylhydroxytoluene, and tert-Butylhydroquinone) as Compared with α-Tocopherol. *Journal of Food Science*, 74, (5), ; 363-c369.

Kumara, S. and Reddy, S.(1993). Oil and protein quality of the selected groundnut verities. Annals of biology Ludhiana. 9(1).

Kumarass and Hout (2001). Extraction, isolation and characterization of anti-tumour principle, alpha-hedrin, from the seeds of *Nigella sativa*. Planted, 67 (1): 29-2.

Litwinienko, G . ; Kasprzsycka- Guttman, T. and Jamanek, D. (1999). Study of Antioxidant Properties of Dihydroxyphenols. *Thermochimica Acta*, 331: 79-86.

Luna, F.J. and Michelena, C.M. (1986). Study of diesel engine response to the use of vegetable oil and diesel fuel blends as fuel. General Communications, 17, p. 51, Cordoba, Spain.

Mahgoub, A. A. (2010) Effect of frequent deep fat frying on the quality characteristics of palm olien, sunflower and corn oils. Thesis, University of Gezira, Sudan.

Mariod, A. A. (2005). Investigation on the oxidative stability of some unconventional Sudanese oils, traditionally used in human nutrition PhD. Thesis, University of Munster, Germany.

Matthaus, B., Ozcan, M.M., (2011). Fatty Acids, Tocopherol, And Sterol Contents Of Some Nigella Species Seed Oil. *Czech Journal of Food Sciences*. 29,145–150.

Menounos, P.; StaPhylakis, K. and Gegiou, D. (1986). The sterols of *Niella sativa* seed oil, *phyto-chemistry*, 25: 761-3.

Misra, J. B; CHauhan, S. and mother, R.S.(1992). Variation in oil and protein nutrition, 63.70.

Nichols, D.S. and Sanderson, K. (2003). "*The nomenclature structure and properties of food lipids*". In: *Chemical and functional properties of food lipids*, Edited by: Sikorski, Z.E. and Kolakowska, A. 29–59. Boca Raton, FL: CRC Press

Nigam, S.N. Dwivedi, S.L; Nagabhushanam, G.V.S; Roa, Y.L.C and Gibbons, R.W.(1994). Registration of ICG Y86564 peanut germ plasm. Crop science 34(3): P.

Osman, U.A. (1996). Study on extraction and characteristics of *Nigella sativa* L. seeds oil. M.Sc. Thesis, University of Khartoum, Sudan.

Padmaa, M. P. (2010) Nigella sativa Linn.– A comprehensive review Indian Journal of Natural Products and Resources **1**(4), pp.409-429

Peers K. E and Swoboda P.A.T. (1982). Deterioration of sunflower seed oil under simulated frying conditions and during small-scale frying of potato chips. *Journal Science Food Agricalture* 33:389–95

Prakash, D., Singh, B.N. and Upadhyay, G. (2001). Antioxidant and free radical scavenging activities of phenols from onion (Allium cepa). *Food Chemistry* 102: 1389-1393.

Prasad, L.H.D and Dutt, K.U.N., (1989). Inter relationships among the properties of fatty oils. *Journal American oil Chemistry society* 66(5): 701.703.

Ramsden, E.N. (1995). Lipids. Biochemistry and food science. Stanley Thomes (Publishers) Ltd.P.47.57.

Saeed, H.M. (1972). *Pharmacography Indica Hamdard*, 15: 218-29.

Salma, C.R.; Souhail, B.; Basma, H.; Christophe, B.; Claude, D. and Hamadi, A.(2007). *Food Chemistry*. , 101, 673.

Sanchez-Muniz, F.J; Cuesta, C. and Garrido-Polonio, C. (1993). Sunflower oil used for frying: combination of column, gas and high-performance size-

exclusion chromatography for its evaluation. *Journal American Oil Chemistry Society*, 70:235–40.

Sanders, T.H.; Vercellotti, J. R.; Grippen, K.L.; Hinsch, R.T.; Rasmussen, G.K., and Edwards, I.H.(1982). Quality factors in exported peanuts form Argentina, China and United states. *Journal American oil Chemistry society*. 69(10): 103. 1035.

Shakak, M.A.S.; Rahama, A.A. and Elfaki, A.E. (2015).Stability of Some Edible Oil Blends Based On Palm Olein. *Journal of Agricultural and Veterinary Siences*. **16**(1): 93- 103.

Steel, R. D.G; Torrie, T. H. and Dickey, D. A. (1997). Principles and procedures of statistics Abiometric Approach. 3rd

Sultan, M.T., Butt, M.S., Anjum, F.M., Jamil, A.; Akhtar, S. and Nasir, M., (2009). Nutritional Profile **o**f Indigenous Cultivar **o**f Black Cumin Seeds and Antioxidant Potential of Its Fixed **a**nd Essential Oil. *Pakistan Journal of Botany*.41, 1321–1330.

Sultan, M.T., M.S. Butt, I. Pasha, M.M.N. Qayyum, F. Saeed and W. Ahmad (2014). Preparation and Evaluation of Dietetic Cookies for Vulnerable Segments Using Black Cumin Fixed Oil. *Pakistan Journal of Botany*., 10: 451-456.

Taghvaei, M. and Jafari, S. M. (2015). Application and stability of natural antioxidants in edible oils in order to substitute synthetic additives, *J.Food Sci.Technol*.52 (3): 1272-1282.

Takruri, H.R.H. and Dameh. M.A.F. (1998). Study **o**f Nutritional Value Of Black Cumin Seeds (*Nigella Sativa L.*). *Journal of the Science of Food and Agriculture*. 76: 404-410.

Warner. K.(2002). Chemistry of frying oils. In C.C.

Yilmaz, M. T. and Karakaya, M. (2009). Differential Scanning Calorimetry Analysis of Goat Fats: *Comparison of Chemical Composition and Thermal Properties*,. 86,. (9). 877-883.

Zaoui, A.; Cherrah, Y.; Lacaille-Dubois, M.A.; Settaf, A.; Amarouch, H. and Hassar, M. (2000). Diuretic and hypotensive effects of Nigella sativa in the spontaneously hypertensive rat. *Therapie*, 55 (3): 379-382.

Zzaman, W.; Silvia, D.; Abdullah, W. and Yang, T. A. (2014). Physicochemical and Quality Characteristics of Cold and Hot Press of Nigella sativa L Seed Oil Using Screw Press. *Journal of applied sciences research*, 10 (12): 36-45.