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Characterization of oils from *Duranta repens* leaf and seed

Emmanuel Agomuo[1], Peter Amadi[2,*], Charity Ogunka-Nnoka[2], Benjamin Amadi[2], Mercy Ifeanacho[2] and Uche Njoku[2]

[1] Imo State University, Owerri, Nigeria
[2] University of Port Harcourt, Choba, Rivers State, Nigeria

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Abstract – The knowledge of the chemical composition of unpopular sources of edible oils has become paramount to supplement the usage of widely known vegetable oils. In this study, the gas chromatographic quantification of fatty acids and phytochemicals was carried out, and the physicochemical and micronutrient composition of *Duranta repens* leaf and seed oil were evaluated using standard methods. The leaf oils contained significantly higher ($p < 0.05$) peroxide, iodine and thiobarbituric acid values, refractive index, and moisture contents, while the saponification value, specific gravity, melting point and pH were significantly higher in the seed oil. The seed oils contained higher Mg, K, Na and vitamin K contents while the leaf oil contained higher Fe, vitamin A and vitamin D contents. The occurrence of the fatty acids were as follows: palmitic > oleic > myristic > stearic > capric > linoleic > lauric > palmitoleic for the seed oil, while for the leaf oil linoleic > palmitoleic > oleic > stearic > palmitic > myristic > capric > lauric > myristoleic. The major phytochemical constituents of the seed oils were catechin (68.12 ug/ml), saponin (44.03 ug/ml), rutin (32.89 ug/ml), linamarin (22.66 ug/ml) and tannins (19.62 ug/ml), while kaempherol (84.05 ug/ml), rutin (62.26 ug/ml) and saponins (45.63 ug/ml) were mostly predominant in the leaf oil. Spartein, anthocyanins and phytates were among the least phytochemicals in composition, for both samples. These chemical properties evaluated, suggest that *Duranta repens* seed oil is more suitable for industrial and therapeutic purposes.

Keywords: fatty acids / micronutrient / phytochemicals / physicochemical / *Duranta repens*

Résumé – Caractérisation des huiles de feuilles et graines de *Duranta Repens*. La connaissance de la composition chimique des sources d'huiles comestibles peu utilisées est devenue primordiale afin de compléter l'utilisation des huiles végétales plus largement connues. Dans cette étude, la quantification, par chromatographie en phase gazeuse, des acides gras et des composants phytochimiques a été effectuée, et la composition physicochimique et en micronutriments de l'huile de feuilles et de graines de *Duranta repens* a été évaluée à l'aide de méthodes classiques. Les huiles de feuilles contiennent des valeurs significativement plus élevées ($p < 0{,}05$) de peroxyde, d'iode et d'acide thiobarbiturique, tandis que la valeur de saponification, la densité, le point de fusion et le pH étaient significativement plus élevés dans l'huile de graines. Les huiles de graines contiennent des teneurs en Mg, K, Na et vitamine K plus élevées, tandis que l'huile de feuille contenait des teneurs supérieures en Fe, en vitamine A et en vitamine D. La concentration relative en acides gras était la suivante : palmitique > oléique > myristique > stéarique > caprique > linoléique > laurique > palmitoléique pour l'huile de graines, et linoléique > palmitoléique > oléique > sté arique > palmitique > myristique > caprique > laurique > myristoléique pour l'huile foliaire. Les principaux constituants phytochimiques des huiles de graines étaient la catéchine (68,12 µg/ml), la saponine (44,03 µg/ml), la rutine (32,89 µg/ml), la linamarine (22,66 µg/ml) et les tanins (19,62 µg/ml) tandis que le kaemférol (84,05 µg/ml), la rutine (62,26 µg/ml) et les saponines (45,63 µg/ml) étaient prédominants dans l'huile de feuilles. La spartéine, les anthocyanines et les phytates comptaient parmi les composants les moins présents, pour les deux échantillons. Ces propriétés chimiques suggèrent que l'huile de graines de *Duranta repens* est plus adaptée à des fins industrielles et thérapeutiques.

Mots clés : acides gras / micronutriment / composés phytochimiques / physicochimie / *Duranta repens*

*Corresponding author: peter_amadi@uniport.edu.ng;
amadi.peter.u@gmail.com

1 Introduction

Fats and oils are non volatile substances that are soluble in organic solvents but insoluble in water. In a generic sense, oils are used to refer to oily or greasy substances (Buba, 2005) while fats are used to describe lipids or triglycerides that are liquid at room temperature (Aremu *et al.,* 2015). These substances along with macromolecules like carbohydrates and proteins, constitute major foodstuffs, and due to their rapid generation of heat, have found increased application in processes that involves frying (Andrew *et al.*, 2012). Two basic sources of oils are from animals and vegetables. The application of plant oils for industrial purposes has been well documented. Vijayan *et al.* (1996) reported the importance of monitoring the quality of oils in order to avoid adulteration of the oils which can cause numerous health effects. The physicochemical properties of different plant oils have been well researched (Gaikwad and Swamy, 2008). Anioara-Arleziana *et al.* (2013) suggested that the physicochemical properties are important determinants of the overall stability and quality of food materials. Some of the important physicochemical properties are acid value, specific gravity, iodine value, saponification value, peroxide value and refractive index. Micronutrients are important properties of food materials that promote quality nutrition (Agomuo *et al.*, 2017). Minerals play numerous roles like in regulating functions like the synthesis of red blood cells, heart function, protein synthesis, etc. For instance, magnesium and zinc are involved in the activation of numerous enzymes (Agomuo *et al.*, 2017), calcium helps in bone formation, sodium and potassium play key roles in maintenance of osmotic balance, and iron in addition to its role in the functioning of the central nervous system, also facilitates the oxidation of some macromolecules (Aremu *et al.*, 2005). The properties of fats and oils are greatly influenced by the constituent fatty acids. The unsaturated fatty acids could either be a non essential fatty acid (ω9) or the essential fatty acids (ω3 and ω6) that can only be obtained from the diet (Assiesa *et al.*, 2004). Kostik *et al.* (2013) observed that vegetable fats and oils contain predominantly saturated and unsaturated fatty acids with aliphatic straight chains. Daniewski *et al.* (2003) reported that in most cases, a number of minor, branched chain, odd number straight chain, and cyclic fatty acids may be present in plant oils. However, it has been shown that a high percentage of unsaturated fatty acids are predominant in triglycerides from plant sources of oils, and the degree of unsaturation is related to the degree of oxidative deterioration. Hence, by that determining the fatty acid composition of oils sheds some light on the characteristics and stability of the oil.

Phytochemicals are plant secondary metabolites that may either have beneficial or deleterious effects on humans. Some phytochemicals promote the functionality of the immune system, minimize inflammation, prevent cardiovascular diseases, and exhibit antiviral and antibacterial properties (James *et al.*, 2007). It is therefore important to determine the phytochemical composition of plant materials to ascertain their potential biological activities. *Duranta repens* also known as yellow bush (the leaves) or pigeon berry (the seeds) is a fast growing, large, spreading shrub with numerous stems that reaches a height of 1–3 m (Okunlola, 2013). It belongs to the Verbenaceae family with the genus *Duranta* made up of about 35 species (Anis *et al.*, 2002). Rowezak (2001) suggested that the fragrant pale blue flowers coupled to the golden orange berries make the plant appear very attractive. Mandvi *et al.* (2014) reported that the flowers and fruits of *Duranta repens* have stimulant and diuretic properties respectively. The fruits in addition to being used to expel intestinal worms, possess antimalarial and larvicidal properties, while the leaves according to Xiao (1992) have been used for the treatment of abscess. After the scrutiny of literature, the dearth of information on the chemical properties of *Duranta repens* leaf and seed oil has necessitated this study. Therefore, this study was carried out to investigate the physicochemical, vitamins and minerals, fatty acid and phytochemical properties of *Duranta repens* fruits and leaf oils.

2 Materials and methods

2.1 Sample collection and preparation

Duranta repens fruits and leaves were harvested from parent trees at farms within Owerri in Imo State, and taken to the Department of Plant Science and Biotechnology Imo State University Owerri, Imo State Nigeria. The fruit samples were washed thoroughly, and then sliced open, for the pulp to be harvested, while the leaves were washed to remove dirt, and sliced. Both samples were separately placed into hot air oven at 40 °C for 5 hrs and afterwards were pulverized to obtain finer ground powder, using an electric grinder and then taken to the laboratory for extraction of its oil.

2.2 Sample preparation

A 100 g of the grounded samples were weighed into a thimble and soaked in 500 ml of a mixture of n-hexane and isopropyl alcohol in a ratio of 3:2 according to the stipulations of Hara and Radin (1978). The thimble was stuffed with cotton to prevent the sample particles from pouring away and left for 24 hrs. The solution obtained was drained, filtered using filter paper and extracted with a soxhlet extractor. The rotary evaporator was used to concentrate the sample and solvent mixture, at a low pressure with a maximum temperature of 45 °C to produce the crude extracts and the extracts were stored at 4 °C until it was used.

2.3 Physicochemical analysis

The melting point, moisture, peroxide value, iodine value, acid value, saponification value and oil yield were determined using the method of A.O.A.C. (2000). The pH was detected using a pH meter, the refractive indices analyzed at 25 °C following the method of Oderinde and Ajayi (2000) by using a Brix refractometer, and the method of Menoyo *et al.* (2002) was adopted for the determination of TBA-reactive substances (TBARS).

2.4 Mineral and vitamin content analysis

Wet digestion of samples (5 ml) using a mixture of concentrated HNO_3 and 60% (v/v) $HClO_4$ was carried out according to the method of A.O.A.C. (2000) where the organic matter in the sample was digested and afterwards diluted to a final volume of 25 ml with deionized distilled water. The levels of Mg, Ca, K, Fe, Cu and Na in the samples were thus evaluated using an atomic absorption spectrophotometer (Buck Scientific model 210 VGP) and flame photometer (Jenway model).

2.5 Fatty acid composition analysis

The oils were refluxed in 2% H_2SO_4 in methanol for 3 hrs at 70 °C to obtain the fatty acid methyl esters. The fatty acid constituents were identified on a gas chromatography (Agilent 6890N) equipped with Flame Ionization Detector and a 30 × 0.32 m DB-225 silica capillary column (J & W Scientifics, USA). The split injector (1 ml) and detector were operated at a temperature of 230 °C and 25 °C respectively, while the oven temperature of 160 °C/2min was increased to 230 °C on a scale of 4 °C/min. Nitrogen was the carrier gas at a flow rate of 1.5 ml/min. The peaks were compared with standard methyl esters while the percentage area was recorded with standard chemstation system.

2.6 Phytochemical determination using GC-FID method

Phytochemical analysis of the oil samples was carried out using an auto system buck 530 chromatographer in gas phase equipped with an on-column automatic injector, flame ionization detector, and with Hp88 capillary column (100 m × 0.25 mm). Chromatographic conditions were: injector temperature 220 °C; detector temperature 250 °C; oven temperature to 180 °C; injection volume 1 ml sample; hydrogen was used as a carrier gas (24 pound per square inch [PSI]). The concentration of each active component was determined based on the ratio between the area and mass of internal standard and area of the peaks of the phytochemicals identified.

3 Results and discussion

The result of Table 1 shows the physicochemical properties of *Duranta repens* leaf and seed oil. The leaf oil had higher peroxide value than the oil from the seeds. Among other parameters, Aremu *et al.* (2015) identified the peroxide value of oils as the commonest lipid oxidation indicator. Adebisi and Olagunju (2011) demonstrated that peroxide values greater than 10 meq/kg indicate oils that are highly prone to auto-oxidation as a result of presence of trace elements or moisture. Therefore, this may suggest that the seed oil possesses a higher shelf life than the leaf oil. The value recorded for the peroxide value of *Duranta repens* seed oil shows more stability of the oil than those of melon seed oil and groundnut seed oil (Nkafamiya *et al.*, 2010). The iodine values in Table 1 imply that the *Duranta repens* seed oil is less unsaturated than the leaf oil. With the classification of Aremu *et al.* (2006) both oils are non drying oils as their iodine values were found below 100 gI_2/100 g, however, the seed oil showed a more preferred industrial relevance when considering the opinions of Aremu *et al.* (2015). The iodine values of both oils in this study were lower than that of *Citrullus colocynthis* (Igwenyi, 2014) while peanut oil and palm oil (Birnin-Yauri and Garba, 2011) recorded higher iodine values than the *Duranta repens* leaf oil reported in this study. The *Duranta repens* seed oil contained higher saponification value implying that the fatty acids in the oil were most predominantly short chains that favor stability. Akintayo and Bayer (2002) reported that low saponification values as in the case of the *Duranta repens* leaf oil, indicate the predominance of long chain fatty acids. The saponification value of the seed oils of *Duranta repens* was comparable to those of *Jathropha curcas* seed oil (Elizabeth *et al.*, 2012) and Sesame seed oil (Mohammed and Hamza, 2008) while that of leaf oil in this study was similar to that of *Telfaria occidentalis* oil (Nwabanne, 2012) and *Anarcadium occidentale* oil (Aremu and Akinwumi, 2014). The results further show that the seed oil is denser and more thermally stable than the leaf oil. The results further implied that both oils are denser than water and therefore might not be applicable for cream production as the oils will retard the flow and spread of the creams on the skin (Oyeleke *et al.*, 2012). Both densities and melting points relate to the thermal behavior and hardness of oils, and for this study, imply that the seed oil of *Duranta repens* is more suitable for deep frying. More so, the specific gravity of *D. repens* seed oil in this study was higher than groundnut seed oil (Musa *et al.*, 2012) and Castor oil (Akpan *et al.*, 2006) but comparable to melon seed oil and Almond oil (Akpambang *et al.*, 2008). The pH and acid values are used to assess the quantity of free fatty acids present in oils. The pH values of both oils suggest a higher acidity recorded for the leaf oil. In general, the acid value can as well suggest the quality of fatty acids in oil which could as well determine the stability and shelf life of an oil. With the suggestions of Aremu *et al.* (2006) on acid values, the leaf oil of *D. repens* in this study is not suitable for cooking and may be poisonous to livestock. Commonly used cooking oils like palm oil (Birnin-Yauri and Garba, 2011) had comparable acid values to that of *D. repens* seed oil in this study while Ayoola and Adeyeye (2010) reported a much lower acid value for groundnut oil when compared to that for *D. repens* leaf in this study. The refractive index of the *D. repens* leaf oil was significantly higher than that of the seed oil (Tab. 1). None of the values for refractive index in this study fell within the

Table 1. Physicochemical properties of *Duranta repens* leaf and seed oil.

Properties	Leaf oil	Seed oil
Peroxide Value (Meq/KOH/kg)	20.00 ± 2.00^a	12.29 ± 0.85^b
Iodine Value (g I_2/100 g)	72.65 ± 3.25^a	44.84 ± 1.74^b
Saponification Value (mg KOH/ g)	166.93 ± 7.47^a	192.50 ± 3.75^b
Specific Gravity	1.02 ± 0.01^a	1.64 ± 0.07^b
Melting Point (°C)	9.01 ± 1.13^a	14.62 ± 1.26^b
pH	5.42 ± 0.04^a	6.16 ± 0.13^b
Acid Value (mg KOH/g)	34.00 ± 3.27^a	21.01 ± 1.51^b
Refractive Index	1.39 ± 0.10^a	0.81 ± 0.03^b
Moisture (%)	7.00 ± 1.10^a	2.41 ± 0.32^b
Thiobarbituric Acid (μg/kg)	0.18 ± 0.01^a	0.10 ± 0.01^b
Oil yield (%)	2.05 ± 0.37^a	7.46 ± 0.92^b

Values are means ± standard deviations of triplicate determinations. Values bearing different superscript letter (a, b) across the row are significantly different ($p < 0.05$).

standard range (1.4677–1.4707) for refined and virgin oils (CODEX-STAN, 1999). The refractive index property plays a key role during quality control by indicating isomerization and hydrogenation which are important when determining the purity of a material. Food materials with low moisture content may have a high storage value due to the fact that the lower the moisture content, the lesser the enhancement of microbial activity. The higher moisture content of the *Duranta repens* leaf oil implies higher susceptibility to microbial growth than the seed oil. The thiobarbituric acid value is also used as an indicator for the degree of lipid oxidation. It shows the amount of polar secondary reaction products. In this study, the results showed clearly that the leaf oil contained higher thiobarbituric acid values, but lower oil yield than the seed oil. Lukaszewicz *et al.* (2004) observed that the presence of thiobarbituric acid in an oil indicates that oxidation has already occurred and can be quantified from the amounts present. Thiobarbituric acid values can also serve as a yardstick for sensory testing to detect food rancidity (Campo *et al.,* 2006).

The micronutrient contents of *Duranta repens* leaf and seed oil are shown in Figure 1A–J. For the mineral contents, the result showed that the magnesium (Fig. 1A), potassium (Fig. 1C) and sodium (Fig. 1F) contents of the seed oil were significantly higher than those for the leaf oil. Magnesium is found in almost all enzymes where thymine pyrophosphate serves as a cofactor. Murray *et al.* (2000) noted that magnesium is also found as a component of kinase enzymes, teeth and bones. Also, the absence of magnesium reduces oxidative phosphorylation. Potassium is the principal cation in intracellular fluid while sodium is the principal cation in extracellular fluids. Both minerals are central in the maintenance of acid-base balance. At the quantities measured, these minerals fell below their individual recommended daily allowance (USDA, 2005) and might require supplementation with other food sources to meet the required levels. The iron content of the leaf oil (Fig. 1D) was significantly higher than that of the seed oil, while the calcium (Fig. 1B) and copper (Fig. 1E) content of both samples were comparable. The results further indicated that 1 kg of the oil can provide the recommended daily allowance (RDA) for copper, while a requirement of 8 kg of the oil is needed to meet the RDA for iron. Further, the vitamin compositions of both *D. repens* leaf and seed oil are shown in Figure 1G–J. Vitamin A and D occurred significantly ($p < 0.05$) higher in the leaf oil, while the seed oil provided significantly higher vitamin K content, but both sources of oil had a comparable vitamin E content. From the reports of Ujowundu *et al.* (2010), the vitamin A content of *D. edulis* seeds was higher than that of *D. repens* seed oil found in this study, but comparable to the vitamin A content of *D. repens* leaf oil. The vitamin A content of the leaf can contribute in alleviating deficiency of vitamin A and can contribute to daily vitamin needs. Tiger nut (Ekeanyanwu and Ononogbu, 2010) and African walnut contained a similar amount of vitamin D to that of *D. repens* seed oil found in this study, while the leaf oil of *D. repens* contained higher concentration of vitamin D, when compared to that of tiger nut and African walnut (Ekeanyanwu and Ononogbu, 2010). In addition to the antirachitic activity, vitamin D plays a role in calcium homeostasis maintenance as well as promotes the intestinal uptake of phosphorus and calcium (Bertone-Johnson *et al.,* 2005). With the results shown in Figure 1I, both indicated that seed and leaf oils contained an equivalent amount of vitamin E to that of groundnut oil, but lower than that of melon oil (Ejoh and Ketiku, 2013). Being an antioxidant, vitamin E helps to prevent the damage caused by free radicals. The results for vitamin K recorded in this present study was lower than that of *Tetracarpidium conophorum*, but can provide for the RDA required from the diet

The fatty acid composition of *D. repens* leaf oil is shown in Table 2. Capric acid and lauric acid identified, had % areas of 1.75 and 1.64 respectively. Kostik *et al.* (2013) detected both fatty acids in coconut oil, corn oil and palm kernel oil, but at higher compositions. Myristic, palmitic and stearic acid had percentage compositions of 2.13%, 6.33% and 6.77% respectively. Popularly consumed vegetable oils like coconut oil and palm oil (Kostik *et al.,* 2013) contained higher percentages of myristic acid and palmitic acid, while the stearic acid content of *D. repens* leaf oil recorded in this study was comparable to that of canola oil but higher than linseed oil, groundnut oil, cottonseed oil and soybean oil (Kostik *et al.,* 2013). Several studies have reported the deleterious effects of small chain fatty acids on the human system mainly by lowering high-density lipoprotein cholesterol and elevating low-density lipoproteins (Zock *et al.*, 1994). Further, the results showed a higher occurrence of unsaturated fatty acids. The unsaturated fatty acids identified were myristoleic acid (1.38%), palmitoleic (20.77%), oleic (11.47%) and linoleic (46.92%). None of the oils evaluated by Kostik *et al.* (2013), contained myristoleic acid. Myristoleic acid is an omega-5 fatty acid, biosynthesized by the enzyme delta-9 desaturase from myristic acid, but it is uncommon in nature. Its activities against LNCaP prostate-cancer cells have been reported by Iguchi *et al.* (2001). Rennie and Tanner (1991) reported the presence of palmitoleic acid in soybean leaf oil, while Artichoke (2.3%) and Kale (3.2%) leaves were reported to contain higher amounts of palmitoleic acid (Vidrih *et al.,* 2009) than the contents of *D. repens* presented in this study. Oyster mushroom oil and Radish leaf oil according to the reports of Vidrih *et al.* (2009) recorded a comparable oleic acid composition to that of *D. repens* leaf oil presented in this study while the linoleic acid composition (46.92%); being the highest amount of constituent fatty acid in the *D. repens* leaf oil evaluated in this study, was comparable to oils from Alfalfa sprouts (44.1%), Parsley leaf (44.8%) and red bell pepper (41.4%) but higher than oils from eggplant, cucumber, red cabbage and lettuce (Vidrih *et al.*, 2009). It is well documented that both monounsaturated fatty acids and polyunsaturated fatty acids induce elevated levels of HDL and reduce LDL levels (FAO/WHO, 2010). Therefore, *D. repens* leaf oil might be beneficial in therapies involving dietary sources for the management of blood lipid levels. The first identified fatty acid in *D. repens* seed oil was capric acid with percentage composition of 2.846 as shown in Table 2. Bello and Anjorin (2012) detected capric acid in cashew nut oil, however, in lower quantity than the value observed for *D. repens* seed oil in this study. From the reports of Kostik *et al.* (2013), palm kernel oil and coconut oil had higher amounts of lauric acid than that presented in this study, while the myristic acid content of *D. repens* was higher than the reports for both melon seed oil and cashew seed oil. Palmitic acid with composition of 42.85%, was the highest constituent fatty acid. The palmitic acid content of similar underexploited plant seeds: *A. lebbeck, C.*

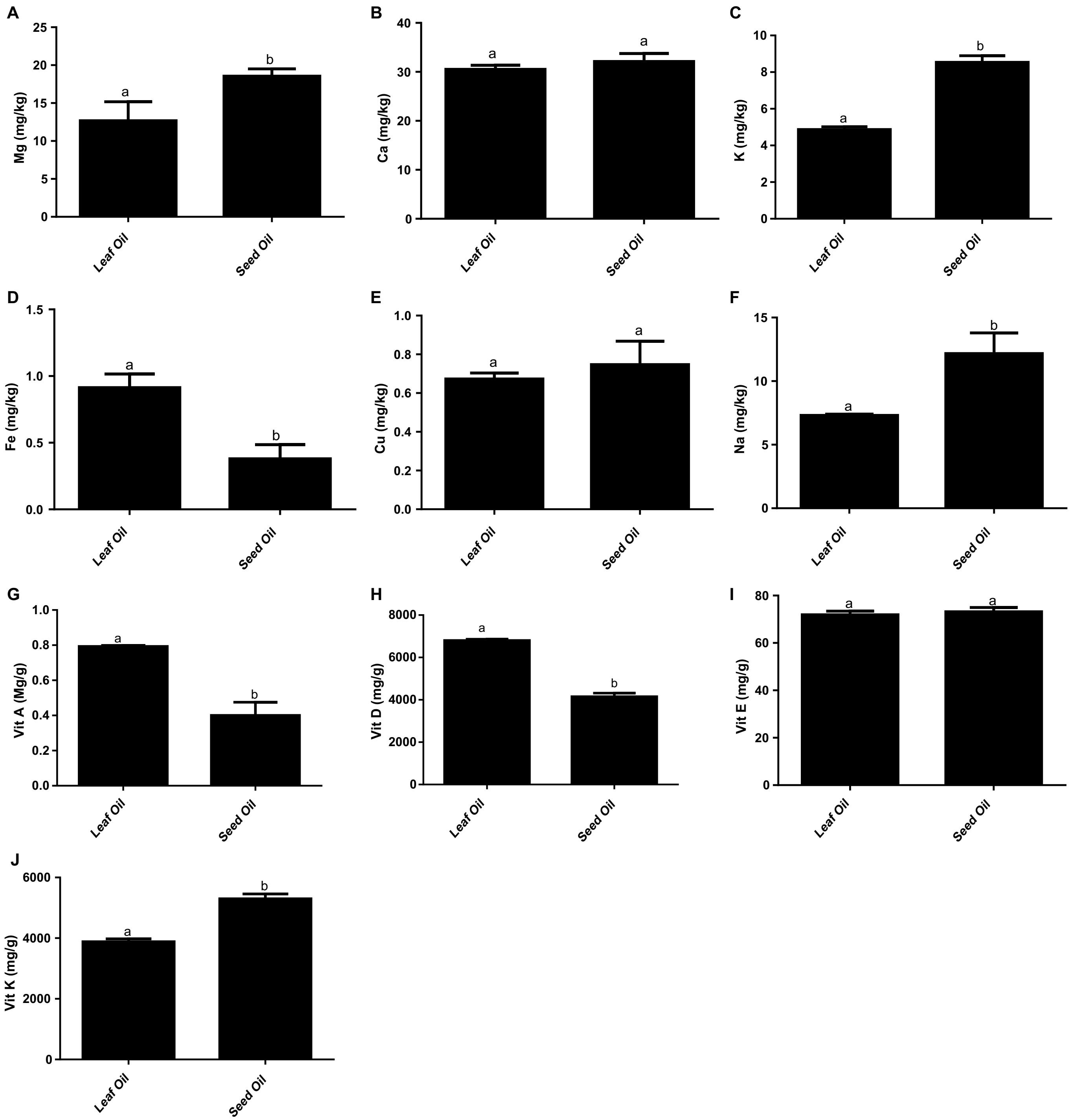

Fig. 1. The micronutrient contents of *Duranta repens* leaf and seed oil. A: magnesium content of *D. repens* leaf and seed oil; B: calcium content of *D. repens* leaf and seed oil; B: potassium content of *D. repens* leaf and seed oil; D: iron content of *D. repens* leaf and seed oil; E: copper content of *D. repens* leaf and seed oil; F: sodium content of *D. repens* leaf and seed oil; G: vitamin A content of *D. repens* leaf and seed oil; H: vitamin D content of *D. repens* leaf and seed oil; I: vitamin E content of *D. repens* leaf and seed oil; J: vitamin K content of *D. repens* leaf and seed oil.

Table 2. Fatty acid composition of *Duranta repens* Leaf and Seed oil.

Name	Leaf oil (%)	Seed oil (%)
C_{10} = Capric	1.75	2.85
C_{12} = Lauric	1.64	0.91
$C_{14:0}$ = Myristic	2.13	13.59
$C_{14:1}$ = Myristoleic	1.38	–
$C_{16:0}$ = Palmitic	6.33	42.86
$C_{16:1}$ = Palmitoleic	20.77	0.89
$C_{18:0}$ = Stearic	6.78	8.05
$C_{18:1}$ = Oleic	11.47	29.35
$C_{18:2}$ = Linoleic	46.92	1.49

Table 3. Phytochemical contents of *D. repens* seed and leaf oil.

Component	Seed oil (%)	Leaf oil (%)
Anthocyanin	1.23	0.78
Oxalate	0.28	0.38
Tannin	6.58	5.75
Rutin	8.44	19.38
Phenol	2.11	2.11
Epicatechin	1.11	0.79
Lunamarine	9.75	9.37
Saponin	18.95	14.21
Sapogenin	5.94	3.50
Ribalinidine	1.87	0.96
Phytate	0.12	0.08
Kaempferol	14.16	26.17
Catechin	29.32	16.50

pulcherrima and D. mespiliformis evaluated by Adewuyi and Oderinde (2014) were lower than the findings of this present study. Only palm oil (Babalola and Apata, 2011) had a comparable amount of palmitic acid to that shown for *D. repens* seed in this study. The palmitoleic acid detected in *D. repens* in this study had an area of 0.898%. This level was from the reports of Orsavova *et al.* (2015) lower than the values for almond oil, higher than sunflower and pumpkin seed oil, but comparable with the level detected for almond oil. Also, sesame oil contained a comparable stearic acid percentage composition (Orsavova *et al.*, 2015) to the values recorded for *D. repens* in this present study. However, coconut oil (2.7%), olive oil (2.3%) and peanut oil (2.1%) all had lower amounts of stearic acid according to Orsavova *et al.* (2015), when compared to the levels (8.05%) recorded for this present study. The second highest amount of fatty acid for *D. repens* seed in this study was recorded for oleic acid (29.35%). From the observations of Bello and Anjorin (2012) groundnut oil, cashew seed oil and pumpkin seed oil all contained higher amounts of oleic acid than that of *D. repens* seed oil in this study. However, *D. repens* seed oil in this study were observed to contain higher composition of oleic acid when compared to that of rubber seed oil (23.74%) and Egusi melon seed oil (14.73%) shown by Bello and Anjorin (2012). Comparing the findings of this present study with the reports of Kostik *et al.* (2013) the linoleic acid content of *D. repens* (1.49%) was much below those for sunflower seed (59.5%), cotton seed (42%), linseed (20.5%) and peanut (20%), but higher than that of coconut oil (0.5%), and comparable to palm kernel oil (1.25%). Generally, the implications of these findings, where a greater percentage of the fatty acids present in *D. repens* seed oil are unsaturated fatty acids indicates a possible negative health effect that can result from the application of this oil for culinary purposes. It is well documented that the excessive intake of saturated fatty acids relates to elevated cholesterol levels and obesity (Brenna *et al.*, 2009) while the consumption of unsaturated fatty acids improves the lipid profile.

Table 3 shows the phytochemical compositions of *D. repens* leaf and seed oil. The results for the flavonoids (anthocyanin, rutin and kaempferol) show that the seed oil had greater amounts of anthocyanin than the leaf oil, while the rutin and kaempferol contents of the leaf oil were found higher than those for the seed oil in Table 3. Wegener and Fintelmann (1999) have reported the antioxidants, cholesterol lowering, anti-inflammatory, hepatoprotective and antimicrobial properties of flavonoids. Anthocyanins are among the flavonoids, with remarkable anti-inflammatory and antioxidant activities (Seeram *et al.*, 2002). Roy *et al.* (2009) found that anthocyanins are active against age related neurodegenerative disorders, cardiovascular diseases, cancer and visual impairments. Paolillo *et al.* (2011) have implicated both rutin and kaempferol as antimicrobial agents coupled with their antioxidant properties. The high amount of constituent rutin and kaempferol could be the explanation to the reports of Jayalakshmi *et al.* (2011) about the high antimicrobial properties of *Duranta repens*. The oxalate content of the *D. repens* leaf oil (0.38%) was higher than that for the seed oil (0.28%), however, the tannin and phytate composition of the leaf oil was lower than the seed oil. This indicates higher potentials of the leaf oil to cause digestive difficulties and astringency than the seed oils, due to higher amounts of these constituent antinutrients. Noonan and Savage (1999) observed that the presence of oxalates and phytates in foods causes selective reabsorption of some minerals. Noonan and Savage (1999) further described the specific impairment in absorption of calcium and iron resulting from high oxalate foods. Similarly, phytates affect the intestinal uptake of minerals by forming stable complexes with dietary minerals, thus inducing the deficiency of the mineral (Lopez *et al.*, 2002). In addition to the tannins astringency, Shimada (2006) has reported that the absorption of some proteins is impeded by the precipitations of tannins. However, tannins have also been reported to have possible anticarcinogenic effect. For the plant phenols, the *D. repens* seed oil produced higher amounts of epicatechins (1.11%) and catechins (29.32%) than the leaf oil, while the phenol content recorded in Table 3 for the leaf oil was equivalent to that of the seed oil. Catechins are useful in treatment of heart diseases and improvement of blood pressure (Khalesi, 2014). Further, Chen *et al.* (2006) have noted the effectiveness of catechin and epicatechin in preventing the appressorial melanization of *Colletotrichum kahawae* thus preventing coffee berry disease. *D. repens* seed oil showed higher concentration of lunamarine, ribalinidine and catechin than the leaf oil. Both lunamarine and ribalinidine are identified as alkaloids. Among other pharmacological effects of alkaloids, their antimalarial (Cordell, 1981), analgelsic, and antioxidant properties (Stary, 1998) have particularly received attention. With the reports of Fozia *et al.* (2010) about the antiplasmodial properties of *D. repens*, it is believed that the alkaloids contribute to the effects. The saponin content of the *D. repens* leaf oil (14.21%) was lower than that of the seed oils (18.95%). Conversely, the seed oil provided a better source for sapogenin than the leaf oil. Saponins exhibit cholesterol lowering, wound healing and hemolytic properties (Okwu and Okwu, 2004) while sapogenins have been found functional in the deactivation of viruses such as the inhibition of the replication of HIV-1 virus possibly through the inhibition of its protease activity (Mengoni *et al.*, 2002).

4 Conclusion

The results of the physicochemical analysis have shown that seed oils are more stable, denser and more thermally stable with much preferred industrial relevance than the leaf oils. Most of the minerals were higher in the seed oils while the leaf oil contained a greater amount of vitamins analyzed. The leaf oil was majorly comprised of unsaturated fatty acids while the seed oils contained majorly saturated fatty acids. The predominant phytochemicals in the leaf oil were kaempferol and rutin, while the seed oil predominantly contained catechin, saponin, sapogenins, and ribalinidine.

Conflicts of interest. The authors declare that they have no conflicts of interest in relation to this article.

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