Review Article

Chemical Composition and Health Benefits of Melon Seed: A Review

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Abstract | Food waste is a big problem today. On the other hand, the market for natural composites for health is growing. Melon (*Cucumis melo L.)* is a very common fruit, eaten all around the world, containing significant quantities of seeds as well as peels that have been discarded. These seeds contain high functional and nutritional potential compounds. It is the most exported and consumed fresh fruit and the residues like seeds and peel are commonly thrown out. It is cultivated in many countries and has high financial value worldwide and all this is due to adaptation to climate and various types of soil., Melon is an excellent source of biologically active compounds for humans due to good taste and rich chemical composition. Glucose, fructose, vitamin A, D, C, K, E, and some vitamins from group B are present in melon. Biologically active compounds like tocopherols, phospholipids, and sterols are present in melon seed in a large amount due to which it has a beneficial effect on humans. Consequently, these seeds can be described as effective electors for the production of innovative functional foods leading to a healthy food chain. It is concluded that the presence of bioactive compounds is fully justified by melon seed, including anti-inflammatory agents, hypoglycemic agent, antimicrobial, anti-genic and antioxidant potential.

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Introduction

In recent years, Melon (*Cucumis melo L.*) has increased production rate and high economic value while the part of the fruit is wasted. Generally, during processing and consumption, the edible parts included peel, and seeds ate discarded. Globally *Cucumis melo* L. is the most exported and consumed fresh fruit and the residues like peel and seeds are commonly discarded. It is cultivated in many countries and has high financial value worldwide and all this is due to adaptation to climate and various types of soil (Rolim *et al*., 2018).

Recently *Cucumis melo* L. variety of melon has high economic value because its production has been promoted in many regions while the large part of the fruit is discarded. Generally, during processing and consumption inedible parts like seeds and peels are discarded (Rolim *et al*., 2018).

This variety of melon is one of the most exported and consumed globally and its peels, seeds, and residue are mainly discarded. Due to the ability to grow in various soil types and climate, this variety of melon is cultivated in many countries of the world and has high economic value. Honeydew melon (*Cucumis melo* L), Cucurbitaceae family fruit, is oval-shaped fruit with a creamy yellow appearance. From Asia to the US market it is a widely used fruit. The ripened fruit is very delicious and due to this reason, it is widely cultivated. It is rich in folic acid, thiamine, and riboflavin. Vitamin C and pro-vitamin A are abundantly present in it (Laur and Tian, 2011). According to researchers in different parts of fruit the concentration of sucrose, total sugars, soluble solids, 5-methyltetrahydrofolic acid, and β-carotene are various (Lester, 2008). The deterioration of fruit occurs rapidly and due to which its shelf life is very short. Its aroma is very distinct. The honeydew aroma is due to (Z,Z)-3, 6-nonadien 1-ol which are present in the fruit. The phenylethyl alcohol imparts sweet-floral characters and (Z, Z)-3, 6-nonadien 1-ol imparts a fresh impact in the odor of the honeydew (Perry *et al*., 2009; Kolayli *et al*., 2010).

Melon seed

There are a large number of seeds in the center of the melon. The fruit is consumed as such and the seeds are discarded. The seeds of melon have moisture 4.5%, crude protein 25.0%, ash 2.4%, crude fat 25.0%, crude fiber 23.3%, and carbohydrates 19.8% (Yanty *et al*., 2008). Petkova and Antova (2015), analyzed seeds of melon and checked their lipids structure and proximity. According to them, melon seeds have 41.6-44.5% fat, 34.4-39.8% proteins, 4.5-8.5% crude fiber, 8.2-12.7% carbohydrates, 3.7-4.2% soluble sugars and 4.6-5.1% minerals. The lipid portions included sterols, tocopherol, and phospholipids were studied. The main fatty acids present in seeds were oleic acid 24.8-25.6% and linoleic acid 51.1-58.5%. Besides them, the oleoyl dilinolein (OLL) 31-34.0%, trilinolein (LLL) 31.3-32.2%, were the main triglycerides present in seeds. Honeydew melon also has phytoene and β-carotene (Ren *et al*., 2013).

Cucumis melo L. of *Cucurbitaceae* family is a plant that is grown annually and spread in countries like Asia, Europe, and Africa (Ivanov *et al*., 1999). According to FAO, Food and Agriculture Organization, the production of melon seeds is about 782,205 tons and its cultivation area is 893,855 hectares (FAO, 2013). Uzbekistan, the USA, France, and Spain are the biggest producers of melon. In recent years, in Bulgaria, the land for melon growing is 11,196 da and in 2013 total production of melon was 14,711 tons. Mainly the melons are growing in Southern and southwest Bulgaria, the least space is used in Northern Bulgaria and the major five varieties in our country are Vidinski, Hybrids, Honeydew, Koravtzi, and Persian. Excellent taste, quality of fruit, and as medicinal plant its application in folk medicine makes it widespread fruit (Jeffrey, 1990). This is recommended mainly in the case of anemia, atherosclerosis, gout, rheumatism, cardiovascular, kidney, and liver diseases (Ivanova, 2012). Therapeutic effects are present in melon seeds included analgesic, anti-inflammatory, and anti-oxidant effects (Chen *et al*., 2014). Melon is an excellent cause of naturally active compounds for humans because of good taste and rich chemical composition. Glucose and fructose, vitamin A, D, C, K, E, and some vitamins from group B are present in melon. The percentage of sucrose in melon is 4.6 to 18% and that of pectin is up to 4.5%. Minerals like magnesium, sodium, phosphorus, potassium, selenium, calcium, and sodium are also present in melon. Along with all the above composition, various aromatic compounds are also present in melon (Ivanova, 2012).

The seeds variety of curcumins melon is known to have 4.5% moisture, 19.8% carbohydrates, 25% crude fat, 25% crude protein, 2.4% ash, and 23.3% crude fiber. Freshly extracted honeydew mainly has 153.4 gI2/100g oil iodine number, 210.2 mgKOH/g oil, and 2.5% fatty acids contents. The color index of oil is 1.6Y+0.4R and its fatty acids contents are 10 from which almost 86.1% are unsaturated. The contents of Linoleic acid are dominant which is 69% followed by palmitic acid 8.4%, and oleic acid 16.8%. The major triglycerides present in the oil are OLL 21.5%, POL 12.4%, LLL 24.9%, and PLL 15.9%. The melting temperature is -5.12°C while the crystallization temperature is -59.01°C. According to electronic nose analysis, the oil has more volatile compounds and linoleic acid contents than sunflower oil (Yanty *et al*., 2008).

Proximity, amino acids as well as minerals in seeds of melon (*Citrullus ecirrhosus*) was studied. The found results for Physico chemical analysis of 3 compositions of melon seeds have moisture 3+0.25, ash 2.12+0.08, crude protein 26.36+0.10, crude lipids 50.6+0.6, crude fiber 2.1+0.29, available carbohydrates 18.69+0.82 and 601°+8. 5 kcal/100g of energy. The amino acid profile of seeds shown that for adults but children the lysine, threonine, and leucine contents are not as much as necessary. The results have shown that the seeds of wild melon have the potential that these can be used as a nutrition source (Umar *et al*., 2013).

Chemical composition of melon seed

Nutrition parameters: The food consumed by humans is mostly from plant and animal sources. The plant-based foods included tubers, leafy vegetables, fruits, and seeds (Oyiza, 2005). Among 30,000 edible plants, there are only 300 which are demonstrated up to 95% of the plants required as human food (Tabuti *et al*., 2004). Plant based foods are used by humans from the first man on earth, Adam and Eve were forbidden to consume apple (Onibon *et al*., 2007). The parts of the plant which bear the seeds are known as fruits and are healthy food supplements because these are composed of proteins, lipids, water, vitamins, carbohydrates, as well as minerals (Umaru *et al*., 2007). Despite the nutritional benefits of plants, there are also the anti-nutritional factors present in plants that change the nutritional status of food and block the bioavailability of some mineral elements (Lo *et al*., 1995).

The melon seeds (*Citrullus lanatus*) have high mineral contents (mg/100g). The contents of zinc in the melon seed is 21.05mg/100g, and that of magnesium is up to 20.46mg/100g. The analysis of minerals showed that more value is for iron which is 144.7mg/100g, zinc 21.05mg per 100g manganese 22.73mg per 100g, per 100g. The concentration of calcium is least among of all which is 0.10mg/100g. The sodium to potassium ratio is 0.043 and the calcium to phosphorus ratio is 0.002 (Jacob *et al*., 2015).

Another study of wild melon (*Citrullus ecirrhosus*) was done. For each 100g it yields 601.7±8.75 kcal energy value, 2.17±0.29 crude fiber, 3.73±0.25 moisture, 26.36±0.10 crude protein, 18.69±0.82 available carbohydrate, 2.12±0.08 ash and 50.67±0.76 crude lipid as a result of proximate analysis (% DW). For children, the requirement of lysine, threonine and leucine is more than adults as revealed by the amino acid profile of seeds. The general results of the studies show that the seeds of wild melon can be used as a nutrition source (Umar *et al*., 2013).

Fatty acids

Biologically active compounds like tocopherols, phospholipids and sterols are present in melon seed oil in a large amount due to which it has a beneficial effect on humans (Azhar *et al*., 2014; Mariod and Matthäus, 2008). The fatty acids composition and physiochemical characteristics studied after checking the lipid composition of melon seeds. The percentages varied depending on the region from where seeds originate and their tested types (Albishri *et al*., 2013; Obasi *et al*., 2012; Yanty *et al*., 2008).

The seeds, which are considered mainly as waste products, are rich in proteins 12.0-35.0% and glycerides 30.0-50.0% (Azhari *et al*., 2014; Obasi *et al*., 2012). By using cold processing these seeds are used for glyceride oil's production globally. The high nutritional value of oil is due to the presence of polyunsaturated fatty acids (PUFA) abundantly. The studies have shown that the main components present in melon seed oil are palmitic acid 7.8-39.36%, linoleic acid 31.0-69.0%, oleic acid 12.1-31.0%, and 4.9-10.45% of the stearic acid (Albishri *et al*., 2013; Azhari *et al*., 2014).

Various studies on the chemical composition of melon seed (*Cucumins melo* L.) were conducted. On a dry weight basis, the melon seeds are known to have 7.16% moisture, 27.41% protein, 30.65% oil, 29.96% carbohydrates, 4.83% ash, 25.32% fiber and a large number of antioxidants like phenolic compounds. Potassium, calcium and magnesium are major minerals that are present in melon (Table 1). The fatty acids present in melon seed oil included linoleic acid, as well as oleic acid, which was spotted after the investigation of oil. After the chromatographic analysis of phenolic compounds, it was shown that flavonoids are the vital group with the highest contents of amentoflavone which are 32.80 μg/g. A considerable amount of phytosterols included up to 206.42 mg/100g β-sitosterol are also present in melon seed oil. The oil is a rich source of tocopherols predominantly β+γ-tocopherol fraction. The results of various studies have revealed that melon seed oil is another source of plant oil and serves as a raw material in many food applications (Mallek *et al*., 2018).

Table 1: *Nutritional compstio of melon seed.*

Parameters	Unit (%)	References
Ash	2.12	Umar *et al*., 2013
crude fiber	23.3	Yanty *et al*., 2008
Total phenolic contents	12.456 mg/100 g	Santos *et al*., 2014
antioxidants	34.71mg/g	Rolim *et al*., 2018
Protein	35	Petkova and Antova, 2015
carbohydrates	18.69	Umar *et al*., 2013

Phenolic and antioxidants

Hydroxycinnamic acid (caffeic, sinapic, ρ-coumaric and ferulic acids) are the products of Phenyl propanoid having importance due to low molecular weight. They are generally linked with the polysaccharides present in cell walls mostly lignin and hemicellulose units. The phenolic acids like flavonoids are widely distributed in nature and relate to the defense functions and attraction of flavoring due to presence in vegetables. Polysaccharides of the cell wall comprised lignin and hemicellulose are linked to the flavonoids. Flavonoids are an important part of the phenolic acid group and extensively dispersed in nature. Flavonoids are present in vegetables and their presence may be related to the attraction of pollinators, defense function, bactericidal, astringent, flavorings, fungicidal and anti-inflammatory effects (Barbosa and Fernandes, 2014). Phosphorus and antioxidants are present in tannins. Polyphenols included phenolic acids, flavonoids, and hydrolyzable tannins which show the anti-proliferative effects. The complex interactions between the generation of reactive oxygen, carcinogenesis, and cellular damage have been checked in many studies. The oxidative stress level is usually increased in bacterial conditions like radiation, iron overload, inflammation, ultraviolet light and various carcinogenic chemicals. Oxidative stress is the main reason for the iceberg of carcinogenesis (Toyokuni, 2016).

The antioxidants are naturally present in vegetables and fruits and have enhanced interest among the scientific community and consumers due to epidemiological and nutritional evidence. These have an increasingly significant effect on chronic diseases like cancer. While, the residues of fruits and vegetables despite functional and nutritional characteristics are discarded often (Sancho *et al*., 2015).

The compounds derived from plants included lycopene, resveratrol, astaxanthin, and phenolic acids are identified for the treatment and prevention of cancer (Li *et al*., 2012; Deng *et al*., 2012). According to many studies, the antioxidants present in fruits and vegetable residue lessen the cancer risks. Besides, the consumption of Polyphenols rich foods can lead to a lower incidence of cancer. Besides, the nutrients from various sources having functional and antioxidant potential had investigated to replace their use instead of synthetic antioxidants in food products because the synthetic antioxidants can be health hazardous (Suhail *et al*., 2012).

Derivatives of phenyl propaniod are an imperative class of low molecular weight phenolic acid, the main example of which is hydroxycinnamic acids (caffeic, sinapic acids, ferulic and r-coumaric). They are commonly linked to polysaccharides of cell wall, usually lignin units and hemicellulose. Flavonoids are present in vegetables and can be related to defense function, fungicidal, the attraction of pollinators, anti-inflammatory effects, astringent, flavoring and bactericidal, as they are extensively distributed in nature as a component of a group of phenolic acids (Barbosa and Fernandes, 2014). Phosphorus and antioxidants are also present in tannins. Phenolic acids, flavonoids, and hydrolyzable tannins are the different types of polyphenols and have shown anti-proliferative effects. According to many studies the cellular damage, generation of reactive oxygen, and carcinogenesis are interrelated. In pathological conditions like radiation, iron overload, inflammation, exposure to ultraviolet light, and various intake of carcinogenic chemical compounds. The oxidative stress may be the initial of carcinogenesis (Toyokuni, 2016).

In recent years, *Cucumis melo* L. species of melon has high economic value and has increased production, but part of the fruit is wasted. Generally, during processing and consumption, the inedible parts like seeds and peels are discarded. The evaluation of antioxidants, phenolic compounds, and antiproliferative activities. The melon residues extracts were prepared and the evaluation of antioxidants, antiproliferative activities and phenolic compounds, were done. Hydroethanolic, hydroethanolic, aqueous extract of the melon peel has the phenolic compounds. Gallic acid in the concentration of 1.016 mg/100g is present in the melon seeds. The aqueous extract of melon peel contains flavonoids especially Catechin 262 μg/100g. In the melon peel extract catechin, gallic acid and eugenol are present. Keeping in view the antioxidant activity, the equivalent of ascorbic acid included 74% hydroethanolic and 89% hydroethanolic are present in peel while 83% hydroethanolic is present in seeds. Different concentrations of melon extracts have iron and copper chelating activity, mainly the aqueous extract of melon peel has 84% copper and 61% iron. The melon peel extract has hydroethanolic with a 68% hydroxyl radical scavenging activity. MTT assay was performed to check the anti-proliferative potential in the human cancer cell line included colorectal carcinoma, cervical carcinoma, cervical adenocarcinoma and kidney carcinoma. The extract in the concentration of 0.1-1.0 mg/ml inhibits the cancer cell lines up to 20-85%. The results showed that in vitro assays the extract of melon residue has a high activity of antioxidants and effective biological activity against tumor cells growth in humans (Rolim *et al*., 2018).

Health benefits of melon seed

analgesic activity and anti-inflammatory: Gill *et al*. (2011) have tested *Cucumis melo* L. var agrestis seed extract for anti-inflammatory activity in rats using carrageen induced paw edema. His analgesic function was also investigated by tail immersion as well as tail flick methods in rats. The paw edema was decreased substantially by 43.4% as well as 56.6%, accordingly, at 200 mg/ kg and 300 mg/ kg of seed extracts, resulting in a higher dosage that resulted in greater pain relief. Next, a further study led by Arora *et al*., 2011 investigated seed extract analgesic activity in albino mice and tail immersion methods in albino rats, using acetic acid induced jerking response. Anti-inflammatory effects were also studied in the same way as in the previous studies, which found that a dosage of 300 mg/ kg of seed extract reduced the rat paw's edema by 61.6 percent. Furthermore, at a dosage of 300 mg/ kg, the analgesic efficacy was 70.6% by using acetic acid-induced writhing method and a significant increase in the pain tolerance was noted in the tail immersion method after 60 min. An increase in the expression of genes identified as interluki-6 (IL-6) TNF-α (responsible for the synthesis of pro inflammatory cytokines) causes inflammation (Sharma *et al*., 2014; Amaro *et al*., 2015).

Anti-bacterial activity and anti-ulcer activity: A trial of bacterial isolates of Gram-positive bacteria (i.e. *Staphylococcus aureus, Streptococcus pyogenes, and Bacillus subtilis*), as well as three strains of Gram-negative bacteria (Shigella dysenterae, Salmonella typhimurium, and Escherichia coli), is performed in vitro in China. An anti-bacterial active agent is being researched. The results of this study therefore found that the isolated essential oil displayed antimicrobial property with a minimum inhibitory concentration of 0.5 to 5 mg / ml of sample, against all bacteria, in particular Gram-positive bacteria (Siddeeg and Alsir, 2014). Likewise, the antiulcer function of the *Cucumis melo* L. methanol extract seeds was tested using water immersion stress, pyloric ligation, and NSAIDs (indomethacin)-induced ulcer models against gastric ulcers. The results concluded that, after administration at 300 mg/ kg, the seed extract suppresses ulcers of the pyloric connection, water immersion stress and NSAID-induced ulcer models by 57.6%, respectively 67.6% and 61.9% (Sood *et al*., 2011).

Anti-hypothyroidism, anti-angiogenic and antidiabetic activity: An *in vivo* research on both normal and propylthiouracil related hypothyroid Wistar albino males rat exhibited substantial increases in thyroid hormone levels (i.e. T3 and T4) after 100 mg/ kg *Cucumis melo* L. was given. It suggested that the peel extracts had relaxing thyroid effects (Parmar and Kar, 2009). Meanwhile, an *in vitro* study was performed on the antiangiogenic activity of the *Cucumis melo* L. trypsin inhibitor. Seeds on umbilical cord vein endothelial cells' three dimensional sculpture. The results showed that the angiogenesis can be reversed by the trypsin inhibitor (Rasouli *et al*., 2017). Chen and Kang (2013) examined the role of eastern melon (*Cucumis melo* L. var. makuwa makino) in osteoplastic seeds and osteoplastic suppression. The tests showed that hexane extract prevented the optical glucoside and the nozzle amylase by 35.5% as well as 61.8%.

Anti-dyslipidemic and anti-adipogenic activity: Dyslipidemia (lipoprotein metabolism dysfunction) happens when an abnormal lipid concentration in the blood is detected. Whilst this term refers to a wide range of conditions, the most common forms of dyslipidemia include high triglycerides, high levels of low-density lipoproteins (LDL), high cholesterol or high-density lipoprotein (HDL), bad cholesterol, and high cholesterol in respect to high LDL and triglycerides (Karlund *et al*., 2014). There has been anti-adipogenic and anti-dyslipidemia activity in the flavonoids, but these activities do not look similar (Kaushik *et al*., 2015). Anti-adipogenic substances also illustrate anti-dyslipidemic activity. The anti-adipogenous activity of CMFE has been found in 3T3-L1 adipocytes to reduce the oil-red-o (furnishes that stained fats and neutral TGs) concentration-dependent accumulation (Mallek-Ayadi *et al*., 2016).

Anticarcinogenic effects of melon

Various forms of polyphenols have shown anti-proliferative effects (hydrolysable tannins, phenol acids, and flavonoids). Polyphenols may interfere in various steps of the growth of malignant tumors by defending DNA from oxidative stress, altering carcinogens and the inhibiting of the appearance of mutant genes as well as the action of prokaryote activating enzymes, and activating enzymes in the xenobiotic detoxifying system (Sabino *et al*., 2015). Oxidative stress can damage all cell components, including DNA, proteins, as well as lipid membranes and the source of cell death. The use of oxidative damage also causes damage to DNA, cell adhesion, proliferation, and survival. Laboratory and Clinical studies have shown that oxidative stress has a beneficial relationship with carcinogenesis (Sonia *et al*., 2016). In many cases, plant molecules form the basis of treatment for human disease and remain a potential source for new therapeutic drugs. In cancer research, the priority is given to phytotherapeutic compounds with strong in vitro cytotoxic function against tumor cells. In addition to toxic characteristics, cytostatic action of phytotherapeutic products can prevent the growth of the tumor and prevent metastasis. Unlike cytostatic agents that harm tumor cells, antioxidants prevent cancer in the course of carcinogenesis and are highly beneficial for cells (Benmeziane *et al*., 2018). Medicinal plants have a history of cancer treatment, mutually in traditional systems of medicine, enabling vegetable extracts to be a possible source of anti-tumor agents; approximately 60 percent of cancer-approved drugs have natural components in their source (Skrovankova *et al*., 2015). This led researchers to look for effective antioxidants and anti-tumor agents in a wide range of sources, particularly food and food waste (Ray *et al*., 2010) used human breast cancer cell MCF-7 and MDA-MB-231 and human primary mammalian epithelial cells as an in vitro model to test the effectiveness, as a cancer agent, of whole bitter melon (Momordica charantia). The findings indicated a substantial reduction in apoptotic cell death as well as cell proliferation. > 80% cell death was detected in MCF-7 as well as MDA-MB-231 cells cured with 2% bitter melon extract. The effects on oriental melon were tested in 5 human cancer cell lines such as MCF-7, HT-29, A549, as well as HepG2 in oriental melon seeds. The ethanol extract from oriental melon seeds demonstrated strong cytotoxic effects especially on the human line of hepatitis (HepG2) and human line of cell breast cancer (MCF-7). These data recommend that melon seeds in oriental ways could become a promising anti-cancer agent against human liver and breast cancer (Widowati *et al*., 2015). The anti-proliferative ability of melon residue extracts in human cell lines including carcinoma of the rectum, cervical adenocarcinoma colorectal carcinoma, and cervical carcinoma were further evaluated by the MTT assays. The proliferation of extracts in all cancer cell lines was inhibited by 20–85 percent. The cytotoxic potential of *Cucumis melo L.* extracts (3-(4, 5, 5-dimethylthiazol-2-yl) was identified by MTS (3-(3-carboxymethoxyphenyl)-2-(4-sulphophenyl)-2Htetrazolium) on HeLa, HepG2, and the NIH3T3 cell lines. Proliferation was inhibited in all cancer cell lines by 20–85%. The extract demonstrated anticancer activity both in cancer cells of HeLa (IC50: 23.649 μg / mL) as well as HepG2 (IC50: 110.403 μg / mL) (Reutter *et al*., 2017).

Conclusions and Recommendations

It is concluded that melon seed contains numerous nutritional and bioactive components. The melon seeds (*Citrullus lanatus*) have high mineral contents (mg/100g). Biologically active compounds like tocopherols, phospholipids, and sterols are present in melon seed in a large amount due to which it has a beneficial effect on humans. The percentages varied depending on the region from where seeds originate and their tested types. The presence of bioactive compounds is fully justified by melon by-products, including anti-inflammatory agents, hypoglycemic agents, antimicrobial, anti-genic and antioxidant potential.

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Novelty Statement

The melon seeds (*Citrullus lanatus*) have high mineral contents (mg/100g). Biologically active compounds like tocopherols, phospholipids, and sterols are present in melon seed in a large amount due to which it has a beneficial effect on humans.

Author's Contribution

Waseem Khalid: Presented the main idea and wrote the manuscript.
Ali Ikram: Wrote the manuscript.
Muhammad Rehan: Explained novelty in the paper.
Farukh Adeem Afzal: Review the manuscript.
Saadia Ambreen: Organized the contents in the manuscript.
Marryam Ahmad: Arranged the reeference.

Afifa Aziz: Data collection
Anam Sadiq: Helped in removing the plagiarism.

Conflict of interest

The authors have declared no conflict of interest.

References

Albishri, H.M., O.A. Almaghrabi and T.A. Moussa. 2013. Characterization and chemical composition of fatty acids content of watermelon and muskmelon cultivars in Saudi Arabia using gas chromatography/mass spectroscopy. Pharmacogn. Mag., 9(33): 58. https://doi.org/10.4103/0973-1296.108142

Amaro, A.L., A.O. Domingos and P.F. Almeida. 2015. Biologically active compounds in melon: Modulation by preharvest, post-harvest, and processing factors. Proc. Impact Active Comp. Food, Elsev., 20: 165–171. https://doi.org/10.1016/B978-0-12-404699-3.00020-2

Arora, R., M. Kaur and N. Gill. 2011. Antioxidant activity and pharmacological evaluation of Cucumis melo var. agrestis methanolic seed extract. Res. J. Phytochem., 5(3): 146-155. https://doi.org/10.3923/rjphyto.2011.146.155

Azhari, S., Y.S. Xu, Q.X. Jiang and W.S. Xia. 2014. Physicochemical properties and chemical composition of Seinat (Cucumis melo var. tibish) seed oil and its antioxidant activity. Grasas Y Aceites, 65(1): 008. https://doi.org/10.3989/gya.074913

Barbosa, T.N.R.M. and D.C. Fernandes. 2014. Bioactive compounds and diseases Cardiovascular: reviewing the scientific evidence. Studies, 41(2): 181-192.

Benmeziane, A., L. Boulekbache-Makhlouf, P. Mapelli-Brahm, N. Khodja, H. Remini, K. Madani and A.J. Meléndez-Martínez. 2018. Extraction of carotenoids from cantaloupe waste and determination of its mineral composition. Food Res. Int., 111: 391–398. https://doi.org/10.1016/j.foodres.2018.05.044

Chen, L. and Y.H. Kang. 2013. *In vitro* inhibitory effect of oriental melon (*Cucumis melo* L. var. *makuwa Makino*) seed on key enzyme linked to type 2 diabetes: assessment of anti-diabetic potential of functional food. J. Funct. Foods, 5(2): 981-986. https://doi.org/10.1016/j.jff.2013.01.008

Chen, L., Y.H. Kang and J.K. Suh. 2014. Roasting processed oriental melon (*Cucumis melo* L. var. *makuwa Makino*) seed influenced the triglyceride profile and the inhibitory potential against key enzymes relevant for hyperglycemia. Food Res. Int., 56: 236-242. https://doi.org/10.1016/j.foodres.2013.11.040

Deng, G.F., X.R. Xu, S. Li, F. Li, E.Q. Xia and H.B. Li. 2012. Natural sources and bioactivities of resveratrol. Int. J. Modern Biol. Med., 1: 1-20.

FAO, 2013. Food and Agriculture Organization of the United Nations 2013.

Gill, N.S., J. Bajwa, K. Dhiman, P. Sharma, S. Sood, P.D. Sharma, B. Singh and M. Bali, 2011. Evaluation of therapeutic potential of traditionally consumed *Cucumis melo* seeds. Asian J. Plant Sci., 10(1): 86-91. https://doi.org/10.3923/ajps.2011.86.91

Ibeto, C.N., C.O.B. Okoye and A.U. Ofoefule. 2012. Comparative study of the physicochemical characterization of some oils as potential feedstock for biodiesel production. ISRN Renew. Energy, https://doi.org/10.5402/2012/621518

Ivanova, P.H., 2012. The melons-raw material for food processing. In: 50 years Food RDI. Food technologies and health, international scientific-practical conference, Plovdiv, Bulgaria, 8 November 2012. Proc. Food Res. Dev. Inst., pp. 23-26.

Ivanov, P.C., L.A.N. Amaral, A.L. Goldberger, S. Havlin, M.G. Rosenblum, Z.R. Struzik and H.E. Stanley. 1999. Multifractality in human heartbeat dynamics. Nature, 399(6735); 461-465.

Jacob, A.G., D.I. Etong and A. Tijjani. 2015. Proximate, mineral and anti-nutritional compositions of melon (Citrullus lanatus) seeds. Br. J. Res., 2(5): 142-151.

Jeffrey, C., 1990. Systematics of the Cucurbitaceae: An overview. Biology and utilization of the Cucurbitaceae, pp. 3-9. https://doi.org/10.7591/9781501745447-003

Karlund, A., U. Moor, M. Sandell and R.O. Karjalainen. 2014. The impact of harvesting, storage and processing factors on health-promoting phytochemicals in berries and fruits. Processes, 2: 596–624. https://doi.org/10.3390/pr2030596

Kaushik, U., V. Aeri and S.R. Mir. 2015. Cucurbitacins. An Insight into Medicinal Leads from Nature. Pharmacog, 9(17): 12–18. https://doi.org/10.4103/0973-7847.156314

Kolayli, S., M. Kara, F. Tezcan, F.B. Erim, H. Sahin, E. Ulusoy and R. Aliyazicioglu. 2010. Comparative study of chemical and biochemical properties of different melon cultivars: Standard, hybrid, and grafted melons. J. Agric. Food chem., 58(17): 9764-9769. https://doi.org/10.1021/jf102408y

Laur, L.M. and L. Tian. 2011. Provitamin A and vitamin C contents in selected California-grown cantaloupe and honeydew melons and imported melons. J. Food Composit. Anal., 24(2): 194-201. https://doi.org/10.1016/j.jfca.2010.07.009

Lester, G.E., 2008. Antioxidant, sugar, mineral, and phytonutrient concentrations across edible fruit tissues of orange-fleshed honeydew melon (*Cucumis melo* L.). J. Agric. Food Chem., 56(10): 3694-3698. https://doi.org/10.1021/jf8001735

Li, F., X.R. Xu, S. Li, G.F. Deng, S. Wu and H.B. Li. 2012. Resources and bioactivities of lycopene. Int. J. Food Nutr. Saf., 1: 15-31.

Lo, T.P., M.E. Murphy, J.G. Guillemette, M. Smith and G.D. Brayer. 1995. Replacements in a conserved leucine cluster in the hydrophobic heme pocket of cytochrome c. Prote. Sci., 4(2); 198-208.

Mallek-Ayadi, S., N. Bahloul and N. Kechaou. 2016. Characterization, phenolic compounds and functional properties of *Cucumis melo* L. peels. Food Chem., 221: 1691-1697. https://doi.org/10.1016/j.foodchem.2016.10.117

Mallek-Ayadi, S., N. Bahloul and N. Kechaou. 2018. Chemical composition and bioactive compounds of Cucumis melo L. seeds: Potential source for new trends of plant oils. Process Saf. Environ. Prot., 113: 68-77. https://doi.org/10.1016/j.psep.2017.09.016

Mariod, A. and B. Matthaeus. 2008. Fatty acids, tocopherols, sterols, phenolic profiles and oxidative stability of *Cucumis melo* var. agrestis oil. J. Food Lipids, 15(1): 56-67. https://doi.org/10.1111/j.1745-4522.2007.00102.x

Obasi, N.A., J. Ukadilonu, E. Eze, E.I. Akubugwo and U.C. Okorie. 2012. Proximate composition, extraction, characterization and comparative assessment of coconut (Cocos nucifera) and melon (Colocynthis citrullus) seeds and seed oils. Pak. J. Boil. Sci., 15(1): 1-9. https://doi.org/10.3923/pjbs.2012.1.9

Onibon, V.O., F.O. Abulude and L.O. Lawal. 2007. Nutritional and anti-nutritional composition of some Nigerian fruits. J. Food Technol., 5(2): 120-122.

Oyiza, F.A., 2005. Determination of nutritional value of species of egg plants (*Selanna* spp). M.Sc. thesis, Department of Chemistry, Usmanu Danfodiyo University Sokoto, Nigeria.

Parmar, H.S. and A. Kar. 2009. Protective role of *Mangifera indica*, *Cucumis melo* and *Citrullus vulgaris* peel extracts in chemically induced hypothyroidism. Chem. Biol. Interact., 177: 254-258. https://doi.org/10.1016/j.cbi.2008.11.006

Perry, P.L., Y. Wang and J. Lin, 2009. Analysis of honeydew melon (*Cucumis melo* var. inodorus) flavour and GC–MS/MS identification of (E, Z)-2, 6-nonadienyl acetate. Flavour. Fragr. J., 24(6): 341-347. https://doi.org/10.1002/ffj.1947

Petkova, Z. and G. Antova. 2015. Proximate composition of seeds and seed oils from melon (*Cucumis melo* L.) cultivated in Bulgaria. Cogent Food Agric., 1(1); 1018779. https://doi.org/10.1080/23311932.2015.1018779

Rasouli, H., S. Parvaneh, A. Mahnam, M. Rastegari-Pouyani, Z. Hoseinkhani and K. Mansouri. 2017. Anti-angiogenic potential of trypsin inhibitor purified from Cucumis melo seeds: Homology modeling and molecular docking perspective. Int. J. Biol. Macromol., 96: 118-128. https://doi.org/10.1016/j.ijbiomac.2016.12.027

Ray, R.B., R. Amit, S. Robert and N. Pratibha. 2010. Bitter melon (Momordica Charantia) extract inhibits breast cancer cell proliferation by modulating cell cycle regulatory genes and promotes apoptosis. Cancer Res., 70: 5. https://doi.org/10.1158/0008-5472.CAN-09-3438

Ren, Y., H. Bang, E.J. Lee, J. Gould, K.S. Rathore, B.S. Patil and K.M. Crosby. 2013. Levels of phytoene and β-carotene in transgenic honeydew melon (*Cucumis melo* L. inodorus). Plant Cell, Tissue Organ Cult., 113(2): 291-301. https://doi.org/10.1007/s11240-012-0269-8

Reutter, B., P. Lant, C. Reynolds and L. Joe. 2017. Food Waste Consequences: Environmentally Extended Input-Output as a Framework for Analysis. J. Clean Prod., 153: 506–514. https://doi.org/10.1016/j.jclepro.2016.09.104

Rolim, P.M., G.P. Fidelis, C.E.A. Padilha, E.S. Santos, H.A.O. Rocha and G.R. Macedo. 2018. Phenolic profile and antioxidant activity from peels and seeds of melon (*Cucumis melo* L. var. reticulatus) and their antiproliferative effect in cancer cells. Braz. J. Med. Biol. Res., 51(4).

https://doi.org/10.1590/1414-431x20176069

Sabino, L.B.S., M.L.C. Gonzaga, D.J. Soares, A.C.S. Lima, J.S.S. Lima, M.M.B. Almeida, P.H.M. Sousa and R.W. Figueiredo. 2015. Bioactive compounds, antioxidant activity, and minerals in flours prepared with tropical fruit peels. Acta Aliment., 44(4): 520–526. https://doi.org/10.1556/066.2015.44.0023

Sancho, S.D.O., A.R.A. Silva, A.N.D.S. Dantas, T.A. Magalhães, G.S. Lopes, S. Rodrigues and M.G.D.V. Silva. 2015. Characterization of the industrial residues of seven fruits and prospection of their potential application as food supplements. J. Chem., 2015: 8 pages. https://doi.org/10.1155/2015/264284

Santos, J., M.B.P.P. Oliveira, E. Ibáñez and M. Herrero. 2014. Phenolic profile evolution of different ready-to-eat baby-leaf vegetables during storage. J. Chromatogr. A, 1327: 118-131. https://doi.org/10.1016/j.chroma.2013.12.085

Sharma, S.P., D.I. Leskovar, K.M. Crosby, A. Volder and A.M.H. Ibrahim. 2014. Root growth, yield, and fruit quality responses of reticulatus and inodorus melons (*Cucumis melo* L.) to deficit subsurface drip irrigation. Agric. Water Manage. 136: 75–85. https://doi.org/10.1016/j.agwat.2014.01.008

Siddeeg, A. and E. Alsir. 2014. Chemical composition and antibacterial activity of the essential oil isolated from Seinat (*Cucumis melo* var. *Tibish*) seeds. Int. J. Technol. Enhancements Emerg. Eng. Res., 2(8): 120-124.

Skrovankova, S., D. Sumczynski, J. Mlcek, T. Jurikova and J. Sochor. 2015. Bioactive Compounds and Antioxidant Activity in Different Types of Berries. Battino M, Ed. Int. J. Mol. Sci., 16(10): 24673–24706. https://doi.org/10.3390/ijms161024673

Sonia, N.S., C. Mini and P.R. Geethalekshmi. 2016. Vegetable peels as natural antioxidants for processed foods. A review. Agriculture, 37(1): 35–41. https://doi.org/10.18805/ar.v37i1.9262

Sood, S., N.S. Gill, B. Singh, P. Sharma, K. Dhiman, M. Bali, P.D. Sharma and J. Bajwa. 2011. Evaluation of antioxidant and antiulcer activity of traditionally consumed *Cucumis melo* seeds. J. Pharmacol. Toxicol., 6(1): 82-89. https://doi.org/10.3923/jpt.2011.82.89

Suhail, N., N. Bilal, H.Y. Khan, S. Hasan, S. Sharma, F. Khan and N. Banu. 2012. Effect of vitamins C and E on antioxidant status of breast- cancer patients undergoing chemotherapy. J. Clin. Pharm. Therapeut., 37(1): 22-26. https://doi.org/10.1111/j.1365-2710.2010.01237.x

Tabuti, J.R.S., S.S. Dhillion and K.A. Lye. 2004. The status of wild food plants in Bulamogi County, Uganda. Int. J. Food Sci. Nutr., 55(6), 485-498. https://doi.org/10.1080/09637480400015745

Toyokuni, S., 2016. Oxidative stress as an iceberg in carcinogenesis and cancer biology. Arch. Biochem. Biophys., 595: 46-49. https://doi.org/10.1016/j.abb.2015.11.025

Umar, K.J., L.G. Hassan, H. Usman and R.S.U. Wasagu. 2013. Nutritional composition of the seeds of wild melon (Citrullus ecirrhosus). Pak. J. Biol. Sci., 16(11): 536-540. https://doi.org/10.3923/pjbs.2013.536.540

Umaru, H.A., R. Adamu, D. Dahiru and M.S. Nadro. 2007. Levels of antinutritional factors in some wild edible fruits of Northern Nigeria. Afr. J. Biotechnol., 6(16): 1935-1938. https://doi.org/10.5897/AJB2007.000-2294

Widowati, W., R.M. Widyanto, D.R. Laksmitawati, P.P. Erawijantari, L. Wijaya and F. Sandra. 2015. Phytochemical, free radical scavenging and cytotoxic assay of *Cucumis melo* L. Extract and β-Carotene. J. Adv. Agric. Tech., 2(2): 114–119. https://doi.org/10.12720/joaat.2.2.114-119

Yanty, N.A.M., O.M. Lai, A. Osman, K. Long and H.M. Ghazali. 2008. Physicochemical properties of *Cucumis melo* var. inodorus (honeydew melon) seed and seed oil. J. Food Lipids, 15(1): 42-55. https://doi.org/10.1111/j.1745-4522.2007.00101.x