Australian Journal of Crop Science AJCS

Aust J Crop Sci. 19(07):784-799 (2025) | https://doi.org/10.21475/ajcs.25.19.07.p334 ISSN:1835-2707

Nutritional and chemical composition of pumpkins (*Cucurbita ssp.*): Special focus on pumpkin seeds

Jane Muthoni*[1,2], and Hussein Shimelis[2]

[1]**Kenya Agricultural and Livestock Research Organization (KALRO), Kenya**
[2]**African Centre for Crop Improvement, University of KwaZulu-Natal, College of Agriculture, Engineering and Science, School of Agricultural, Earth and Environmental Sciences, Private Bag X01, Scottsxille 3209, Pietermaritzburg, South Africa**

***Corresponding author:** jayney480@yahoo.com
ORCID ID: https://orcid.org/0000-0002-9450-1222

Submitted: 20/01/2025

Revised: 24/02/2025

Accepted: 08/04/2025

Abstract: Pumpkin leaves, fruits, male flowers, vine tips and seeds are all consumed as food. In most tropical countries, pumpkin is mainly grown for the mature fruit which is cooked and the flesh eaten. Pumpkins are consumed both as vegetables and medicines in many parts of the world. They have been used to treat various conditions such as diabetes, hypertension, cancer and hepatitis, among others. Pumpkin fruit is rich in carbohydrates, proteins, lipids, macro-and micronutrients and other health-promoting chemical compounds. Pumpkins are also grown for seeds and pumpkin seed oil. The seeds are consumed directly as a snack after salting and roasting. The objective of this review was to highlight the nutritional value as well as chemical composition of the pumpkin fruit parts especially the seeds. Pumpkin seeds are rich in protein, fibres, minerals, fatty acids, phytosterols, antioxidants such as carotenoids and tocopherols as well as macro- and micronutrients. Pumpkin seed oil is rich in unsaturated fatty acids mostly oleic and linoleic fatty acids; this makes the oil healthy for human consumption. Because of their potential benefits to human health, pumpkin seeds can be considered as natural functional food. Variation in the chemical composition of pumpkin seeds among *Cucurbita* species and cultivars might be due to differences in soil conditions, climate, genetic factors, fertilization conditions, harvest time, post-harvest handling and the processing methods.

Keywords: *Cucurbita pepo; Cucurbita moschata; Cucurbita maxima; Pumpkin.*

Introduction

The term pumpkin refers to the five main species of genus *Curcubita* that are cultivated around the world (Ekanayaka et al., 2019). These are *Cucurbita argyrosperma* Huber (formerly known as *C. mixta* Pang), *C. ficifolia, C. maxima* D (giant/tropical/African pumpkin*)*, *C. moschata* D (butternut/winter squash) and *C. pepo* L.(Courgette/Zucchini)*.* The cultivated species are widely grown throughout tropical, subtropical and temperate regions of the world (Whitaker and Bemis, 1975). *Cucurbita moschata* D*, C. pepo* L *and C. maxima* D are the most commonly cultivated species worldwide and have high production (Martins et al., 2015). The objective of this review was to highlight the nutritional value as well as chemical composition of the pumpkin fruit parts especially the seeds.

An overview of utilization of pumpkins

Pumpkin leaves, fruits (immature and mature), male flowers, tips of the vines and seeds are all consumed as food (Fu et al., 2006). The leaves and growing tips are consumed as vegetables in Africa and Mexico; in Italy and Latin America, flowers are also conmumed as vegetables (Andres, 2004; Merrick 1992; Nee 1990). In most African countries pumpkin is mainly grown for the mature fruit which is cooked and the flesh eaten (Oluoch, 2012). Pumpkins are popularly cultivated in Asia for domestic consumprion as well as commercial purposes (Elhardallou et al., 2014). In Korea, pumpkin fruit flesh is consumed in soups and juices, or it is incorporated into various foods such as rice cakes, candies, and breads (Kim et al., 2012); *C. moschata* and *C. maxima* are the most frequently consumed species there. In Indonesia, pumpkin is one of the popular vegetables consumed locally (Rohman and Irnawati, 2020). *Curcurbita maxima* is popular in Bangladesh (Amin et al., 2019b) where it is locally known as "Mistikumra (Habib et al., 2015). In India, pumpkin is the principal ingredient of several culinary vegetables; it is utilized at immature and mature fruit stage (Kulkarni and Joshi, 2013). In the US and Canada, pumpkin is a Halloween and Thanksgiving staple; in these temperate countries, they consume more *C. pepo* than other species (Kim et al., 2012). Pumpkin seeds and pumpkin seed oil are also consumed in some countries (Kim et al., 2012). The seeds are used as additives to some food dishes (Alfawaz, 2004). They are commonly used in culinary practices in Southeast Asian countries (Rohman and Irnawati, 2020) as well as in the southern parts of Austria, Slovenia, and Hungary (Murkovic et al., 1996b). Pumpkin seeds are also roasted or fried like groundnuts and eaten as snack or for oil extraction (Ndegwa, 2016). The seeds are consumed directly as a snack in many cultures throughout the world; they are especially popular in Arab countries after salting and roasting (Al-Khalifa, 1996; Benalia et al., 2015). In Egypt and Tunisia, pumpkin seeds are the alternative to the western popcorn and they are commonly eaten for leisure as a part of the local lifestyle (Abdel-Rahman, 2006; Rezig et al., 2012). In Cameroon and other parts of central and west Africa, *C. moschata* is grown for seeds. The seeds are first roasted, the shells removed, and the kernel pound into a paste and consumed with the main dish; whole roasted seeds are also eaten as a snack (Oluoch, 2012; Ndegwa, 2016; Benalia et al., 2015; Abdel-Rahman, 2006). In Mexico, *C. argyrosperma* (*C. mixta* Pang.) is cultivated for its large edible seeds as well as fruits (Applequist et al., 2006). Pumpkin seeds are good sources of oil; the oil is cholesterol-free and can be used for cooking, soap making and as domestic and industrial lubricants (Lawal, 2009). In Austria and some countries of Eastern Europe, pumpkins are grown primarily for the production of seeds that are used for extraction of salad oil (Murkovic and Pfannhauser, 2000); the oil is usually exported to other countries to generate income (Nyabera et al., 2019). Pumpkin seed oil , also known as pepita oil, is commercialised in the United States, Austria, Slovenia, Croatia, and Hungary (Fruhwirth and Hermetter, 2007; Xiang et al., 2017). Pumpkin seed oil can be a substitute of conventional edible oil (Sharmin et al., 2022). Although pumpkin seed oil is not produced commercially to a large extent, it is consumed as salad oil, soup ingredient and minced meat seasoning or frying oil in some countries like Austria, Slovenia and Hungary (Türkmen et al., 2017). Pumpkin seed oilcakes, which remains after oil extraction, can be used as poultry or fish feed; it is nutritionally rich as it contains considerable amount of protein and low cellulose (Markovic and Bastic, 1976).

Nutraceutical properties of pumpkins

Pumpkins are consumed both as vegetables and medicines in many countries such as China, Argentina, Bangladesh, India, Mexico, Brazil, the USA, and Korea mainly for preventing diabetes and eliminating intestinal parasites (Fu et al., 2006). Pumpkin has been used to treat various conditions such as diabetes, hypertension, cancer, hepatitis, macular dystrophy, abdominal cramps and distension caused by intestinal worms, inflammation and obesity, among others (Yadav et al., 2010; Adam et al., 2011; Marcus and Grollman, 2002). Pumpkin also helps in increasing fertility, immune system, eyesight, tackling convulsion, and promoting heart and skin health (Rahman et al., 2019; Hosen et al., 2021). Species such as *Cucurbita ficifolia, C. maxima, C. moschata,* and *C. pepo* are used in the treatment of *Diabetes Mellitus* in Mexico due to their antidiabetic effects (Huerta-Reyes et al., 2022). Several species of *Cucurbita* are used in traditional medicine as anthelmintic; Fu et al. (2006) reviewed the pharmacological properties of several squashes (*C. moschata, C. pepo, C. maxima, C. mixta*, C. *ficifolia*, and *Telfairia occidentalis*) and reported that they are antidiabetic, antimicrobial and anticancer. Studies by Adams et al. (2011), Ceclu et al. (2020) and Sedigheh et al. (2011) suggest that pumpkin may aid in managing blood sugar levels and improving insulin sensitivity, which are crucial factors for diabetes management. Carotenoids, methanol and certain types of sugars (polysaccharides) present in pumpkin might reduce glycemia and could render insulin available in diabetic patients (Saha et al., 2012). Studies on animals and on patients with type 2 diabetes indicate that the juice of *Cucurbita ficifolia* (also called Siam pumpkin) have a hypoglycemic effect. Pumpkins possess antioxidant capabilities (Dini et al., 2013; Chen and Huang, 2019) and can inhibit kidney stone formation (Batool et al., 2022). Pumpkin seeds are said to treat kidney stones (Agrawal and Shahani, 2021) probably due to their high phosphorus content. Their high zinc content (Kim et al., 2012) is essential for boosting immunity and improving bone density. Studies have reported that pumpkin can benefit the treatment of benign prostate hyperplasia, because of its high content of β -sitosterol (Tsai et al., 2006; Gossell-Williams et al., 2006). β-sitosterol is a phytosterol, which are integral components of plant cell membranes and are abundant in vegetable oils, nuts, seeds, and grains (Weihrauch and Gardner, 1978). Phytosterols can lower both total serum cholesterol and LDL-cholesterol in humans by inhibiting the absorption of dietary cholesterol (Piironen et al., 2000), and can prevent cancer (Raicht et al., 1980). Antioxidants play an important role in decreasing DNA damage, diminishing lipid peroxidation, maintaining immune functions and inhibiting the development of degenerative diseases such as cancer, diabetes, cardiovascular and neurological diseases (Roura et al., 2007; Gropper et al., 2005). Vitamin C is a strong water-soluble antioxidant that protects cells and cellular components from free radicals by donating electrons, and regenerating other antioxidants, such as vitamin E (tocopherols) (Keith, 2006). Vitamins C and E are essential for visual health (Lien and Hammond, 2011). Tocopherols and carotenoids have been suggested to be fat-soluble antioxidants.

Nutritional properties of pumpkins

Pumpkin is recognized as a functional food (Adams et al., 2011; Al Jahani and Cheikhousman, 2017). Functional foods are food products that provide additional health benefits beyond their normal nutritional contributions (Roberfroid, 2002). Functional foods (or healthy foods) have been defined as a new range of different foods containing biologically active ingredients such as phytochemicals, antioxidants, fatty acids and other compounds present in fruits, vegetables and seeds. When functional foods are included in diet, important benefits to consumer´s health are provided (Soto et al., 2006). Functional food products contribute to the prevention of chronic non-transmissible diseases related to nutrition (Murkovic et al., 1996a). Moreover, there is increased interest in the effects of nutrition on cognitive and immune functions, work capacity and physical performance (Roberto et al., 2019). Pumpkin is rich in vitamin C, vitamin E, lycopene and dietary fiber (Aruah et al., 2011). Pumpkin seeds are rich in protein, fibres, minerals, polyunsaturated fatty acids, phytosterols, antioxidant vitamins such as carotenoids and tocopherols and trace elements such as zinc (Ryan et al., 2007; Stevenson, et al., 2007; Applequist, et al., 2006; Glew, et al., 2006). The seeds' antioxidant activity is due to the presence of fat-soluble antioxidants (tocopherols and carotenoids) and a strong water-soluble antioxidant (vitamin C). Pumpkin fruit peels and flesh contain essential minerals as well as phytochemicals (β-carotene, total flavonoids, and total phenolics) that can help with anti-aging and the immune system (Hosen et al., 2021). The principal antioxidant

Table 1. Nutritional value of pumpkin fruit flesh/pulp.

C. maxima								*C. moschata*			*C. pepo*		
	(mg/100 g)	(g/kg raw weight)	(mg/100 g)					(mg/100 g)	(g/kg raw weight)	g/100g wet weight	(g/kg raw weight)	% raw weight	% dry weight
Protein		11.31 ± 0.95	10.447 - 10.623	7.25±1.43 (mg/g FW)	1.66±0.03 (%FW)	1.44+ 0.031 (% FW)		0.7(g/100g)	3.05 ± 0.65	0.60-1.35	2.08 ± 0.11	4.75	3.070 ± 0.10
Carbohydrates		133.53 ± 1.44	8.507-5.537			2.65+ 0.151 (% FW)		2.2(g/100g)	43.39 ± 0.84	3.59-5.68	26.23 ± 0.20	9.22	66.647 ± 0.10
Fat		4.20 ± 0.23	1.403-1.873		0.41±0.04 (%FW)	0.34+ 0.028 (%FW)		0.2(g/100g)	0.89 ± 0.11	0.14-0.15	0.55 ± 0.14	1.50	2.300 ± 0.10
Energy ((kcal/100g)			79.563-75.587					13					
Crude fiber		10.88 ± 0.35	1.553-3.447						7.41 ± 0.07	0.34-0.55	3.72 ± 0.02	3.65	11.463 ± 0.10
Vitamin C(mg/100g FW)	13.8 ± 0.23		12.500-39.500	15.00±0.02	20.98±0.34 (mg/100 g FW)	2.42+ .031(mg/100 gFW)		7.9 ± 0.17		2.30-29.70			
Vitamin E (α-Tocopherol)	1.74 ± 0.08	2.31 ± 0.03 (mg/kg raw weight)						0.64 ± 0.05	1.54 ± 0.99 (mg/kg raw weight)				
Total carotenoids		17.69± 12.20 (mg/kg raw weight)		7.47±0.10 (mg/100g FW)					5.70 ± 0.39 (mg/kg raw weight)				
β -carotene	1.67 ± 0.06	17.04 ± 12.18 (mg/kg raw weight)			0.77±0.03 (mg/100 g FW)	3.0+0.028 (mg/100 gFW)		0.58 ± 0.13	5.70 ± 0.39 (mg/kg raw weight)	18.00-1.6.0 (mg/100g dry wight)			
Total phenols	436.16± 2.89			0.47±0.01 (mg/g FW)	13.80±0.17 (mg GAE/100 g W)			453.72 ± 5.61					
Total flavonoid	8.23 ± 0.03							5.36 ± 0.07					
Source	Zhou et al., 2017	Kim et al.,2012	Amin et al., 2019a	Sharma and Ramana Rao, 2013	Zhao et al.,2015	Kulkarni and Joshi, 2013		Zhou et al.,2017; Holland et al., 1991	Kim et al., 2012	Al-Barbary et al., 2011	Kim et al.,2012	Hashash et al., 2017	Adebayo et al., 2013

compounds of pumpkin are carotenoids (Mbogne et al., 2015); the main carotenoids found in pumpkins are zeaxanthin, lutein, β-carotene and retinol equivalent. The major carotenoids important to humans are α-carotene, β-carotene, lycopene, lutein, zeaxanthin, and β -cryptoxanthin (Jaswir et al., 2014). Beta-carotene can be converted to β-cryptoxanthin and zeaxanthin through the hydroxylation process (Rodriguez-Amaya and Mieko, 2004). Natural antioxidants like carotenoids (Sharma and Rao, 2013; Shi et al., 2013), vitamin C (Biesiada et al., 1962), phenols (Nawirska-Olszanska et al., 2013) and some certain type of polysaccharides (Košťálová et al., 2013) found in the pumpkin have been proven to possess antioxidant activity which can provide protection against free radical damage and subsequently reduce the risk of developing degenerative chronic diseases (Adams et al., 2011; Song et al., 2013). The orange colour of pumpkin fruit flesh is due to the high content of β-carotene that is transformed into vitamin A in the human body after consumption (Palm, 1997); this makes pumpkin an excellent source of vitamin A. In addition to being a precursor of vitamin A, β-carotene also has an antioxidant effect that might improve on certain functions of the immune system (Krinsky and Johnson 2005). Lutein, α-carotene and β-carotene are the primary carotenoids present in pumpkin flesh (Jaswir et al., 2014; Kumar et al., 2018). Beta-carotene reduces skin damage from the sun and acts as an anti-inflammatory agent while α-carotene is thought to slow the aging process, reduce the risk of developing cataracts, and prevent tumor growth. Beta-carotene is one of the few carotenoids that have provitamin A activity; it has 100% provitamin A activity compared to α-carotene that has approximately 53% provitamin A activity (Sharma and Rao, 2013). Beta-carotene concentration is influenced by plant variety, sun exposure, temperature, water availability, and the chemical composition of the soil. Vitamin E (tocopherols) protects the cell from oxidative damage by preventing the oxidation of unsaturated fatty acids in cell membrane (Kim et al., 2012). Polyphenols are among major determinants of quality traits such as colour, aroma, bitterness and astringency of fresh fruits and fruit products such as jam, juices, jellies etc. Sharma and Rao (2013) found that the total phenols in *C. maxima* fruit decreased from 0.56mg/g fresh weight in a young immature fruit to 0.47±0.01 mg/g fresh weight when the fruit ripened. In the same study, they found that vitamin C increased from 4.30±0.31mg/100g fresh weight at young stage to 15.00±0.02mg/100g when the fruit ripened. The carotenoids also increased from 0.67±0.03mg/100g fresh weight in a young immature fruit to 7.47±0.10mg/100g fresh weight when the fruit ripened. This eleven-fold increase in carotenoid is responsible for development of fruit flesh colour from yellow at young immature stage to orange upon fruit ripening. Similar results for carotenogenesis during ripening were also reported in *C. moschata* 'Menina Verde' (Arima and Rodriguez-Amaya, 1988) and *C. moschata* 'Menina Brasileira' (Arima and Rodriguez-Amaya, 1990). Carotenoid biosynthesis increases during maturing or ripening of carotenogenic fruits and fruit vegetables (Gross, 1987). Lutein was found to be the predominant carotenoid in all the 11 cultivars of *C. maxima* (Kulczyński and Gramza-Michałowska, 2019) while Norshazila et al. (2014) observed that β-

Table 2. Chemical composition of pumpkin seeds.

	C. maxima						*C. moschata*			*C. pepo*				
	(mg/100 g)		(g/kg raw weight)	% dry weight	100g	100 g	(g/kg raw weight)	%	% wet weight	(g/kg raw weight)	% dry weight	% dry weight	% dry weight	% wet weight
Protein	21.313-20.677		274.85 ± 10.04	33.48	39.25 (g)	14.31(g)	298.11 ± 14.75	8.51 ± 0.44	30.27-31.10	308.83 ± 12.06	25.40 ± 0.61	37.1-44.4	27.48	39.50
Carbohydrates	5.183-14.540		129.08 ± 8.25	28.68	11.48(g)	24.45 (g)	140.19 ± 7.60	4.43 ± 017	02.01-06.57	122.20 ± 7.47	25.19 ± 3.3	9.9-21.9	28.03	10.93
Fat/Crude oil	23.447-17.893		524.34 ± 1.32	30.66	27.83(g)	52.13 (g)	456.76 ± 11.66	46.18 ± 0.83	33.68-36.43	439.88 ± 2.88	41.59 ± 2.71	34.4-43.6	38.00	33.46
Energy (kcal/100g)	311.54-227.64			524.58	453	628			445.72-467.3			546-598	564	
Fiber			161.54 ± 6.79	3.07	16.84(g)	2.55 (g)	108.51 ± 8.36	30.66 ± 0.25	15.42-19.71	148.42 ± 0.55	2.49 ± 0.11		1.00	1.59
Vitamin C	15.000-10.750													
Source	Amin et al., 2019a		Kim et al.,2012	Karaye et al., 2013	Alfawaz, 2004	Amoo et al.. 2004	Kim et al.,2012	Can-Cauich et al., 2021	Khalifa et al., 2012	Kim et al.,2012	Ardabili et al., 2011	Idouraine et al., 1996	Elinge et al., 2012	Hashash et al., 2017

Table 3. Composition of major fatty acid in pumpkin seed oils.

	C. maxima								*C. moschata*					*C.pepo*						
	% seed oil	% fat	% fat	% fat	mg/100 g	% seed oil	% fat	% seed oil	g/100 g oil	% seed oil	% fat	% fat	% fat	% fat	% fat	% seed oil	% seed oil	% fat	% seed oil	% seed oil
Palmitic acid	17.39	10.84 ± 0.12	15.97 ± 0.39	19.23	20.784 - 22.840	14.2 ± 0.4	10.48-12.51	12.20-18.79	21.51-22.25	17.39 ± 0.42	12.78 ± 0.11	20.88 - 21.03	13.47-19.08	12.97 ± 0.72	13.9–20.0	19.1 ± 0.8	12.8-15.8	9.65-10.88	10.68 ± 0.42	12.90 - 13.11
Stearic acid	27.06	5.84 ± 0.03	4.68 ± 0.56	6.39	4.519 - 6.600	5.8 ± 0.2	6.6-7.86	4.90-6.55	7.84-8.48	7.26 ± 0.23	7.33 ± 0.20	14.27 - 14.43	9.37-10.98	4.67 ± 0.15		7.4 ± 0.2	5.2-8.3	4.68-5.40	8.67 ± 0.27	6.97-7.32
Oleic acid	40.58	14.83 ± 0.05	44.11 ± 0.63	37.38	25.417-23.823	41.4 ± 0.7	21.49-24.94	11.70-27.35	23.28-25.59	17.03 ± 0.45	31.34 ± 0.12	15.92 - 16.41	31.22-37.45	32.40 ± 0.56	18.4–39.6	42.8 ± 0.5	46.6-60.4	35.55-37.42	38.42 ± 0.37	28.33 - 28.82
Linoleic acid	14.97	56.60 ± 0.29	34.77 ± 0.95	36.15	49.416-46.511	37.0 ± 0.5	49.06-52.13	52.59-63.87	40.22-43.56	57.40 ± 0.67	35.72 ± 0.25	39.75 - 40.73	37.63-39.09	36.40 ± 0.82	42.1–48.5	30.4 ± 0.3	9.6-27.9	40.22-45.05	39.84 ± 0.08	49.51 - 50.22
Linolenic acid		0.24 ± 0.01	Trace	Not detected	2.248-0.359	0.2 ± 0.0	3.99-5.83			0.25 ± 0.04	Not detected		0.03-0.14	Not detected	0.23—1.0		0.12-0.79	2.88-5.22	0.68 ± 0.14	0.13-0.15
SFA		17.4	21.0	26.47	27.1-	21.1	20.46-	18.24-	31.48-	25.24 ±	20.11 ±		25.89-	18.62 ±	15.2-	26.5		16.48-	19.35 ±	

		7 ± 0.13	7 ± 1.19		32.528		22.33	27.36	32.78	0.72	0.11		29.03	0.64	22.4			18.16	0.16	
MUFA		14.90 ± 0.04	44.12 ± 0.57	37.38	25.417-23.823	41.7	21.55-25.02	11.8-27.61	23.03-25.15	17.11 ± 0.46	31.34 ± 0.12		31.40-37.67	32.40 ± 1.66	77.1-83.8	43.1		35.59-37.49	80.65 ± 0.16	78.79 - 79.03
PUFA		56.84 ± 0.29	34.78 ± 0.85	36.15	51.66 - 46.87	37.2	54.46-56.96	52.74-64.53	40.22-43.56	57.65 ± 0.71	35.72 ± 0.25		37.66-39.24	36.40 ± 0.82		30.4		44.35-47.93		
Peroxide value (meq of O_2/kg oil)			2.33 ± 0.65									6.37-8.23				1.5 ± 0.0			10.85 ± 0.62	
Acid value (mg KOH/g of oil)			7.54 ± 0.02									0.57-0.64			11.2 ± 2.2 to 28.7 ± 3.9	1.6 ± 0.0			0.78 ± 0.02	
Source	Habib et al., 2015	Kim et al., 2012	Rezig et al., 2012	Sharmin et al., 2022	Amin et al., 2019a	Montesano et al., 2018	Srbinoska et al., 2012	Koltsov and Danilin, 2021	Can-Cauich et al., 2021	Boujemaa et al., 2020	Kim et al., 2012	Ali et al., 2022	Prommaban et al., 2021	Kim et al., 2012	Benalia et al., 2015	Nyam et al., 2009	Idourain e et al., 1996	Srbinoska et al., 2012	Ardabili et al., 2011	Huda et al., 2023

Table 4. Tocopherol content of pumpkin seed oils.

	C. maxima								*C. moschata*			*C. pepo*					
	mg/kg oil extract	mg/kg raw weight	mg/100 g	mg/kg oil extract	μg/g oil	mg/kg of oil	mg/kg of oil	mg/kg	mg/kg of oil	mg/kg raw weight	mg/kg of oil	mg/kg raw weight	mg/kg of oil	mg/kg of oil	mg/100 g of oil	mg/kg oil extract
α-Tocopherol	47.2	20.79 ± 1.33	128 ± 14.42	35.73-38.04	27.1-75.1	22.02 ± 1.82	15.840 ± 0.661	54.0	8.357 ± 0.106	25.74 ± 0.73	18.96 ± 0.51	21.33 ± 3.65	0-31.9	8.49 ± 0.34	15.19 ± 1.84	27.91-38.59
γ - Tocopherol	119.7	28.70 ± 2.13	113.66 ± 1.52	81.82-83.20	74.9-492.8	626.67 ± 47.45	1417.797 ± 0.783	112.0	265.513 ± 0.427	66.85 ± 4.90	476.86 ± 29.14	61.65 ± 17.66b		334.54 ± 13.56	61.32 ± 1.17	89.90-115.20
δ-Tocopherol	195.0		177 ± 14.17		35.3-1109.7	19.98 ± 0.45		544.0			11.06 ± 0.29		39.0-130	7.02 ± 1.14	4.14 ± 0.33	
(β+γ)-Tocopherol													39.3-155.1			
Total Tocopherol	361.9		418.66 ± 33.36	117.55-121.24			1433.637 ± 0.604	640.0	273.870 ± 0.374				104.7-221.2			
Source	Sharmin et al., 2022	Kim et al., 2012	Rezig et al., 2012	Srbinoska et al., 2012	Roberto et al., 2019	Boujemaa et al., 2020	Al-Turky et al., 2024.	Amin et al., 2019b	Al-Turky et al., 2024	Kim et al., 2012	Boujemaa et al., 2020	Kim et al., 2012	Benalia et al., 2015	Boujemaa et al., 2020	Nyam et al., 2009	Srbinoska et al., 2012

carotene was the predominant carotenoid in cultivars of *C. moschata.* The different proportions of lutein and beta-carotene may be influenced mainly by variety, the growing conditions, the maturation period, and the storage time of the pumpkin. It seems that during the growth and maturation of the plant, as well as the storage of fruit, the conversion of individual carotenoids may proceed at different rates (Kulczyński and Gramza-Michałowska, 2019). Jaswir et al. (2014) showed that long-term storage of pumpkins resulted in the accumulation of lutein and β -carotene with a slight decrease in zeaxanthin. The biosynthesis and metabolism of carotenoids in vegetables can significantly be affected by the differences in growing environment such as temperature, nutrient availability, water availability, soil composition, intensity of sunlight, ripening stage, post harvesting (Rodriguez-Amaya, 1999). It has been documented that different species and/or varieties of *Cucurbita spp.* grown in different areas of the world have differences in their phytochemical contents (Younis et al., 2000). Karanja et al. (2014) found that β-carotene content in fresh pumpkin pulp from *Curcubita* ssp. collected from Eastern and Central Kenya ranged from 14.7 to 35.09µg/g.

Pumpkin flesh/pulp

Pumpkin fruit flesh is rich in carbohydrates, proteins, macro- and micronutrients and energy such that no other single food has such high nutritional potential (Kiharason et al., 2017; Habib et al., 2015). The amount of carbohydrates can vary depending on the variety of the pumpkin, its origin, maturity, as well as the soil and climate conditions during growth (Hagos et al., 2023). *Curcubita maxima* has been found to have significantly more carbohydrates, proteins and fats in the fruit flesh and peel than *C. pepo* and *C. moschata* (Mbogne et al., 2015; Kim et al., 2012; Table 1). This high carbohydrate concentration may contribute to the sweet taste of *C. maxima.* Due to its sweet taste, *C. maxima* is called 'Danhobak' in Korean language; 'Dan' meaning sweet and 'hobak' meaning pumpkin (Kim et al., 2012). Pumpkin fruit flesh is low in calories (PROTA, 2018) and fat (Kim et al., 2012) but rich in vitamin A, C, E, lycopene, potassium, and proteins (González et al., 2001). Nutritionally, pumpkin fruits can be compared to tomatoes; tomato fruits are rich in β-carotene (1.64mg/100g) and vitamin C (27.04mg/100g) (Dar and Sharma, 2011) while pumpkin is also a good source of β-carotene (0.72-2.48mg/100g) (Aruah et al., 2011) and vitamin C (22.9mg/100g) (González et al., 2001). Carotene content of some Spanish pumpkin varieties was found to be higher than that of carrots (Teotia, 1992). Pumpkins are rich in potassium, calcium, iron, magnesium, phosphorus, manganese, copper, and zinc (Kulczyński and Gramza-Michałowska, 2019); potassium is the most abundant mineral in pumpkin (USDA, 2015). Karanja et al. (2014) found that the most abundant mineral in pumpkin pulp was potassium; they obtained values ranging from 166 to 191.8mg/100g on dry weight basis. Kulczyński and Gramza-Michałowska (2019) found potassium in *C. maxima* pulp to range from 4692.70 to 9965.70mg/100g dry matter. Pumpkin fruit flesh and seeds have been found to be rich in proteins, antioxidant such as carotenoids and tocopherols (Stevenson et al., 2007), and minerals (Kim et al., 2012). Pumpkin fruit flesh is rich in vitamin E (α- tocopherol and γ-tocopherol) (Kulczyński and Gramza-Michałowska, 2019; Seleim et al., 2015). The content of α-tocopherol in pumpkin pulp was found to be significantly greater than in the peel (Kulczyński and Gramza-Michałowska, 2019); Kim et al. (2012) found the opposite to be the case. The contents of α- tocopherol and γ-tocopherol in *C maxima* were found to be the highest in the seeds (20.79) and (28.70mg/kg raw weight) respectively, compared to the fruit flesh and peel (Kim et al., 2012).

Pumpkin seeds

Pumpkin seeds, being the storage parts of the plant, have higher nutrient contents than the fruit flesh (Raihana et al., 2015; Mansour et al., 1993; Dhiman et al., 2009; Kim et al., 2012; Quintana et al., 2018).The main nutritionally relevant components of pumpkin seed are proteins (30–51%) and oil (up to 40%). The seeds are also rich in carbohydrates (up to 10%) and microelements between 4 and 5% (Srbinoska et al., 2012). They are also rich in triterpenes, lignans, phytosterols, polyunsaturated fatty acids, antioxidative phenolic compounds, carotenoids, tocopherol, and minerals (Fu et al., 2006). The protein is nutritionally balanced; pumpkin contains all the 9 essential amino acids and is rich in glutamic acid and arginine (Alfawaz et al., 2004; Younis et al., 2000; Kim et al., 2012; Glew et al., 2006); the contents of amino acids were found to be much higher in the seeds than the fruit pulp and peel (Kim et al., 2012; Amin et al., 2019a; Mohammed et al., 2014). Moreover, species belonging to the *Cucurbitaceae* family have an unusual amino acid known as cucurbitin, which is responsible for the anti-inflammatory and antiparasitic functional properties of the pumpkin (Salama et al., 2006). Amin et al. (2019a) found that the protein content in seeds of indigenous and hybrid varieties of *C. maxima* were 21.313±0.50 and 20.677±0.61mg/100g, respectively. These figures were higher than in the fruit flesh and peel. The fiber content in the seeds were 46.647±0.84 and 52.377±0.61mg/100g, while the energy was 311.54±0.56 and 227.64±0.75kcal/100g, for the indigenous and hybrid varieties respectively. These figures were also higher than in the pulp and peel. Kim et al. (2012) found that the protein content in *C. maxima* seeds was 274.85±10.04g/kg raw weight while the fat and fiber were 524.34±1.32 and 161.54±6.79g/kg raw weight, respectively. These figures were higher than the contents in the pulp and peel. They also found out the the carbohydrates, protein and fat contents in the pulp and peel of *C. maxima* were higher than in the corresponding parts in *C. pepo* and *C. moschata* while the contents in the seeds of the three species were similar. Pumpkin seeds are rich in phytosterols (e.g. β-sitosterol) (Phillips et al., 2005; Ryan et al., 2007). Gossell et al. (2006) and Tsai et al. (2006) stated that pumpkin oil have high content of β- sitosterol which is beneficial for the treatment of benign prostate hyperplasia. Sitosterol was found to be the major sterol in the *C. maxima* seed oil (Rezig et al., 2012). Because of these beneficial effects on human health, pumpkin seeds can be considered as a natural functional food (Roberto et al., 2019). Kim et al. (2012) found that *C. pepo* seeds had significantly more β-sitosterol (383.89±48.15mg/kg raw weight) than *C. moschata* and *C. maxima* which contained 277.58±23.48 and 235.16±1.44mg/kg raw weight, respectively. Differences in the chemical composition of pumpkin seed among *Cucurbita* species and cultivars from different parts of the world might be affected by soil conditions, climate, genetic factors, fertilization conditions, and the harvest time (Younis et al., 2000).

The seed oil

Pumpkin seeds are rich in oils; the oil content depends on the seed variety, maturity, seed weight, length etc. (Türkmen et al., 2017). Pumpkin seed oil content is comparable to cotton seed (15–24%), safflower (30-35%), soybean (17–21%), rapeseed (40-48%) and olive (12- 50%) (Lisa et al., 2018; Nichols and Sanderson, 2003). Pumpkin seeds contain about 38 to 60% oil (Lazos, 1986; Markovic and Bastic, 1976) that mostly contain oleic and linoleic fatty acids (Tsaknis et al., 1997; Table 3). Oil contents in *C. maxima* seeds were found to be 30.03% (Sharmin et al., 2022), 48.6% (Tsaknis et al., 1997), 31.6–38.6% and 10.9–30.9% (Stevenson et al., 2007) and 43.4-58.7% (Koltsov and Danilin, 2021). Studies have shown that the fatty acids content in *C. maxima* seeds is up to 50% of total weight of the seed with predominance of unsaturated-short chain fatty acids (Amoo et al., 2004). Pumpkin seed oil mainly contain triglycerides with palmitic, stearic, oleic, and linoleic acid as the dominant fatty acids (Khalifa et al., 2012; Srbinoska et al., 2012, Kim et al., 2012). Stevenson et al. (2007) evaluated the seed oil content and fatty acid composition of twelve cultivars of *C. maxima* grown in Iowa and found that the oil yield and total unsaturated fatty acid contents ranged between 10.9-30.9% and 73.1-80.5%, respectively. They also found that the predominant fatty acids were linoleic, oleic, palmitic, and stearic acid. Ardabili et al. (2011) found that four major fatty acids, namely, linoleic, oleic, palmitic, and stearic were predominant in *C. pepo* seed oil and they constituted more than 97% of the total amount of fatty acids. Bardaa et al. (2016) found that the main fatty acids in *C. pepo* seed oil were palmitic acid (14.828), oleic acid (25.817) and linoleic acid (50.88); the three accounted for about 90% of the total fatty acids. Younis et al. (2000) found the fatty acid composition of the Eritrean *C. pepo* seed oil were 8.0% stearic, 13.3% palmitic, 29.0% oleic, and 47.0% linoleic acid. Can-Cauich et al. (2021) found the oil yield of *C. moschata* seeds to range from 32.37 to 46.18% depending on the extraction method. Quintana et al. (2018) found the oil content of *C. moschata* seeds to be 52.6% compared to the pulp which had 0.77%. Ali et al. (2022) found the seed oil yield of different genotypes of *C. moschata* to range from 31.7 to 36.9%. Al-Khalifa (1996) found that the fatty acids in lipid extract of Egyptian *C. moschata* seeds were 6.3% palmitic, 13.1% stearic, 26.2% oleic, and 53.2% linoleic acid. Khalifa et al. (2012) found that the protein and oil contents in *C. moschata* seeds ranged from 30 to 31% and 33 to 36% (on wet weight basis), respectively. The major lipid components were the triglycerides which constituted about 69.09 to 80.31% of the total lipids. In addition, the total unsaturated fatty acids in the seed oils ranged from 70 to 73% of the total fatty acid composition of the oil and consisted mainly of oleic and linoleic acids, while the total saturated fatty acids ranged from 26.66 to 27.96% and consisted mainly of palmitic acid (16.02 to 17.17%) followed by stearic acid (8.97 to 10.50% of total fatty acids). Furthermore, they found that oleic acid was the predominant fatty acid in seed oils and ranged from 38.00 to 46.04% of the total fatty acids. Predominance of oleic fatty acid in pumpkin seed oils was also found by Sabudak (2007) and Nyam et al. (2009). Other studies indicated that linoleic acid was the major fatty acid in the pumpkin seed oils followed by oleic (Stevenson et al., 2007; Szterk et al., 2010; Kim et al., 2012). Alfawaz et al. (2004) determined 18.14% oleic acid, 53% linoleic acid and 1.27% linolenic acid in *C. maxima* seed oil. The seed oil of *C maxima* were found to contain 56.60 linoleic, 14.83 oleic, 10.84 palmitic and 5.84% stearic acid (Kim et al., 2012). Amin et al. (2019a) found *C. maxima* seed oil to contain 49.416 linoleic, 25.417 oleic, 20.784 palmitic and 4.519 stearic acid (mg/100g) fatty acids concentrations. Hegazy and El Kinawy (2011) found that the fatty acids in *C. maxima* seed oil were mainly unsaturated fatty acids (linoleic acid, 42.05%) and (oleic acid, 33.16%) with lower levels of saturated fatty acids (palmitic acid, 15.52%) and (stearic acid, 9.27%). In other studies, *C. pepo* seed oil was found to contain more linoleic acid (43.1-55.6%) than oleic acid (20.4-37.8%) (Lazos, 1986; Al-Adawy and Taha, 2001). Huda et al. (2023) found the linoleic acid in *C. pepo* seed oil to range from 49.51 to 50.22%, oleic acid to range from 28.33 to 28.82 while total unsaturated fatty acids ranged from 78.79 to 79.03%. Benalia et al. (2015) reported that the dominant fatty acids in *C. pepo* seed oils were palmitic (13.9–20.0%), oleic (18.4–39.6%) and linoleic (42.1–48.5%)(Table 3). The content of these three ranged from 78.1 to 97.6% of the total fatty acid composition of the oil. In addition, they found that the total saturated fatty acids (SFA) ranged from 15.2 to 22.4%, total unsaturated fatty acids (UFA) ranged from 77.1 to 83.8% while UFA/SFA ratio ranged from 3.4 to 5.5. Unsaturated fatty acids having one or more double bonds on the carbon chain are considered healthier than saturated fatty acids (no double bond)(Dunford, 2020). The high content of linoleic acid is an important nutritional aspect because it is an essential fatty acid (EFA), together with linolenic acid, and a lack of either of the two leads to ill health and causes deficiency symptoms (Amin et al., 2019a). The term essential fatty acids (EFA) refers to those omega-3 and omega-6 polyunsaturated fatty acids (PUFA) that must be provided by foods because they cannot be synthesized in the body yet are necessary for health (Kaur et al., 2014). Studies have positively correlated EFA intake with the reduction of numerous disorders (cardiovascular, neurological, visual, and cancerous) (Kaur et al., 2014). Kim et al. (2012) reported that PUFA dominated in the *C. maxima* seed oils at 56.84±0.29% fat while the monounsaturated fatty acids (MUFA) were the least at 14.90±0.04% fat. Differences in the fatty acid composition in pumpkin seed oils may be due to several factors including variety, growing area, climate and state of ripeness (Murkovic et al., 1999; Rombaut et al., 2009). When the temperature is lower during the last weeks of seed filling, there will be a shift in content from oleic to linoleic acid. Linoleic acid content is always higher in localities where lower average temperature prevails (Younis et al., 2000; Murkovic et al., 1996a). Younis et al. (2000) reported that in the *C. pepo* extracts, content of oleic and palmitic acid decreased as the average growing temperature decreased. Also, it is confirmed that increased linoleic acid content is followed by decreased oleic acid content (Younis et al., 2000; Murkovic et al., 1996a).

Fatty acid composition of the pumpkin seed oils can be used to evaluate its stability and nutritional quality. Although unsaturated fatty acids are good for health, their oxidative and thermal stability is lower than that of the saturated fatty acids. Stability of fatty acids decreases as the number of double bonds on the molecule increases. For example, the ratios of the rates of oxidation of oleic acid (one double bond): linoleic acid (two double bonds): linolenic acid (three double bonds) have been reported as 1:10:20, meaning that linoleic and linolenic acids oxidize 10 and 20 times faster than the oleic acid, respectively (Dunford, 2020). According to Choe and Min (2006) the rate of linoleic acid oxidation is 10 – 40 times higher than that of oleic and the rate of linolenic oxidation is 2-4 times faster than that of linoleic. It has been reported that linoleic acid oxidizes ~ 50 times faster than oleic acid (Brinkmann, 2000). The oxidative stability of pumpkin seed oil is influenced primarily by the ratio of linolenic to oleic acid (Srbinoska et al., 2012). In addition, the high amount of linoleic acid makes pumpkin seed oil prone to oxidation (Rezig et al., 2012). A high degree of unsaturation makes the oil to oxidize easily when used for deep-fat frying. During oil oxidation and degradation, off-flavours and harmful chemical compounds are formed; hence, an oxidized oil with highly unsaturated fatty acid content can be more harmful to human health than a good quality saturated fat or oil (Dunford, 2020). Therefore, edible oil industry has focused attention on high oleic acid vegetable oils such as high oleic corn, sunflower and canola which have been found to have enough oxidative stability to be used in demanding applications such as frying (Petukhov et al., 1999; Warner and Knowlton, 1997). On the other hand, a reduction in saturated and a moderate increase in monounsaturated and n-3 and n-6 polyunsaturated fatty acids enhances nutritional quality of the oil by preventing coronary heart disease and other diseases in humans (Benalia et al., 2015). Although, linolenic acid is an omega-3 fatty acid with positive health effects, it easily oxidizes and it is undesirable in edible oils because of the off-flavors and potentially harmful oxidation products formed (Achu et al., 2006). Warner and Gupta (2003) showed that decrease in linolenic acid from 2 to 0.8% in oils improved flavour and oxidative stability of fried food. This shows that for oil to be good for frying, its linolenic acid level should be less than 1%, as in pumpkin seed oils and therefore, pumpkin seed oils can be used as frying oils. Thus, pumpkin seed oils with very low linolenic acid content provide high oxidative stability, making it suitable for industrial application and giving it a long shelf life (Stevenson et al., 2007; Table 3). High degree of unsaturation makes pumpkin seed oil suitable for the use as valuable drying agent (Habib et al., 2015). Pumpkin seed oil is a rich source of linoleic acid; the unsaturated nature of this oil qualifies it to be promising edible oil. The high level of linoleic and oleic acids confirm that the oil is liquid and not solid oil; hence, it cannot easily solidify at ordinary temperature. The presence of high amounts of the essential linoleic acid suggests that the pumpkin seed oil is highly nutritious; hence, consumption of this oil can prevent the risk of heart problems. As the pumpkin seed oil is rich in both oleic and linoleic acids, it may be used as edible cooking and salad oils or for margarine manufacture (Benalia et al., 2015; Nyam et al., 2009). The high percentage of oleic acid in the oil makes it desirable in terms of nutrition and high stability cooking and frying oil (Nyam et al., 2009). As a measure of nutritional value, the ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids (SFA) in *C. maxima* seed extracts varied from 2.51 to 2.78, depending on the extraction solvent used (Srbinoska et al., 2012); Murkovic et al. (1996a) reported 2.81 PUFA/SFA ratio in seed extracts of *C pepo*. Benalia et al. (2015) found the ratio of total unsaturated fatty acids/total saturated fatty acids in *C. pepo* seed oils to range from 3.4 to 5.5. Srbinoska et al. (2012) found the ratio of linoleic/oleic acid to range from 1.97 to 2.43 in *C. maxima* seed oil depending on the extraction solvent used. In the same study, they found the ratio to range from 1.09 to 1.27 in *C. pepo* seed oil extracts. Consequently, pumpkin seed oils have a high stability to oxidative rancidity process which is also coincident with a low peroxide value (Amoo et al., 2004). The peroxide value of oil is a measure of primary oxidation; it is the most important indicator of oxidation level in oil (Bardaa et al., 2016). Oxidation of oil is often related to the deterioration of lipids leading to the development of rancidity, and formation of compounds that cause undesirable flavours, polymerisation, and other types of reactions that reduce the shelf life and nutritional value of the oil (Can-Cauich et al., 2021). Peroxide value measures the quantity of peroxides in the oil; these are intermediates of oxidative reactions that decompose via transition metal irradiation or at elevated temperatures to form free radicals (Can-Cauich et al., 2021). High peroxide values suggest that the oil has begun to degrade (Rezig et al., 2012); it has been shown that oils become rancid when the peroxide value ranges from 20.0 to 40.0meqO_2/kg oil (Ajayi et al., 2006). The maximum peroxide value for the category of extra-virgin olive oil (EVOO) is 20meqO_2/kg oil (Bardaa et al., 2016). The Codex Alimentarius Commission (1982) stipulated permitted maximum peroxide levels of 10meq peroxide/kg oil for soybean, cottonseed, rapeseed and coconut oils. Peroxide value is used as an indicator of oil deterioration while acid value is used as an indicator of oil edibility (Roberto et al., 2019). Acid value of a fat or oil is the number of milligrams of potassium hydroxide required to neutralize 1g of the fat or oil. It is measures the number of free fatty acid presents it (Sayeed et al., 2004). The Codex Alimentarius Commission expressed the permitted maximum acid values of 10 and 4mgKOH/g oil for virgin palm and coconut oils, respectively (Alfawaz, 2004). The maximum acid index of edible oils is 15mgKOH/g of oil (Krishnamurthy, 1982). A high acid value may indicate a higher tendency to become rancid while a lower free fatty acid (FFA) content indicates suitability of the oil for edible purposes (Habib et al., 2015). The free fatty acid given as Acid value/1.99 is an indication of the shelf life and edibility value of the oil. It is an inversely proportional relationship; the lower the FFA value, the better the quality of the oil (Boujemaa et al., 2020). A high percentage of free fatty acid (above 1.15%) indicates that the oil is not suitable for edible purposes (Habib et al., 2015). Boujemaa et al. (2020) found the percent FFA for C. *maxima, C. moschata* and *C. pepo* fresh seed oils were 0.57±0.05, 0.65±0.05 and 0.86±0.05%, respectively. In other studies, percent FFA ranged from 2.75 to 4.93% for *C. pepo* (Hernández-Santos et al., 2016) and 1.0% for *C. moschata* (Al-Khalifa, 1996). Habib et al. (2015) reported acid value of 0.516mgKOH/g of oil and low FFA value of 0.26% for *C. maxima* seed oil. Bardaa et al. (2016) found the peroxide value of *C. pepo* oil to be 8.66±0.21 meqO_2/kg while the acid value was 1.4±0.01. Khalifa et al. (2012) found the acid value of *C. moschata* seed oil to range from 0.59 to 0.99mgKOH/g oil while peroxide value ranged from 2.99 to 3.09meq/kg. The low peroxide value was indicative of a high oxidative stability for pumpkin seed oils. Consequently, pumpkin seed oil has great potential in fats and oils industry not only as edible oil but also as a potential nutraceutical (Rezig et al., 2012). The

Table 5. Macro- and micronutrients in pumpkin seeds.

	C. moschata		*C. maxima*				*C. pepo*		
	(mg/100 g) dry weight		(mg/100 g) dry weight				(mg/100 g) dry weight	(µg/g)	mg/100g dry weight
Potassium (mg/100 g) dry weight	125.09 ± 2.03	80-90	886.56	753.11	35.87	434.71-557.65	223.57	20692-28384	237.24
Phosphorus (mg/100 g)		240-360	824.53	1036.82	224.14	0.740-0.68	33.65		47.68
Magnesium (mg/100 g)		260-300	146.13	364.43	34.87	4.340-3.693	60.45	7352-8561	67.41
Calcium (mg/100 g)	50.83 ± 3.81	210-240	271.89	139.70	29.47	4.0- 3.757	6.65	243-2788	9.78
Zinc (mg/100 g)	5.01 ± 2.04	7.34-9.14	25.19	1.09	3.98	18.777-16.433	0.85	197-266	14.14
Sodium (mg/100 g)	4.41 ± 0.01	40-70	356.75	68.58	29.69	1.350-0.98	155.06		170.35
Iron (mg/100 g)	6.52 ± 0.16	10.13-18.93	15.37	13.66	4.27	6.017-5.507	12.39	164-231	3.75
Source	Can-Cauich et al., 2021	Khalifa et al., 2012	Rezig et al., 2012	Alfawaz, 2004	Amoo et al., 2004	Amin et al., 2019a	Hashash et al., 2017	Idouraine et al., 1996	Elinge et al., 2012

quality of oil and its oxidative stability are important for the desired uses by the consumers. The yield, quality, and oxidative stability of oil can be affected by variety, climate, soil, growing conditions as well as by the extraction method, among others (Can-Cauich et al., 2021; Nyam et al., 2009). Extraction techniques affect the oil stability and antioxidant activities (Rezig et al., 2018). A recent study showed that pumpkin seed oil extracted through mechanical pressuring had lower peroxide value compared to oils extracted by organic solvent (Can-Cauich et al., 2021). The use of high temperatures during the extraction of vegetable oils promotes the formation of primary oxidation products (peroxides and hydroperoxides) and secondary oxidation products (aldehydes and carbonyls, among others); this might explain why mechanical pressing extraction at 45^{0}C resulted in less oxidation (more stability) compared with organic solvent extraction at 76^{0}C (Can-Cauich et al., 2021). Rezig et al. (2018) compared two different extraction methods, namely solvent extraction and cold (mechanical) pressing. They found that pumpkin seed oil extracted by mechanical extraction exhibited the best stability and highest tocopherol levels. In addition, it had the highest values of total carotenoids, total phenolic compounds (TPC), β-carotene, quercetin, squalene, fecosterol, stigmasterol and antioxidant activities. Antioxidant compounds such as phenolic compounds, tocopherols, phytosterols, and carotenoids increases the oxidative stability of edible oils due to their antioxidant properties (Rezig et al., 2012; Nour et al., 2018). Consequently, refining processes that reduce the contents of antioxidant compounds may render the oil more susceptible to oxidative deterioration (Redondo-Cuevas et al., 2018).

Anti-oxidant properties

Pumpkin seed oil has strong antioxidant properties and has several health benefits such as prevention of the growth and reduction of the size of prostate, retardation of the progression of hypertension, mitigation of hypercholesterolemia and arthritis, reduction of bladder and urethral pressure and improving bladder compliance, alleviation of diabetes by promoting hypoglycemic activity, and lowering levels of gastric, breast, lung, and colorectal cancer (Fu et al., 2006; Stevenson et al., 2007; Nishimura et al., 2014). The antioxidant potential of seed oils can be attributed to PUFA, tocopherols, total phenolic compounds, phytosterols, and carotenoids (Latif and Anwar, 2011; Zhang et al., 2010; Redondo-Cuevas et al., 2018). Pumpkin seed oil is a significant source of vitamin E (tocopherol) (Stevenson et al., 2007). Tocopherols, collectively known as vitamin E, are classified into α-, β-, γ-, and δ-isomers according to the number and position of methylsubstituents on the phenolic ring moiety (Galli et al., 2017). Tocopherols are natural lipophilic antioxidants mainly found in vegetable oils (Rezig et al., 2012). Tocopherol homologues are phenolic antioxidants that occur naturally in vegetable oils and provide some protection against oxidation by terminating free radicals (Ardabili et al., 2011). The main sources of tocopherols are almond oil and other nut oils, olive oil, sunflower oil, rapeseed oil, corn oil, linseed oil, and soybean oil (Szewczyk et al., 2021). Tocopherols in seed oil are extremely important due to their role in the protection against oxidative deterioration of polyunsaturated fatty acids in plant material; due to their capacity to reduce damage from free radicals, tocopherols play a putative role in prevention of Alzheimer's disease and cancer (Tucker and Townsend, 2005). Diets high in pumpkin seeds have been associated with lower risks of gastric, breast, lung, and colorectal cancers (Huang et al., 2004; Lowe and Ku, 1996). Most diets supply tocopherols, especially α-tocopherol and γ-tocopherol due to their relatively high concentration in food products (Szewczyk et al., 2021). In *C. maxima* and *C. pepo* seed oil, α-and γ-tocopherol were present in higher concentration than β- and δ-tocopherol (Srbinoska et al., 2012; Nyam et al., 2009). Boujemaa et al. (2020) found γ–tocopherol to be the most abundant in *C. maxima, C. moschata* and *C. pepo* seed oils (Table 4); γ-tocopherol ranged from 334.54 to 626.67mg/kg of oil while α and δ-tocopherol ranged from 8.49 to 22.02mg/kg and from 7.02 to 19.98mg/kg, respectively, across all the three *Curcubita* species. In addition, γ–tocopherol in *C. maxima* seed oil was 1.2 and 1.8 times higher than those of *C. moschata* and *C. pepo*, respectively. Kim et al. (2012) found only α- and γ-tocopherols in *C. pepo, C. maxima* and *C. moschata* peels, flesh and seed; similarly, Kulczyński and Gramza-Michałowska (2019) found that cultivars of *C. maxima* contained only α- and γ-tocopherols in the fruit pulp. However, Rezig et al. (2012) found δ-tocopherol to be the main component and represented about 42.27% of total tocopherols in *C. maxima* seed oil, followed by α -tocopherol and then γ-tocopherol (Table 4). Similarly, Amin et al. (2019b) found δ-tocopherol to be predominant in *C. maxima* seed oil at 544mg/kg, followed by γ-and α–tocopherol at 112.0 and 54.0mg/kg, respectively. Ryan et al. (2007) found that pumpkin seeds contain more α-tocopherol (0.9mg/100g) than butter beans (0.7mg/100g), spelt (0.6mg/100g), buckwheat (0.1mg/100g), maize (0.2mg/100g), millet (0.2mg/100g), linseed (0.1mg/100g), mustard (0.6mg/100g), and poppy (0.2mg/100g). In addition they found that pumpkin seeds contained the largest amounts of β+γ-tocopherol (14.8mg/100g). It has been reported that γ- and δ-forms possess a much higher antioxidant activity than α- and β-forms; however, α-tocopherol is considered to have a higher vitamin potency than any other tocopherol isomer (Murkovic and Pfannhauser, 2000; Tsaknis et al., 1997). It is the main form of vitamin E with the highest tissue concentration; only α-tocopherol is retained at high levels in plasma and tissues. Plasma and body tissues are 90% saturated with α-tocopherol while other forms of vitamin E are degraded and excreted (Lee and Ulatowski, 2019). Consequently, only α-tocopherol is recognized as a nutrient (vitamin) that is able to meet vitamin E requirements in humans (Szewczyk et al., 2021). The α- and γ-tocopherol have the highest concentration in food products (Szewczyk et al., 2021); α-tocopherol is the most abundant isoform representing 90–95% of tocopherol content in extra virgin olive oil (EVOO) (Beltrán et al., 2010). Alpha tocopherol is recommended for human and animal consumption because it has a higher biological activity than other tocopherols (Szewczyk et al., 2021); natural α-tocopherol is the most biologically active isomer; biological activity of the other isomers is expressed as the α-tocopherol equivalent (%), which is 50% for β-, 10% for γ- and 3% for δ-tocopherol (Szewczyk et al., 2021). However, γ-tocopherol shows a higher antioxidant capacity compared to α-tocopherol (Fatnassi et al., 2009). The γ-tocopherol has much higher antioxidant properties and therefore could be important in controlling or preventing pre-diabetes or vascular injury (Yadav et al., 2010; Lampi et al., 1999). Stevenson et al. (2007) found that the total tocopherol contents in *C. maxima* cultivars varied from 589 to 1234μg/g. Khalifa et al. (2012) found that the tocopherol content of seed oils of *C. moschata* ranged from 67 to 158mg/100g of oil. Srbinoska et al. (2012) found slightly higher content of tocopherols in *C. pepo* whole seed extract (153.79mg/kg extract) compared to *C. maxima* (121.24mg/kg extract). Indrianingsih et al. (2019) found that the antioxidant activity of *C. moschata* seeds is higher than that of *C. maxima* seeds. In addition, the contents of fat and protein in *C. moschata* seeds were also higher (28.49 and 19.23%) than that in *C. maxima* seeds, which were 10.42% and 12.33%, respectively. Benalia et al. (2015) found that *C pepo* seed oils had a relatively high level of total tocopherols (104.7–221.2mg/kg of oil) (Table 4), which would be expected to contribute to good oxidative stability of the oil during storage and processing. This content was higher than those of olive (114mg/kg oil), Babassu (60–130mg/kg oil) and coco (less than 50mg/kg oil) (Kamal-Eldin and Andersson, 1997) but lower than of other oleaginous seeds such as cotton (380–1200mg/kg oil) and maize (330–3720mg/kg oil) (Benalia et al., 2015). Al-Turky et al. (2024) found that *C. maxima* seeds oil was rich in tocopherols (1433.637mg/kg oil) compared to *C. moschata* which had 273.870mg/kg oil. Gliszczyńska-Świgło et al. (2007) found the total tocopherol contents of grapeseed oil (121mg/kg), olive oil (177mg/kg), and peanut oil (226mg/kg) to be lower than some conventional edible oils like soybean oil (829mg/kg), maize (829mg/kg), sunflower oil (609mg/kg) and rapeseed oil (468mg/kg). High levels of δ- tocopherol in the oils may contribute to the greater stability towards oxidation (Benalia et al., 2015). It has been found that the high tocopherols contents in *C. maxima* seed oil is the reason for high oxidative stability (Stevenson et al., 2007; Rezig et al., 2012) and makes *C. maxima* oil a good choice to use in industrial applications and for incorporation into human diet. Due to their role in the protection against oxidative deterioration of polyunsaturated fatty acids in plant material, tocopherols in seed oil are extremely important (Rezig et al., 2012). In addition, phenolic acids and sterols also enhance shelf life and resistance of the oils against oxidation (Rezig et al., 2012; Siger et al., 2008). In the food industry, tocopherols are used as an antioxidant for frying oil, margarine, fried snacks, among others (Akoh, 2006). The tocopherol content in seeds may be affected by several factors such as the oil extraction process, maturity, storage conditions, climate and the method of determination of tocopherols (Murkovic et al., 1996b; Rabrenovic et al., 2014).

Macro- and micronutrients

Pumpkin seeds are a good source of potassium, phosphorus and magnesium; they also contain moderately high amounts of Ca, Na, Mn, Fe, Zn and Cu, and these elements make pumpkin seed valuable for food supplementation (Petkova and Antova, 2015; Lazos, 1986; Raphael et al., 2014). Rezig et al.(2012) found potassium to be the most prevalent element in seeds of *C. maxima*, followed in decreasing order by phosphorus, sodium, calcium, magnesium, copper, zinc, iron, and manganese (Table 5). Potassium helps reduce blood pressure and water retention, protect against stroke and helps prevent osteoporosis and kidney stones. High iodine is due to high content of unsaturated fatty acids and indicates that the seed oil has the good qualities of edible oil and drying oil purposes (Eromosele et al., 1997; Ardabili et al., 2011). Pumpkin seeds are a good source of zinc, containing about 1.5 milligrams of zinc per 20 grams, or 10.3 milligrams per 100 grams. Zinc is believed to play a role in the proper functioning of some sense organs such as those required for tastes, sense and smell (Payne, 1990). Zinc ion is required by all the steroid hormone receptors to maintain their secondary structure and function and to normalise the concentration of testosterone, LH and FSH (Agrawal and Shahani, 2021). High concentration of zinc in the human prostate gland helps in normal functioning. Bataineh et al. (2002) and Vartsky et al. (2003) indicated that zinc plays an important role in proteins structure, cell membranes and protection against damage, as it helps in growth and development of the immune response, functioning of nervous system and reproduction. Zinc also play a critical role in protein and carbohydrate metabolism and also vitamin A mobilization from its storage site in the liver and facilitates the synthesis of DNA and RNA (Guthrie, 1989). Pumpkin seeds have highest iron content (95.85 ± 33.01ppm) in comparison with 11 types of seeds and nuts known for its nutritional value (Kim et al., 2012).

Conclusion

Pumpkin fruit is rich in carbohydrates, proteins, lipds, macro- and micronutrients and other health-prmoting chemical compounds. Pumpkin seeds, being the storage parts of the plant, have higher nutrient content than the fruit flesh. The seeds are rich in protein, fibres, minerals, polyunsaturated fatty acids, phytosterols, antioxidant vitamins such as carotenoids and tocopherols as well as macro- and micronutrients.

References

Abdel-Rahman MK (2006) Effect of pumpkin seed (*Cucurbita pepo* L) diets on benign prostatichyperplasia (BPH): Chemical and morphometric evaluation in rats. World Journal of Chemistry 1 (1): 33-40.

Abukutsa-Onyango M (2007) The diversity of cultivated african leafy vegetables in three communities in western Kenya. African Journal of Food Agriculture Nutrition and Development 7(3):1-15.

Achu MB, Fokou E, Tchiegang C, Fotso M, Tchouanguep FM (2006) Chemical characteristics and fatty acid composition of *Cucurbitaceae* oils from Cameroon. IUFoST 2006, 13th World Congress of Food Sci. Technol. DOI: 10.1051/ IUFoST: 20060026.

Adams GG, Imran S, Wang S, Mohammad A, Kok S, Gray DA, Channell GA, Morris GA, Harding SE (2011) The hypoglycaemic effect of pumpkins as anti-diabetic and functional medicines. Food Research International 44(4):862-867.

Adebayo OR, Farombi AG, Oyekanmi A (2013) Proximate, mineral and anti-nutrient evaluation of pumpkin pulp (*Cucurbita Pepo*). IOSR Journal of Applied Chemistry 4 (5): 25-28.

Agrawal K, Shahani L (2021) Pumpkin seeds and oil as sources of bioactive compounds and their therapeutic uses: A review. Bulletin of Environment, Pharmacology and Life Sciences 10 (8): 01-08.

Ajayi IA, Oderinde RA, Kajogbola DO, Uponi JI (2006) Oil content and fatty acid composition of some underutilized legumes from Nigeria. Food Chemistry 99: 115–120.

Akoh CC (2006) Handbook of functional lipids. p. 325–350. In: Lee JH, Min DB (eds) Nutraceuticals, aging, and food oxidation. Taylor & Francis Group, CRC Press

Al Jahani A, Cheikhousman R (2017). Nutritional and sensory evaluation of pumpkin based (*Cucurbita maxima*) functional juice. Nutr Food Sci 47: 346–356.

Al-Barbary FS, Khalefa AH,. Mohamed SA, Abdel-Rahman EA (2011) Evaluation and utilization of some Egyptian pumpkin (*Cucurbita moschata*) cultivars. Journal of Food and Dairy Science, Mansoura University 2 (10): 555 – 567.

Alfawaz MA (2004) Chemical composition and oil characteristics of pumpkin (*Cucurbita maxima*) seed kernels. Food Sci Afric Res Center, King Saud University Research Bulletin 129: 5–18.

Ali SMA, Ali MM, Hassan AB (2022) The physical and chemical characteristics of seeds oil of local Sudanese pumpkin (*Cucurbita moschata* Duchesne). Journal of Oleo Science. doi : 10.5650/jos.ess22007

Al-Khalifa AS (1996) Physicochemical characteristics, fatty acid composition, and lipoxygenase activity of crude pumpkin and melon seed oils. Journal of Agricultural Food Chemistry 44 (4): 964–966.

Al-Turky HM, Maysoon A, Ibrahim B (2024) The antioxidant capacity of pumpkin seed oil and its impact on the stability. Results in Chemistry 12 (2024) 101883.

Amin MZ, Islam T, Uddin MR, Uddin MJ, Rahman MM, Satter MA (2019a) Comparative study on nutrient contents in the different parts of indigenous and hybrid varieties of pumpkin (*Cucurbita maxima* Linn.). Heliyon 5 (2019) e02462.

Amin MZ, Islam T, Mostofa F, Uddin MJ, Rahman MM, Satter MA (2019b) Comparative assessment of the physicochemical and biochemical properties of native and hybrid varieties of pumpkin seed and seed oil (*Cucurbita maxima* Linn.). Heliyon 5: e02994

Amoo I, Eleyinmi A, Ilelaboye N, Akoja, S (2004) Characterization of oil extracted from gourd (*Cucurbita maxima*) seed. J Food Agric Environ 2: 38-39.

Andres TC (2004) Diversity in tropical pumpkin (*Cucurbita moschata*): Cultivar origin and history. p. 113-118. In: Lebeda A, Paris HS (eds) Proceedings of Cucurbitaceae, 8th EUCARPIA Meeting on Cucurbit Genetics and Breeding, Olomouc, Czech Republic, 12-17 July 2004.

Applequist WL, Avula B, Schaneberg BT, Wang YH, Khan IA (2006) Comparative fatty acid content of seeds of four *Cucurbita* species grown in a common (shared) garden. Journal of Food Composition and Analysis 19: 606–611.

Ardabili AG, Farhoosh R, Haddad Khodaparast HM (2011) Chemical composition and physicochemical properties of pumpkin seeds (*Cucurbita pepo* Subsp. *pepo* Var. Styriaka) grown in Iran. J Agric Sci Tech 13: 1053-1063.

Arima HK, Rodriguez-Amaya DB (1988) Carotenoid composition and vitamin A value of commercial Brazilian squashes and pumpkins. Journal of Micronutrient Analysis 4: 177–191.

Arima HK, Rodriguez-Amaya DB (1990) Carotenoid composition and vitamin A value of a squash and a pumpkin from Northeastern Brazil. Archivos Latinoamericanos de Nutricio´n 40: 284- 292.

Aruah CB, Uguru MI, Oyiga BC (2010) Variations among some Nigerian *Cucurbita* landraces. African Journal of Plant Science 4 (10): 374-386.

Aruah CB, Uguru MI, Oyiga BC (2011) Nutritional evaluation of some Nigerian pumpkins (*Cucurbita spp*.). Fruit, Vegetable and Cereal Science and Biotechnology 5 (2): 64-71.

Bardaa S, Halima NB, Aloui F, Mansour RB, Jabeur H, Bouaziz M, Sahnoun Z (2016) Oil from pumpkin (*Cucurbita pepo* L.) seeds: Evaluation of its functional properties on wound healing in rats. Lipids in Health and Disease 15:73

Bataineh ZM, Hani IHB, Al-Alami JR (2002) Zinc in normal and pathological human prostate gland. Saudi Medical Journal 23(2):218-20.

Batool M, Ranjha MMAN, Roobab U, Manzoor MF, Farooq U, Nadeem HR, Nadeem M, Kanwal R, Abd Elgawad H, Al Jaouni SK, Selim S, Ibrahim SA (2022). Nutritional value, phytochemical potential, and therapeutic benefits of pumpkin (*Cucurbita* sp.). Plants (Basel), 11(11), 1394

Beltrán G, Jiménez Marquez A, Rio C, Sánchez S, Martínez L, Uceda M, Aguilera M (2010) Variability of vitamin E in virgin olive oil by agronomical and genetic factors. Journal of Food Composition and Analysis 23(6):633-639.

Benalia M, Amar Djeridane A, Nadhir Gourine N, Nia S, Ajandouz E, Yousfi M (2015) Fatty acid profile, tocopherols content and antioxidant activity of Algerian pumpkin seeds oil (*Cucurbita pepo* L). Mediterranean Journal of Nutrition and Metabolism 8: 9–25.

Biesiada A, Nawirska A, Kucharska A, Sokó£- £êtowska A(1962) Chemical composition of pumpkin fruit depending on cultivar and storage. Ecol Chem Eng A 18: 9-18.

Boujemaa I, El Bernoussi S, Harhar H, Tabyaoui M (2020) The influence of the species on the quality, chemical composition and antioxidant activity of pumpkin seed oil. Oilseeds & fats Crops and Lipids (OCL) 2020, 27, 40

Brinkmann B (2000) Quality criteria of industrial frying oils and fats. European Journal of Lipid Science and Technology 102: 539–541.

Can-Cauich CA, Sauri-Duch E, Cuevas-Glory LF, Betancur-Ancona D, Ortiz-Vázquez E, Ríos-Soberanis CR, Chel-Guerrero L, González-Aguilar GA, Moo-Huchin VM (2021) Physicochemical properties and stability of pumpkin seed oil as affected by different extraction methods and species. International Food Research Journal 28(1): 148 – 160.

Ceclu L, Mocanu DG, Nistor OV (2020) Pumpkin–health benefits. Journal of Agroalimentary Processes and Technologies 26(3): 241-246.

Chen L, Huang G (2019) Antioxidant activities of phosphorylated pumpkin polysaccharide. International Journal of Biological Macromolecules 125: 256-261.

Choe E, Min DB (2006) Mechanisms and factors for edible oil oxidation. Compr Rev Food Sci Food Saf 5:169–186.

Codex Alimentarius Commission (1982) Recommended international standards for edible fats and oils, 1st edn, Vol. XI Rome, Italy: FAO/WHO.

Dar RA, Sharma J (2011) Genetic variability studies of yield and quality traits in tomato (*Solanum lycopersicum* L.). International Journal of Plant Breeding and Genetics 5(2):168-174.

Dhiman AK, Sharma KD, Attri S (2009) Functional constituents and processing of pumpkin: A review. Journal of Food Science and Technology 46(5):411-417.

Dini I, Tenore GC, Dini A (2013) Effect of industrial and domestic processing on antioxidant properties of pumpkin pulp. LWT-Food Science and Technology 53(1): 382-385.

Dunford N (2020) Properties of High Oleic Seed Oils. Available at https://extension.okstate.edu/fact-sheets/properties-of-high-oleic-seed-oils.html.

Ekanayaka EMMM, Chandrasekara BSG, Balasooriya BANK (2019) Evaluation of exotic pumpkin hybrids with local pumpkin varieties in the intermediate low country 1 (IL1) of Sri Lanka. Proceeding of the Open University Research Sessions (OURS 2019).

El-Adawy TA, Taha KM (2001) Characteristics and composition of watermelon, pumpkin, and paprika seed oils and flours. J Agric Food Chem 49: 1253–1259.

Elhardallou SB, Elawad AM, Khairi NA, Gobouri AA, Dhahawi HO (2014) A review on omega-3 and omega-6 essential fatty acids: Uses, benefits and their availability in pumpkins (*Cucurbita maxima*) seed and desert dates (*Balanites aegyptiaca*) seed kernel oils. Pakistan J Biol Sci 17: 1195–1208.

Ellinge CM, Muhammad A, Atiku FA, Itodo AU, Peni IJ, Sanni OM, Mbongo AN (2012) Proximate, mineral and anti-nutrient composition of pumpkin (*Cucurbita pepo* L.) seeds extract. Int J Plant Res 2:146–150.

Eromosele IC, Eromosele CO, Innazo P, Njerim P (1997) Studies on some seeds and seed oils. Bioresour Technol 64: 245–247.

Esquinas-Alcazar JT, Gulick PJ (1983) Genetic resources of *Cucurbitaceae:* A Global Report, IBPGR, Rome.

Fatnassi S, Nehdi I, Zarrouk H (2009) Chemical composition and profile characteristics of Osage orange *Maclura pomifera* (Rafin.) Schneider seed and seed oil. Ind Crops Prod 29: 1–8.

Fruhwirth GO, Hermetter A (2007) Seeds and oil of the Styrian oil pumpkin: Components and biological activities. European Journal of Lipid Science and Technology 109(11): 1128-1140.

Fu C, Shi H, Li Q (2006) A review on pharmacological activities and utilization technologies of pumpkin. Plant Foods for Human Nutrition 61(2):73-80.

Galli F, Azzi A, Birringer M, Cook-Mills JM, Eggersdorfer M, Frank J, Cruciani G, Lorkowski S, Özer NK (2017) Vitamin E: Emerging aspects and new directions. Free Radic Biol Med 102: 16–36.

Glew RH, Glew RS, Chuang LT, Huang YS, Millson M, Constans D, Vanderjagt DJ (2006) Amino acid, mineral and fatty acid content of pumpkin seeds (*Cucurbita* spp) and *Cyperus esculentus* nuts in the Republic of Niger. Plant Foods for Human Nutrition 61: 51–56.

Gliszczyńska-Świgło A, Sikorska E, Khmelinskii I, Sikorski M (2007) Tocopherol content in edible plant oils. Pol J Food Nutr Sci 57(4A):157–161.

González E, Montenegro Mariana A, Nazareno Monica A, Lopez de Mishima Beatriz A (2001) Carotenoid composition and vitamin A value of an Argentinaian squash (*Cucurbita moschata*). Archivos Latinoamericanos de Nutrición 51(4):395-399.

Gossell WM, Davis A, O'Connor N (2006) Inhibition of testosterone- induced hyperplasia of the prostate of Sprague-Dawley rats by pumpkin seed oil. Journal of Medicinal Food 9:284–286.

Gropper SS, Smith JL, Groff JL (2005) Advanced nutrition and human metabolism, 4th edn, Thomson Wadsworth Publishing Co, Belmont, CA, USA. p.381-405.

Gross J (1987) Pigments in fruits. London: Academic Press.

Grubben GJH, Chigumira-Ngwerume F (2004) *Cucurbita moschata* Duch. In: Grubben GJH, Denton OA (eds) PROTA 2: Vegetables/Legumes. [CD-Rom].PROTA, Wageningen, Netherlands.

Guthrie H (1989) Introductory nutrition, 7th edn, Time mirror Mosby college publishers, Boston.

Gwanama C, Labuschagne M, Botha A (2000) Analysis of genetic variation in *Cucurbita moschata* by random amplified polymorphic DNA (RAPD) markers. Euphytica 113(1):19-24.

Habib A, Biswas S, Siddique AH, Manirujjaman M, Uddin B, Hasan S, Khan MMH, Uddin M, Islam M, Hasan M, Rahman M, Asaduzzaman M, Sohanur RM, Khatun M, Islam MA, Rahman M (2015) Nutritional and lipid composition analysis of pumpkin seed (*Cucurbita maxima* Linn.). Journal of Nutrition and Food Sciences 5(4): 374.

Hagos M, Chandravanshi BS, Redi-Abshiro M,Yaya EE (2023) Determination of total phenolic, total flavonoid, ascorbic acid contents and antioxidant activity of pumpkin flesh, peel and seeds. Bulletin of the Chemical Society of Ethiopia 37(5): 1093-1108.

Hashash MM, El-Sayed M, Abdel-Hady A, Morsi E (2017) Nutritional potential, mineral composition and antioxidant activity squash (*Cucurbita pepo* L.) fruits grown in Egypt. European journal of biomedical and pharmaceutical sciences 4(3): 5–12.

Hernández-Santos B, Rodríguez-Miranda J, Herman-Lara E, Torruco-Uco JG, Carmona-García R, Juárez-Barrientos MJ, Chávez-Zamudio R, Martínez-Sánchez CE (2016) Effect of oil extraction assisted by ultrasound on the physicochemical properties and fatty acid profile of pumpkin seed oil (*Cucurbita pepo*). Ultrasonics Sonochemistry 31: 429–436.

Hosen M, Rafii MY, Mazlan N, Jusoh M, Oladosu Y, Chowdhury MFN, Muhammad I, Khan MMH (2021) Pumpkin (*Cucurbita* spp.): A crop to mitigate food and nutritional challenges. Horticulturae 7:352.

Huang XE, Hirose K, Wakai K, Matsuo K, Ito H, Xiang J, Takezaki T, Tajima K (2004) Comparison of lifestyle risk factors by family history for gastric, breast, lung and colorectal cancer. Asian Pac J Cancer Prev 5:419-427.

Huda MR, Abd El-Aleem IM, El-Hadary A (2023) Comparison of the chemical compositions, physiochemical analysis and other bioactive compounds of various pumpkin (C*urcubita pepo* L.) varieties. Annals of Agricultural Science, Moshtohor 61(1) : 69 – 66.

Huerta-Reyes M, Tavera-Hernández R, Alvarado-Sansininea JJ, Jiménez-Estrada M (2022) Selected species of the cucurbitaceae family used in Mexico for the treatment of *Diabetes Mellitus*. Molecules 27, 3440. https://doi.org/10.3390/ molecules27113440

Idouraine A, Kohlhepp EA, Weber CW (1996) Nutrient constituents from eight lines of naked seed squash (*Cucurbita pepo* L.). Journal of Agricultural and Food Chemistry 44: 721–724.

Indrianingsih AW, Rosyida VT, Apriyana W, Hayati SN, Nisa K, Darsih C, Kusumaningrum A, Ratih D, Indirayati N (2019) Comparisons of antioxidant activities of two varieties of pumpkin (*Cucurbita moschata* and *Cucurbita maxima*) extracts. In: IOP Conference Series: Earth and Environmental Science. The 2nd International Conference on Natural Products and Bioresource Sciences, Tangerang, Indonesia, 1-2 November 2019.

Jaswir I, Shahidan N, Othman R, Has-Yun Hashim YZ, Octavianti F, Noor bin Salleh M (2014) Effects of season and storage period on accumulation of individual carotenoids in pumpkin flesh (*Cucurbita moschata*). Journal of Oleo Science 63(8):761-767.

Kamal-Eldin A, Andersson RA (1997) A multivariate study of the correlation between tocopherol content and fatty acid composition in vegetable oils. J Am Oil Chem Soc 74:375-376.

Karanja JK, Mugendi BJ, Khamis FM, Muchugi AN (2014) Nutritional evaluation of some Kenyan pumpkins (*Cucurbita spp*.). International Journal of Agriculture and Forestry 4(3): 195-200.

Karaye IU, Aliero AA, Muhammad S, Bilbis LS (2013) Evaluation of nutrient and anti-nutrient contents of selected Nigerian cucurbits seeds. RJPBCS; 4: 137.

Kaur N, Chugh V, Gupta AK (2014) Essential fatty acids as functional components of foods—A review. J Food Sci Technol 51: 2289–2303.

Keith RE (2006) Ascorbic acid. p. 29-46. In: Driskell JA, Wolinsky I (eds) Sports Nutrition: Vitamins and Trace Elements. Boca Raton, FL: CRC Press.

Khalifa AH, Abdel-Rahman EA, Mohamed SA, Al-Barbari FS (2012) Characteristics of seeds and seed oils of some Egyptian pumpkin cultivars. Journal of Food and Dairy Science, Mansoura Univ 3 (12): 681 – 697.

Kiharason JW, Isutsa DK, Ngoda PN (2017) Nutritive value of bakery products from wheat and pumpkin composite flour. Global Journal of Biosciences and Biotechnology 6(1): 96-102.

Kim MY, Kim EJ, Kim Y-N, Choi C, Lee B-H (2012) Comparison of the chemical compositions and nutritive values of various pumpkin (*Cucurbitaceae*) species and parts. Nutr Res Pract 6: 21–27.

Koltsov VA, Danilin SI (2021) IOP Conference Series: Earth and Environmental Science 845 01200

Košťálová Z, Hromádková Z, Ebringerová A, Polovka M, Michaelsen TE, Paulsen BS (2013) Polysaccharides from the Styrian oilpumpkin with antioxidant and complement-fixing activity. Ind Crop Prod 41: 127-133.

Krinsky NI (1993) Actions of carotenoids in biological systems. Ann Rev Nutr 13: 561-587（1993）

Krishnamurthy RG (1982) Cooking oils, salad oils and salad dressings. p. 315–341. In: Swern D (ed) Bailey's industrial oil and fat products, Vol. 2, 4th edn, John Wiley and Sons, New York, USA.

Kulczyński B, Gramza-Michałowska A (2019) The profile of carotenoids and other bioactive molecules in various pumpkin fruits (*Cucurbita maxima* Duchesne) cultivars. Molecules 24(18):3212- 3224.

Kulkarni AS, Joshi DC (2013) Studies on selected physico-chemical properties of pumpkin. Asian J Dairy Food Res 32 (2) : 126-129.

Kumar V, Mishra DP, Yadav GC, Yadav S, Kumar S (2018) Determining relationships between yield and biochemical traits in pumpkin. The Pharma Innovation Journal 7(1): 14-18.

Lampi A, Kataja L, Kamal-Eldin A, Piironen V (1999) Antioxidant activities of α- and γ-tocopherols in the oxidation of rapeseed oil triacylglycerols. J Am Oil Chem Soc 76: 749–755.

Latif S, Anwar F (2011) Aqueous enzymatic sesame oil and protein extraction. Food Chem 125: 679–684.

Lawal AB (2009) Correlation and Path Coefficient studies in squash pumpkin (*Cucurbita maxima* L.). Advances in Horticultural Science 23(3): 197-200.

Lazos ES (1986) Nutritional, fatty acid and oil characteristics of pumpkin and melon seeds. J Food Sci 51: 1382-1383.

Lee P, Ulatowski LM (2019) Vitamin E: Mechanism of transport and regulation in the CNS. IUBMB Life 71: 424–429.

Lien EL, Hammond BR (2011) Nutritional influences on visual development and function. Progress in Retinal and Eye Research 30(3):188-203.

Lisa SA, Kabir MA, Hossain MA, Khan S (2018) Nutritional value of some indigenous *Cucurbitaceae* oilseeds and physicochemical properties of their oils. J Chem Bio Phy Sci 9(1):001–009.

Lowe FC, Ku CJ (1996) Phytotherapy in treatment of benign prostate hyperplasia: A critical review. Urology 48:12–20.

Mansour EH, Dworschák E, Lugasi A, Barna E, Gergely A (1993) Nutritive value of pumpkin (*Cucurbita pepo* Kakai 35) seed products. Journal of the Science of Food and Agriculture 61(1): 73-78.

Marcus DM, Grollman AP (2002) Botanical medicines—The need for new regulations. The New England Journal of Medicine 347(25): 2073.

Markovic VV, Bastic LV (1976) Characteristics of pumpkin seed oil. J Am Oil Chem Soc 53: 42-44.

Martins S, Ribeiro De Carvalho C, Carnide V (2015) Assessing phenotypic diversity of *Cucurbita* Portuguese germplasm. The Journal of Agriculture and Forestry 61(1):27-33.

Mbogne JT, Youmbi E, Ibouraïman B, Ntsefong GN (2015) Agromorphological, chemical and biochemical characterization of pumpkin (*Cucurbita maxima* and *Cucurbita moschata, Cucurbitaceae*) morphotypes cultivated in Cameroun. Research in Plant Sciences 3(1):12-17.

Merrick LC (1992) Systematics, evolution, and ethnobotany of a domesticated squash, *Cucurbita argyrosperma*. PhD Thesis, Cornell Univ, Ithaca, NY.

Mohammed SS, Paiko YB, Mann A, Ndamitso MM, Mathew JT, Maaji S (2014) Proximate, mineral and anti-nutritional composition of *Cucurbita maxima* fruits parts. Nigerian Journal of Chemical Res*earch* 19(1): 37–49.

Montesano D, Blasi F, Simonetti MS, Santini A, Cossignani L (2018) Chemical and nutritional characterization of seed oil from *Cucurbita maxima* L. (var. Berrettina) pumpkin. Foods 7: 30; doi:10.3390/foods703003

Murkovic M, Pfannhauser W (2000) Stability of pumpkin seed oil. Eur J Lipid Sci Technol 102: 607–611.

Murkovic M, Hillebrand A, Winkler J (1996b) Variability of vitamin E content in pumpkin seeds (*Cucurbita pepo* L.). Z Lebensm Unters Forsch 202: 275– 278.

Murkovic M, Hillebrand A, Draxl S, Winkler J, Pfannhauser W(1999) Distribution of fatty acids and vitamin E content in pumpkin seeds (*Cucurbita Pepo* L.) in breeding lines. Acta Hortic 492: 47– 55.

Murkovic M, Hillebrand A, Winkler J, Leitner E, Pfannhauser W (1996a) Variability of fatty acid content in pumpkin seeds (*Cucurbita pepo* L.). Z Lebensm Unters Forsch 203: 216–219.

Nawirska-Olszanska A, Kita A, Biesiada A, Sokol-Letowska A, Kucharska AZ (2013) Characteristics of antioxidant activity and composition of pumpkin seed oils in 12 cultivars. Food Chem 139: 155-161.

Ndegwa R (2016) Socio-economic factors influencing smallholder pumpkin production, consumption and marketing in Eastern and Central Kenya regions. M.Sc. Thesis (Agribusiness Management and Trade), School of Agriculture and Enterprise Development, Kenyatta University, Kenya.

Nee M (1990)The domestication of *Cucurbita* (*Cucurbitacea*). Econ Bot 44:3–58.

Nichols DS, Sanderson K (2003) The nomenclature, structure, and properties of food lipids. p. 29–59. In: Sikorski ZE, Kolakowska A (eds) Chemical and functional properties of food lipids. CRC Press.

Nishimura M, Ohkawara T, Sato H, Takeda H, Nishihira J (2014) Pumpkin seed oil extracted from *Cucurbita maxima* improves urinary disorder in human overactive bladder. Journal of Traditional and Complementary Medicine4(1): 72-74.

Norshazila S, Irwandi J, Othman R, Zuhanis Y (2014) Carotenoid content in different locality of pumpkin (*Cucurbita moschata*) in Malaysia. International Journal of Pharmacy and Pharmaceutical Sciences 6(3):29-32.

Nour V,Corbu AR, Rotaru P, Karageorgou I, Lalas S (2018) Effect of carotenoids extracted from dry tomato waste on the stability and characteristics of various vegetable oils. Grasas y Aceites 69(1): article ID e238.

Nyabera LA, Runo SM, Nzuki IW, Amwayi PW (2019) Phenotypic diversity of pumpkins from western Kenya using fruit morphological characters. African Crop Science Journal 27 (3): 427 – 435.

Nyam KL, Tan CP, Lai OM, Long K, Che Man YB (2009) Physicochemical properties and bioactive compounds of selected seed oils. Food Science and Technology 42: 1396–1403.

OECD (2016) Squashes, pumkins, zucchinis and gourds (*Cucurbita* species). p. 84-130. Safety assessment of transgenic organisms in the environment. OECD consensus documents, volume 5. Organisation for Economic Co-operation and Development (OECD) Paris, France.

Oluoch MO (2012) Production practices of pumpkins for improved productivity. Scripta Horticulturae 15:181-189.
Paris HS, Brown RN (2005) The genes of pumpkin and squash. HortScience 40(6): 1620- 1630.
Paris HS (2001) History of the cultivar-groups of *Cucurbita pepo*. Horticultural Reviews 25: 71-170. http://dx.doi.org/10.1002/9780470650783.ch2
Payne WJA (1990) An introduction to animal husbandry in the trophics. p. 92-110. Longman Publishers Singapore.
Petkova ZY, Antova GA (2015) Changes in the composition of pumpkin seeds (*Cucurbita moschata*) during development and maturation. Grasasy Aceites 66 (1) January–March 2015, e058.
Petukhov I, Malcolmson LJ, Przybylski R, Armstrong L (1999) Frying performance of genetically modified canola oils. Journal of the American Oil Chemists' Society 76: 627–632.
Phillips KM, Ruggio DM, Ashraf-Khorassani M (2005) Phytosterol composition of nuts and seeds commonly consumed in the United States. Journal of Agricultural and Food Chemistry 53: 9436–9445.
Piironen V, Lindsay DG, Miettinen TA, Toivo J, Lampi AM (2000) Plant sterols: Biosynthesis, biological function and their importance to human nutrition. J Sci Food Agric 80:939-966.
Prommaban A, Kuanchoom R, Seepuan N, Chaiyana W, (2021) Evaluation of fatty acid compositions, antioxidant, and pharmacological activities of pumpkin (*Cucurbita moschata*) seed oil from aqueous enzymatic extraction. Plants, 10, 1582. https://doi.org/10.3390/ plants10081582
PROTA (2018) Available online: https://www.protasoftware.com/news/protastructure-2018-release.
Quintana SE, Marsiglia RM, Machacon D, Torregroza E, García-Zapateiro LA (2018) Chemical composition and physicochemical properties of squash (*Cucurbita moschata*) cultivated in Bolivar department (Colombia). Contemporary Engineering Sciences 11(21): 1003 – 1012.
Rabrenovic B, Dimic EB, Novakovic MM, Tešević V, Basić Z (2014) The most important bioactive components of cold pressed oil from different pumpkin (*Cucurbita pepo* L.) seeds. LWT-Food Sci Technol 55: 521–527.
Rahman MM, Juahir H, Islam MH, Khandaker MM, Ariff TM, Nik WMN (2019) Prophetic vegetable pumpkin, Its impressive health benefits and total analysis. Bioscience Research 16(4):3987-3999.
Raicht RF, Cohen BI, Fazzini EP, Sarwal AN, Takahashi M (1980) Protective effect of plant sterols against chemically induced colon tumors in rats. Cancer Res 40:403-5.
Raihana AN, Marikkar JMN, Amin I, Shuhaimi M (2015) A review on food values of selected tropical fruits' seeds. International Journal of Food Properties 18(11): 2380- 2392.
Raphael K, Clive W, Amos M, Misheck M, Clarice N, Perkins M, Abigail M (2014) Proximate composition of pumpkin gourd (*Cucurbita Pepo*) seeds from Zimbabwe. International Journal of Nutrition and Food Sciences 3(4): 279-283.
Redondo-Cuevas L, Castellano G, Torrens F, Raikos V (2018) Revealing the relationship between vegetable oil composition and oxidative stability: A multifactorial approach. Journal of Food Composition and Analysis 66: 221-229.
Rezig L, Chouaibi M, Ojeda-Amador RM, Gomez-Alonso S, Salvador MD, Fregapane G, Hamdi S (2018) *Cucurbita maxima* pumpkin seed oil: From the chemical properties to the different extracting techniques. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 46:663-669.
Rezig L, Chouaibi M, Msaada K, Hamdi S (2012) Chemical composition and profile characterisation of pumpkin (*Cucurbita maxima*) seed oil. Industrial Crops and Products 37:82-87.
Roberfroid MB (2002) Global view on functional foods: European perspectives. The British Journal of Nutrition 88(2):133-138.
Roberto L-M, Jessami M, Josefa R, Leyla S, Yasna S, Natalia V, Luis P-D (2019) Pumpkin seeds (*Cucurbita maxima*). A review of functional attributes and by-products. Rev Chil Nutr 46(6): 783-791.
Rodriguez-Amaya DB, Mieko M (2004) Harvest Plus Handbook for carotenoid analysis. HarvestPlus Technical Monograph Series 2. pg 4.
Rohman A, Irnawati I (2020) Pumpkin (*Cucurbita maxima*) seed oil: Chemical composition, antioxidant activities and its authentication analysis. Food Research 4 (3) : 578 – 584.
Rombaut R, De Clercq N, Foubert I, Dewettinck K (2009) Triacylglycerol. Analysis of fats and oils by evaporative light scattering detection. J Am Oil Chem Soc 86:19-25.
Roura S, Del Valle C, Aguero L, Davidovich L (2007) Changes in apparent viscosity and vitamin C retention during thermal treatment of butternut squash (*Cucurbita moschata* Duch) pulp: Effect of ripening stage. Journal of Food Quality 30(4):538-551.
Ryan E, Galvin K, O'Connor TP, Maguire AR, O'Brien NM (2007) Phytosterol, squalene, tocopherol content and fatty acid profile of selected seeds, grains, and legumes. Plant Foods for Human Nutrition 62:85–91.
Sabudak T (2007) fatty acid composition of seed and leaf oils of pumpkin, walnut, almond, maize, sunflower and melon. Chemistry of Natural Compounds 43(4): 465–467.
Salama A (2006) Las Cucurbitáceas, Importancia Económica, Bioquímica y Medicinal. Ed. Unibiblos. Bogotá, Colombia: Universidad Nacional de Colombia.
Sayeed MA, Abbas Ali MA, Sohel FI, Astaq Mohal Khan GRM, Yeasmin MS (2004) Physico-chemical characteristics of Mesua Ferrea seed oil and nutritional composition of its seed and leaves. Bull Chem Soc Ethiop 18: 157-166.
Sedigheh A, Jamal MS, Mahbubeh S, Somayeh K, Mahmoud RK, Azadeh A, Fatemeh S (2011) Hypoglycaemic and hypolipidemic effects of pumpkin (*Cucurbita pepo* L.) on alloxan-induced diabetic rats. African Journal of Pharmacy and Pharmacology 5(23): 2620-2626.
Seleim MAA, Ali HM, Hassan MAM (2015) Comparative study of the beta-carotene, alpha-tocopherol and pectin values from three cultivars of pumpkin (*Cucurbita maxima*). World J Dairy Food Sci 10: 132–140.

Sharma S, Ramana Rao TV (2013) Nutritional quality characteristics of pumpkin fruit as revealed by its biochemical analysis. International Food Research Journal 20(5): 2309-2316.
Sharmin AL, Kabir A, Khan S (2022) Utilization of seed from *Cucurbita maxima,* a pumpkin variety of Bangladesh, converting into refined oil and oilcake. Discover Food 2:19
Shi X, Wu H, Shi J, Xue SJ, Wang D, Wang W, Cheng A, Gong Z, Chen X, Wang C (2013) Effect of modifier on the composition and antioxidant activity of carotenoid extracts from pumpkin (*Cucurbita maxima*) by supercritical CO2. LWT-Food Sci Technol 51: 433-440.
Siger A, Nogala-Kalucka M, Lampart-Szczapa E (2008) The content and antioxidant activity of phenolic compounds on cold-pressed plant oils. J Food Lipids 15: 137–149.
Song Y, Yang Y, Zhang Y, Duan L, Zhou C, Ni Y, Liao X, Li Q, Hu X (2013) Effect of acetylation on antioxidant and cytoprotective activity of polysaccharides isolated from pumpkin (*Cucurbita pepo*, lady godiva). Carbohyd Polym 98: 686-691.
Soto D, Wittig E, Guerrero L, Garrido F, Fuenzalida R (2006) Alimentos Funcionales: Comportamiento del Consumidor Chileno. Rev Chil Nutr 33 (1): 43-54.
Srbinoska M, Hrabovski N, Rafajlovska V, Sinadinović-Fišer S (2012) Characterization of the seed and seed extracts of the pumpkins *Cucurbita maxima* D. and *Cucurbita pepo* L. from Macedonia. Macedonian Journal of Chemistry and Chemical Engineering 31 (1): 65–78.
Stevenson DG, Eller FJ, Wang L, Jane JL, Wang T, Inglett GE (2007) Oil and tocopherol content and composition of pumpkin seed oil in 12 cultivars. J Agric Food Chem 55:4005–4013. https:// doi. org/ 10. 1021/ jf070 6979
Szewczyk K, Chojnacka A, Górnicka M (2021) Tocopherols and tocotrienols—Bioactive dietary compounds; What is certain, What is doubt? International Journal of Molecular Sciences 22, 6222. https://doi.org/10.3390/ ijms22126222
Szterk A, Roszko M, Sosin´ska E, Derewiaka D, Lewicki PP (2010) Chemical composition and oxidative stability of selected plant oils. J Am Oil Chem Soc 87:637–645.
Teotia MS (1992) Advances in chemistry and technology of pumpkin. Indian Food Packer 46(1): 9-31.
Tsai YS, Tong YC, Cheng JT, Lee CH, Yang S, Lee HY (2006) Pumpkin seed oil and phytosterol-F can block testosterone/prazosin-induced prostate growth in rats. Urologia internationalis 77: 269-274.
Tsaknis J, Lalas S, Lazos ES (1997) Characterization of crude and purified pumpkin seed oil. Grasas Aceites 48: 267–272.
Tucker JM, Townsend DM (2005) Alpha-tocopherol: Roles in prevention and therapy of human disease. Biomed Pharmacother 59 :380–387.
Türkmen Ö, Özcan MM, Seymen M, Paksoy M, Uslu N, Fidan S (2017) Physico-chemical properties and fatty acid compositions of some edible pumpkin seed genotypes and oils. J Agroalimentary Proc Technol 23(4):229–35.
Uduwerella HMIA, Arampath PC, Mudannayake DC (2021) Physicochemical and functional properties of pumpkin seed flour of *Cucurbita maxima* and *Cucurbita moschata* species. Tropical Agricultural Research 32(2): 201-211.
USDA (2015) United States Department of Agriculture (USDA), Agricultural Research Service: National Nutrient Database for Standard Reference. Available online: http://www.ars.usda.gov/ba/bhnrc/ndl.
Vartsky D, Shilstein S, Bercovich A, Huszar M, Breskin A, Chechik R, Korotinsky S, Malnick SD, Moriel E (2003) Prostatic zinc and prostate specific antigen: An experimental evaluation of their combined diagnostic value. Journal of Urology 170:2258–2262.
Warner K, Gupta M (2003) Frying quality and stability of low-and ultra-low-linolenic acid soybean oils. Journal of the American Oil Chemists' Society 80:275-280.
Warner K, Knowlton S (1997) Frying quality and oxidative stability of high-oleic corn oils. Journal of the American Oil Chemists' Society 74: 1317–1321.
Weihrauch JL, Gardner JM (1978) Sterol content of foods of plant origin. J Am Diet Assoc 73:39-47.
Whitaker TW, Bemis WP (1975) Origin and evolution of the cultivated *Cucurbita*. Bulletin of the Torrey Botanical Club 102(6):362-368.
Wu T, Zhou J, Zhang Y, Cao J (2007) Characterization and inheritance of a bush-type in tropical pumpkin (*Cucurbita moschata* Duchesne). Scientia Horticulturae 114:1–4.
Xiang C, Xu Z, Liu J, Li T, Yang Z, Ding C (2017) Quality, composition, and antioxidant activity of virgin olive oil from introduced varieties at Liangshan. LWT - Food Science and Technology 78: 226-234.
Yadav M, Jain S, Tomar R, Prasad G, Yadav H (2010) Medicinal and biological potential of pumpkin: An updated review. Nutrition Research Reviews 23(2):184-190.
Younis YMH, Ghirmay S, Al-Shihry SS (2000) African *Cucurbita pepo* L.: Properties of seed and variability in fatty acid composition of seed oil. Phytochem 54:71–75.
Zhang S, Zu YG, Fu YJ, Luo M, Liu W, Li J, Efferth T (2010) Supercritical carbon dioxide extraction of seed oil from yellow horn (*Xanthoceras sorbifolia* Bunge.) and its anti-oxidant activity. Bioresour Technol 101: 2537–2544.
Zhao J, Liu W, Chen D, Song Y, Zhang Y, Ni Y, Li Q (2015) Physico-chemical and antioxidant properties of different pumpkin cultivars grown in China. Advance Journal of Food Science and Technology 9(4): 308-316.
Zhou CL, Mi L, Hu XY, Zhu BH (2017) Evaluation of three pumpkin species: Correlation with physicochemical, antioxidant properties and classification using SPME-GC–MS and E-nose methods. Journal of Food Science and Technology 54(10):3118-3131.