POTENTIAL DOMESTIC AND INDUSTRIAL UTILIZATIONS OF OKRA SEED: A REVIEW

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Abstract
The paper reviewed the chemical properties of seed and seed oil of okra. Various published articles on chemical composition of seed and seed oil of okra were reviewed. The reported values of the proximate composition of okra seed ranged from 2.69 to 13.99%, 18.96 to 41.11%, 14.01 to 31.04%, 3.20 to 30.81%, 3.42 to 5.68% and 6.69 to 36.83% for moisture, crude protein, crude fat, crude fibre, ash and carbohydrate, respectively. The chemical composition of okra seed oil varied from 3.21 to 12.77meq/Kg, 113.57 to 127.20g/100g, 2.37 to 3.74%, 183.10 to 196.30mg KOH/g, and 4.18 to 35.99mg KOH/g for peroxide value, iodine value, free fatty acid, saponification value and acid value respectively. The fatty acid composition of the seed oil were found to be 0.19 to 0.38%, 21.97 to 30.42%, 0.31 to 0.98%,2.64 to 4.75%, 16.81 to 27.49%, 36.56 to 49.54%, 0.17 to 2.64% and 0.16 to 0.52% for myristic, palmitic, palmitoleic, stearic, oleic, linoleic, linolenic and behenic acids respectively. The review revealed that okra seed has high crude protein, crude fibre, crude fat and carbohydrate contents with appreciable level of other nutrients such as iron, magnesium, manganese, zinc, calcium, copper and phosphorus. The major saturated fatty acids in okra seed oil are palmitic acid and stearic acid while unsaturated fatty acids are linoleic acid and oleic acid. The review indicated that okra seed could be used for fortification/supplementation in food system while okra seed oil which is edible could be useful in food system especially in shortening and margarine industries.

Keywords: Okra seed, Okra seed oil, Food supplementation, Fatty acid, Chemical composition

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1. INTRODUCTION

Okra fruit [*Abelmoschus esculentus* L. (Moench)] is an essential vegetable crop cultivated in different parts of the world (Sami et al., 2013; Gemede et al., 2014; Roy et al., 2014). Okra pod is available throughout the year in Nigeria. It is a vertical dicotyledonous plant connected to cotton plant and its source believed to be from Africa (Adetuyi et al., 2011). The okra plant consists of trunk, stems, leaves and pods with its pod comprising of pulp, seeds and calyx. The various portions of okra plant have distinct medicinal, commercial and culinary benefits (Dong et al. 2014). Okra pods contain seeds that are small in size with strong seed coat consisting of great amount of crude fibre (Dhruve et al., 2015). Okra pod is mainly cultivated for its under-matured fruits which are consumed as green vegetable, after cooking alone or with other vegetable crops (Adelakun et al., 2010; Agbo et al., 2010; Adetuyi and Adelabu, 2011). The immature fruits of okra plant could be harvested one week after flowering or 2-3 months after sowing depending on the variety cultivated (Adetuyi et al., 2008). Okra pod is a famous domestic vegetable crop and important energy food for human being (Hassan and Ali, 2015). The motivation of using okra pods in meal preparation is that the fruits are commonly grown in Africa and always available (Acquistucci and Francisci, 2002). Okra pods have certain vital vitamins and minerals that are essential for human metabolic activities (Hassan and Ali, 2015). The abundant nutrient content in okra fruits is found in its dried seed (Dhruve et al., 2015; Acikgoz et al., 2016). Okra seed is recognized for its abundant protein attributes particularly its important amino acids comparative to various other plant proteins (Hassan and Ali, 2015). Okra seeds which are a good source of protein and oil have been utilized as non-caffeinated substitute for coffee and cottage production of oil in many countries (Gemede et al., 2014; Roy et al., 2014; Dhruve et al., 2015). Sami et al. (2013) reported that oil from okra seed is a great source of unsaturated fatty acids. Okra seeds are suitable for consumption and the left over cake after oil extraction is high in protein (Acikgoz et al., 2016). Adelakun et al. (2010) disclosed that nowadays in Nigeria, okra seeds are limited to re-generation purpose. Adelakun et al. (2010) further reported that a great proportion of okra seeds are discarded as unfit for seedling purposes, thereby resulting in postharvest loss. Little or no concerted effort has been made in the literature to provide a one-stop publication on domestic and industrial products made from okra seed and seed oil. Thus, the review is intended to reveal the:

(a). nutritional composition of okra seed

(b). chemical composition of okra seed oil and

(c). potential utilizations of okra seed and seed oil.

2. PHYSICAL AND CHEMICAL PROPERTIES OF OKRA SEED

2.1. Physical properties of okra seed

The physical properties of okra seeds vary with respect to moisture levels (Sahooa and Srivastava, 2002; Calsir et al., 2005; Acikgoz et al., 2016). At 8.16% moisture level, okra seed was reported to possess 4.59 mm, 5.92 mm and 4.71 mm for the thickness, length and width, while at 19.56%, the thickness, length and width was found to be 5.23 mm, 6.80 mm and 5.30 mm (Sahooa and Srivastava, 2002). Sahooa and Srivastava (2002) further reported that as the moisture content increased from 8.16 to 87.57%, there was an increase in thickness (5.36 mm), length (7.30 mm) and width (5.40 mm). Sahooa and Srivastava (2002) also reported that there were increments in coefficient of static friction on mild steel (0.389 - 0.480), bakelite (0.345 - 0.480), aluminum (0.390 - 0.484) and galvanised iron (0.368 - 0.493) with increment in moisture content (8.16 - 87.57 %) of okra seed. This trend was also observed by Calsir et al. (2005) who reported that as the moisture content increased from 6.35 to 15.22 %, okra seeds recorded increment in its volume (47.38 - 54.68 mm^3), terminal velocity (5.20 to 5.68 ms^{-1}), porosity (48.92 - 52.08 %) and projected area (0.22 - 0.33 cm^2) while there was a reduction in sphericity (0.90 to 0.89) and bulk density (636.10 - 577.99 kgm^{-3}). On the other hand, Acikgoz et al. (2016) reported a length (5.29 mm), width (4.32 mm), thickness (4.53 mm), geometric mean diameter (4.70 mm), weight (0.07 g), volume (61.72 mm^3), surface area (69.21 mm^2) and sphericity (0.89) for mature seeds of okra at 11.65 % moisture. However, it was reported by Sahooa and Srivastava (2002) that as the moisture content of okra seed increased from 8.16 to 87.57%, there was a reduction in the porosity (46.34 to 43.20 %), bulk density (0.592 to 0.558 g/cm^3) and true density (1.107 to 0.986 g/cm^3). Hence, physical properties are important in predicting the storage stability and shelf life of the okra seed (Acikgoz et al., 2016).

2.2. Proximate composition of okra seed

The proximate composition of okra seed depends on variety and maturity phase of okra fruit, and differences in methods of analysis (Ndangui et al. 2010). The proximate composition of okra seeds as reported by Calsir et al. (2005), Adelakun et al. (2009), Ndangui et al. (2010), Soares et al. (2012), Dhruve et al. (2015) and Acikgoz et al. (2016) is shown in Table 1. The proximate composition ranged from 2.69 to 13.99 %, 18.96 to 41.11 %, 14.01 to 31.04 %, 3.20 to 30.81 %, 3.42 to 5.68 % and 6.69 to 36.83 % for moisture, crude protein, crude fat, crude fibre, ash and carbohydrate content respectively.

The moisture content reported for pumpkin seed (5.20 %), *Lannea microcarpa* seed (3.24 %) and melon seed (4.27 %) by Ardabili et al. (2011), Bazongo et al. (2014) and Obasi et al. (2012) respectively were similar to range of moisture contents reported for okra seed. The crude protein contents of okra seed were higher than those reported by Obasi et al. (2012) for coconut (10.57 %) and melon seed (11.67 %).

Table 1: Proximate composition (%) of okra seed

Moisture content	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrate	References
6.35	19.10	20.00	26.34	4.63	NR	Calsir et al. (2005)
10.38	41.11	31.04	3.45	3.42	10.60	Adelakun et al. (2009)
9.45	24.85	23.44	9.70	5.68	36.83	Ndangui et al. (2010)
13.99	22.14	14.01	30.81	4.01	6.69	Soares et al. (2012)
2.69	18.96	14.40	3.20	5.21	21.28	Dhruve et al.(2015)
9.95	28.21	22.62	NR	5.21	NR	Acikgoz et al. (2016)

NR – Not Reported

However, the crude protein contents of pumpkin seed (25.40 %) and *Lannea microcarpa* seed (21.14 %) reported by Ardabili et al. (2011) and Bazongo et al. (2014) respectively were similar to that of okra seed. The high protein content of okra seed makes it desirable as an alternative source of animal protein for people living in low income countries. The fat contents of okra seed were lower than those reported for pumpkin seed (41.59%), *Lannea microcarpa* seed (64.90 %) and melon seed (49.05%) by Ardabili et al. (2011), Bazongo et al. (2014) and Jacob et al. (2015) respectively. However, the fat content of okra seed was higher than the one reported by Mathew et al. (2014) for cherry seed (13.00%). On the other hand, the fat content of guava seed (19.01%) reported by Mathew et al. (2014) is similar to those of okra seed. Okra seed has appreciable amount of fat content which could be beneficial to human in areas of good skin and functioning of cell (Mathew et al. (2014). Also, okra seed could serve as alternate source of oil. The crude fibre reported for melon seed (5.51%) and cherry seed (10.00%) by Obasi et al. (2012) and Mathew et al. (2014) respectively were similar to that of okra seed, although the crude fibre content reported for pumpkin seed (2.49%) is lower. Since, okra seed has high crude fibre content, its inclusion in diet may be beneficial as Jacob et al. (2015) reported that fibre lowers the presence of various cancers and cholesterol in human body. The ash content of okra seed were higher than those reported by Ozcan et al. (2012), Bazongo et al. (2014) and Mathew et al. (2014) for grape seeds (1.2 – 2.6%), *Lannea microcarpa* seed (3.11%) and cherry seed (2.00%) respectively. However, ash contents of melon seed (6.70%) reported by Jacob et al. (2015) is higher than that of okra seed. The reported carbohydrate content of cherry seed (62.30%) and guava seed (53.95%) by Mathew et al. (2014) were higher than those of okra seed. However, the reported carbohydrate contents of *Lannea microcarpa* seed (10.85%) and melon seed (7.22%) by Bazongo et al. (2014) and Jacob et al. (2015) respectively were within the range of okra seed.

2.3. Mineral composition of okra seed

Different values of mineral content of okra seeds are reported in the literature. Ndangui et al. (2010) reported that okra seeds contained 1450.00 mg/100g phosphorus, 78.65 mg/100g calcium, 3259.00 mg/100g magnesium, 109.76 mg/100g potassium and 54.78 mg/100g sodium. Adelakun et al. (2010) on the other hand, reported that okra seeds had 24.01 mg/kg phosphorus, 34.42 mg/kg potassium, 1.88 mg/kg calcium, 12.65 mg/kg magnesium, 20.74 mg/kg sodium, 322.43 mg/kg iron, 35.43 mg/kg copper, 158.94 mg/kg zinc and 248.98 mg/kg manganese. Dhruve et al. (2015) who worked on ten genotypes of okra seeds reported values ranging from 0.02 to 0.12%, 0.09 to 0.22% and 15.96 to 77.50 ppm for magnesium, calcium and potassium respectively. The phosphorus (1450 mg/100g), calcium (78.65 mg/100g), magnesium (3259 mg/100g), potassium (109.76 mg/100g) and sodium (54.78 mg/100g) were reported by Ndangui et al. (2010). The phosphorus (5.77 mg/100g), calcium (0.10 mg/100g), magnesium (20.46 mg/100g), potassium (4.94 mg/100g) and sodium (0.21 mg/100g) have been reported for melon seed (Jacob et al., 2015). Also, according to Mathew et al. (2014) cherry seeds contained phosphorus (10.01mg/100g), calcium (6.64 mg/100g), magnesium (3.21 mg/100g), potassium (13.93mg/100g) and sodium (9.23mg/100g). Thus, okra seed is more nutritious than melon and cherry seeds in terms of mineral composition. The various reports on the mineral contents showed that okra seed has high contents of iron, magnesium, manganese, zinc, calcium copper and phosphorus. Magnesium and calcium are essential parts of bone and functioning well in human growth and development, phosphorus is required for well performing of kidney and cell development and copper is essential for functioning of nerve and assists body to utilize sugar and iron appropriately (Ndangui et al., 2010; Jacob et al., 2015). Hence, consumption and inclusion of okra seed in diet could serve as desirable alternative source of minerals.

2.4. Utilisation of okra seed flour in food fortification

Okra seed flour has been used in supplementation/fortification in order to improve nutrient composition and functional properties of foods. Otunola et al. (2007) reported that inclusion of okra seed flour in 'ogi' (Africa's fermented maize flour) increased the protein (6.50 to 12.40%), fat (1.66 to 2.34%), crude fibre (0.27 to 0.34%), ash (0.05 to 0.11%), calcium (0.03 to 0.27 mg/g), sodium (0.01 to 0.06 mg/g), iron (0.01 to 0.04 mg/g) and vitamin C (0.40 to 0.65 mg/g) contents but reduced carbohydrate content (85.22 to 74.51%). Also, Otunola et al. (2007) reported that the blends showed increased pasting temperatures (74 – 78 °C) and pasting times (23 – 28 min) as the level of inclusion of okra seed increased. For the sensory evaluation, Otunola et al. (2007) reported that 'ogi' porridge substituted with 10% and 20% okra seed flour were found acceptable by sensory panelists, while samples with 30%, 40% and 50% levels of substitution were unacceptable by the panelists. Otunola et al. (2007) revealed that the unpleasant taste and the dark brown colour bestowed on 'ogi' porridge by okra seed flour may be improved by the addition of suitable additives. Adetuyi and Adelabu (2011) supplemented plantain flour with okra seed flour at 10%, 20% and 30% and reported that as the level of okra seed flour increased in the flour blends, there were significant increases in protein (3.88 to 10.50%), fat (6.01 to 14.06%), fibre (3.03 to 9.98%), ash (2.72 to 6.42%), water absorption capacity (160 to 260) and oil absorption capacity (95.92 to 123.20) while there was a decrease in moisture (11.23 to 9.25%), carbohydrate (59.64 to 49.79%), bulk density (0.76 to 0.74g/cm^3) and swelling capacity (5.32 to 4.20g). Also, Adetuyi and Adelabu (2011) reported that there were significant increases in zinc (0.10 to 1.27 mg/100g), potassium (11.13 to 13.00 mg/100g) and iron (3.30 to 5.12 mg/100g) and decreases in calcium (5.11 to 3.12 mg/100g) and phytate (1.93 to 0.91 g/100g). The authors concluded that supplementing plantain flour with okra seed flour increased the accessibility protein, fat, fibre and ash. Also, increased water absorption capacity and oil absorption capacity indicated usefulness as a thickening agent in food system. Adetuyi and Komolafe (2011) reported that supplementation of plantain flour with okra seed flour increased the vitamin C content from 1.85 to 2.59 mg/100g.

3. CHEMICAL AND FATTY ACID COMPOSITION OF OKRA SEED OIL

3.1. Chemical composition of okra seed oil

The chemical composition of okra seeds oil as reported by Ndangui et al. (2010) and Dong et al. (2014) is shown in Table 2. However, it should be noted that Ndangui et al. (2010) extracted okra seed oil by blye/Dyer and soxhlet methods while Dong et al. (2014) extracted oil by Supercritical carbon dioxide method, soxhlet and screw press methods. The quality of okra seed oil ranged from 3.21 to 12.77 meq/Kg, 113.57 to 127.20 g/100g, 2.37 to 3.74%, 183.10 to 196.30 mg KOH/g and 4.18 to 35.99 mg KOH/g for peroxide value, iodine value, free fatty acid, saponification value and acid value respectively. The peroxide values of okra seed oil were higher than those reported by Bazongo et al. (2014) and Abbas et al. (2008) for *Lannea microcarpa* seed oil (1.48 meq/Kg) and tobacco seed oil (1.51 - 2.30 meq/Kg) respectively. On the other hand, the peroxide values of melon seed oil (7.90 meq/Kg), pumpkin seed oil (10.85 meq/Kg) and aloe ferox seed oil (8.90 meq/Kg) reported by Milovanović and Pićurić-Jovanović (2005), Ardabili et al. (2011) and Dangarembizi et al. (2013) respectively were within the range of these attributes reported for okra seed. Peroxide value is a good index for detecting the deterioration of oils and values above 20 show rancid taste and unpleasant smell (Etong et al. 2014). Hence, the low level of peroxide value of seed oil shows less oxidative rancidity and high antioxidant of the oil (Etong et al. 2014). The reported iodine values of okra seed oil were higher than the ones reported by Ardabili et al. (2011), Bazongo et al. (2014) and Dangarembizi et al. (2015) for pumpkin seed oil (104.36 g/100g), *Lannea microcarpa* seed oil (61.33 g/100g) and *Cassia abbrevieta* seed oil (26.48 g/100g) respectively while the iodine value of melon seed oil (119.00 g/100g) reported by Milovanović and Pićurić-Jovanović (2005) is within the range reported for okra seed oil.. Okra seed oil, with iodine value of less than 180, cannot be regarded as a drying oil since according to Codex Alimentarius Commission (1982), a pleasant drying oil must have minimum iodine value of 180. Thus, Basco (1995) declared that okra seed oil is a semi drying oil which could be useful industrially in the production of surface coatings and alkyd resins. The reported values for free fatty acid value of okra seed oil were higher than those obtained by Milovanović and Pićurić-Jovanović (2005) and Ardabili et al. (2011) for melon seed oil (0.52%) and pumpkin seed oil (0.30%) respectively. However, the free fatty acids of okra seed oil were lower than that reported by Dangarembizi et al. (2013) for aloe ferox seed oil (25.90%). However, the free fatty acid value of cooking oils [Wangansa (2.43%), Kings (2.92%), Turkey (2.81%), Gino (2.43%) and Controller oil (3.37%)] sold in Nigerian markets as reported by Obasi et al. (2012) were within the range reported for okra seed. Saponification value is a good index to detect adulteration (Akubugwo and Ugbogu 2007). The saponification values of okra seed oil were lower than those reported by Dangarembizi et al. (2013) and Dangarembizi et al. (2015) for aloe ferox seed oil (241.90 mg KOH/g) and *Cassia abbrevieta* seed oil (376.16 mg KOH/g). respectively. However, the saponification value of melon seed oil (188.00 mg KOH/g), pumpkin seed oil (190.69 mg KOH/g) and *Lannea microcarpa* seed oil (194.23 mg KOH/g) reported by Milovanović and Pićurić-Jovanović (2005), Ardabili et al. (2011) and Bazongo et al. (2014) respectively were within the range of okra seed oil. Also, the saponification value of cooking oils [soya bean (192.45 mg KOH/g), Wangasa (186.53 mg KOH/g), Kulikuli (194.95 mg KOH/g) and Controller oils (196.36 mg KOH/g)] sold in Nigerian markets as reported by Obasi et al. (2012) were within the reported saponification values of okra seed. Basco (1995) had earlier reported that the saponification value of okra seed oil is comparable to that of commercial oils, so okra seed oil could be an important ingredient for the production of soap. The reported acid values of okra seed oil were higher than those reported by Milovanović and Pićurić-Jovanović (2005), Ardabili et al. (2011) and Bazongo et al. (2014) for melon seed oil (1.00 mg KOH/g), pumpkin seed oil (0.78 mg KOH/g) and *Lannea microcarpa* seed oil (1.21 mg KOH/g) respectively while the acid value of aloe ferox seed oil (51.50 mg KOH/g) reported by Dangarembizi et al. (2013) were higher than the values for okra seed oil.

Table 2: Chemical composition of okra seed oil

Peroxide value (meq/Kg)	Iodine value (g/100g)	Free fatty acid (%)	Saponification value (mg KOH/g)	Acid value (mg KOH/g)	Oil extraction method used	References
4.13	126.40	2.37	183.10	NR	Blye and Dyer	Ndangui et al. (2010)
3.21	127.20	3.74	196.30	NR	Solvent extraction	Ndangui et al. (2010)
3.32	113.57	NR	185.67	6.30	Supercritical Carbon dioxide	Dong et al. (2014)
3.91	115.03	NR	187.29	35.99	Solvent extraction	Dong et al. (2014)
12.77	114.82	NR	188.06	4.18	Screw press expression	Dong et al. (2014)

NR – Not Reported

Table 3: Fatty acid composition of okra seed oil

Myristic acid (C14:0)	Palmitic acid (C16:0)	Palmitoleic acid (C 16:1)	Stearic acid (C18:0)	Oleic acid (C18:1)	Linoleic acid (C18:2)	Linolenic acid (C18:3)	Behenic acid (C22:0)	Oil extraction method used	References
0.38	25.85	0.36	2.79	25.18	42.15	2.25	NR	Solvent extraction	Ndangui et al. (2010)
0.34	25.72	0.38	2.64	24.61	43.40	1.86	NR	Blye and Dyer	Ndangui et al. (2010)
0.31	30.42	0.39	3.93	21.08	37.78	0.17	0.25	Solvent extraction	Jarret et al. (2011)
0.19	28.74	0.31	4.12	20.38	44.48	NR	0.22	Solvent extraction	Soares et al. (2012)
0.36	28.50	0.45	4.17	25.13	36.56	0.89	0.16	Solvent extraction	Dong et al. (2014)
0.22	28.98	0.44	4.14	24.38	38.35	ND	0.32	Supercritical carbon dioxide	Dong et al. (2014)
0.24	24.16	0.48	4.75	27.49	37.83	ND	0.45	Screw press expression	Dong et al. (2014)
0.23	27.52	0.41	3.80	20.98	44.14	2.16	0.52	Solvent extraction	Awolu et al. (2014)
0.20	21.97	0.98	3.39	23.74	46.65	2.64	0.25	Enzymatic extraction	Awolu et al. (2014)
NR	28.60	NR	3.57	16.81	49.54	1.48	NR	Solvent extraction	Acikgoz et al. (2016)
0.30	30.40	0.60	2.70	16.90	47.70	0.20	0.20	Cold press extraction	Topkafa (2016)

NR – Not Reported; ND – Not Detected

3.2. Fatty acid composition of okra seed oil

The fatty acid composition of okra seed oil as reported by Ndangui et al. (2010), Jarret et al. (2011), Soares et al. (2012), Dong et al. (2014), Awolu et al. (2014), Acikgoz et al. (2016) and Topkafa (2016) is shown in Table 3. The authors extracted oils using different methods, such as Blye/Dyer and soxhlet, supercritical carbon dioxide, screw press expression and enzymes-assisted aqueous methods. The fatty acid composition of okra seed oil which varied widely among the authors ranged from 0.19 to 0.38%, 21.97 to 30.42%, 0.31 to 0.98%, 2.64 to 4.75%, 16.81 to 27.49%, 36.56 to 49.54%, 0.17 to 2.64% and 0.16 to 0.52% for myrisic acid, palmitic acid, palmitoleic acid, stearic acid, oleic acid, linoleic acid, linolenic acid and behenic acid respectively. The variations in the reported fatty acid composition may probably be due to the differences in cultivar and maturity level of okra, oil extraction methods, methods of analyses and equipment (Murkovic et al. 1999). The range of values for myristic acid content of okra seed oil is lower than 20.5% reported for dikanut seed (Etong et al. 2014). On the other hand, the palmitic acid content of okra seed oil was higher than those reported by Milovanović and Pićurić-Jovanović (2005), Ardabili et al. (2011) and Ozcan et al. (2012) for melon seed oil (12.42%), pumpkin seed oil (10.68%) and grape seed oil (8.00 – 10.20%) respectively. However, the palmitic acid content of *Cassia abbrevieta* (26.50%) and okra seed oil are within the same range. The palmitic acid of *Lannea microcarpa* seed oil (34.45%) reported by Bazongo et al. 2014 is higher than those of okra seed oil. Okra seed oil is a possible raw material for palmitic acid which is an essential ingredient for manufacture of esters, soap and plasticizers (Ndangui et al. 2010). The palmitoleic acid reported for pumpkin seed oil (0.58%) by Ardabili et al. (2011) is within the range of that of okra seed oil. The stearic acid of melon seed oil (10.20%), pumpkin seed oil (8.67%) and *Lannea microcarpa* seed oil (8.35%) reported by Milovanović and Pićurić-Jovanović (2005), Ardabili et al. (2011) and Bazongo et al. (2014) respectively were higher than those of okra seed oil. However, the stearic acid of aloe ferox seed oil (2.90%) and *Cassia abbrevieta* seed oil (4.10%) reported by Dangarembizi et al. (2013) and Dangarembizi et al. (2015) respectively were within the range values of. stearic acid of okra seed oil. The oleic acid content of okra seed oil is higher than the ones reported by Milovanović and Pićurić-Jovanović (2005) and Dangarembizi et al. (2013) for melon seed oil (14.20%) and aloe ferox seed oil (12.00%) respectively. However, the oleic acid contents of pumpkin seed oil (38.42%), *Lannea microcarpa* seed oil (43.45%) and *Cassia abbrevieta* seed oil (37.80%) reported by Ardabili et al. (2011), Bazongo et al. (2014) and Dangarembizi et al. (2015) respectively were higher than those of okra seed oil. The reported values of linoleic acid for *Anarcadium occidentale* oil (2.5%) and *Lannea microcarpa* seed oil (11.20%) by Aremu et al. (2007) and Bazongo et al. (2014) respectively had much lower values of linoleic acid than okra seed oil (36.56 - 49.54%). The linoleic acid content (39.84%) of pumpkin seed oil is within the range reported for okra seed oil. The values of linoleic acid of melon seed oil (62.20%), grape seed oil (60.70 – 68.50%), aloe ferox seed oil (71.80%) and safflower seed oil (70.66%) reported by Milovanović and Pićurić-Jovanović (2005), Ozcan et al. (2012), Dangarembizi et al. (2013) and Matthaus et al. (2015) respectively were higher those of okra seed oil. Basco (1995) reported that linoleic acid which is high in okra seed oil is important in human diet and the oil could serve as cooking oil and find applications in shortening and margarine industries. Linoleic acid is a common and important fatty acid often used in cosmetic, plastic, paint and pharmaceutical industries and has many health benefits (Lautenschläger, 2003; Ndangui et al., 2010; Dangarembizi et al., 2013). The linolenic acid contents of melon seed oil (1.02%), pumpkin seed oil (0.68%) and *Lannea microcarpa* seed oil (0.35%) reported by Milovanović and Pićurić-Jovanović (2005), Ardabili et al. (2011) and Bazongo et al. (2014) respectively were within the range of reported values of linolenic acid of okra seed oil (0.17 - 2.64%). The value of behenic acid of *Lannea microcarpa* seed oil (0.20%) reported by Bazongo et al. (2014) is within the range of values of behenic acid of okra seed oil (0.16 - 0.52%). It should be noted that the major fatty acid in okra seed oil is linoleic acid, followed by palmitic acid, oleic acid and stearic acid. This showed that the major saturated fatty acids in okra seed oil are palmitic acid and stearic acid while unsaturated fatty acids are linoleic acid and oleic acid.

4. CONCLUSION

The review revealed that okra seed has high crude protein, crude fibre, crude fat and carbohydrate contents with appreciable mineral contents especially iron, magnesium, manganese, zinc, calcium, copper and phosphorus. The major saturated fatty acids in okra seed oil are palmitic acid and stearic acid while the unsaturated fatty acids are linoleic acid and oleic acid. In conclusion, okra seed could be useful in fortification /supplementation and thickening agent in food system while okra seed oil could be useful in food and nutrition programmes in developing countries.

5. REFERENCES

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