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CANTALOUPE SEEDS: ACTIVITIES AND BENEFITS A COMPLETE GUIDE

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***Abstract:* -** Melon (Cucumis melo L.) has a high economic value, and its production has increased in recent years; however, a portion of the fruit is wasted. During processing and consumption, inedible parts such as peel and seeds are typically discarded. Melon residue extracts were studied and their phenolic compounds, antioxidants, and antiproliferative activities were investigated. Melon, due to its pleasant taste and diverse chemical composition, is an excellent source of biologically active compounds for humans. Melon contains glucose, fructose, vitamin A, D, C, K, E, and some vitamins from group B. Total phenolic compounds were discovered in hydroethanolic, hydromethanolic, and aqueous extracts, particularly melon peel (1.016 mg gallic acid equivalent/100 g). The total flavonoid content of melon peel aqueous extract was found to be 262 mg of catechin equivalent (CA)/100 g. Significant amounts of gallic acid, catechin, and eugenol were found in all melon peel extracts. Total antioxidant capacity, expressed as ascorbic acid equivalent, was 89, 74, and 83 mg/g for hydroethanolic and hydromethanolic extracts in peels and hydromethanolic extracts in seeds, respectively. Cold pressing was used to extract the oil from the seeds, which was then tested for parameters such as iodine value, saponification value, and fatty acid profile. The findings revealed a high iodine value as well as the presence of polyunsaturated fatty acids like omega-6 (linoleic acid) and monounsaturated fatty acids like omega-9 (oleic acid). It also contains saturated fatty acids like palmitic and stearic acid. The seeds offer potential for development as value-added products, dietary supplements, and medicines.

***Keywords:* -** Musk Melon seeds, Nutritional Analysis, Phytochemical Analysis, Antioxidant Activity

Introduction

The conscious production model has become one of the major challenges to be addressed today [46], given the remarkably high waste of natural resources, notably evidenced, which requires the awareness of individuals regarding the control of waste generation [8]. In this sense, reducing food waste is essential for a sustainable food system to guarantee food and nutritional security [1], translating into prevention practices such as integral use of food [11].

Because of the large amounts of peels and seeds that are typically discarded, the fruit juice industry is a major producer of food waste. However, these by-products, particularly those high in vitamins, minerals, fiber, oils, and bioactive compounds with functional properties, have a high potential for inclusion in the human diet [46].

Botanical description, distribution and cultivation regions of melon

Melon (Cucumis melo L.) is a significant horticultural crop in many parts of the world. It is grown in temperate climates in Europe, Asia, and Africa, and it can also be found in arid areas. Angola, Cape Verde, China, India, Japan, Nepal, Indonesia, and Australia are all home to wild melon [18] [37]. The origin of the melon is a source of contention because, according to Kirkbride's monograph, Africa appears to be the main centre of melon diversity. C. melo L., on the other hand, originated in Africa, according to [39] but its central diversity is Asia, from Turkey to Japan [14].

Although melon is the most common name, it is also known as sweet melon, round melon, muskmelon, casaba, cantaloupe, and winter melon [18]. Because both ripe fruits are large and often sweet, C. melo L. is frequently confused with watermelon, Citrullus lanatus [34]. Melon is classified as a member of the Cucurbitaceae family (Table 1), which includes 825 species such as cucumber, pumpkins, watermelon, and squash [21] [49]. Because the morphology of its fruits varies greatly in characteristics such as size, shape, colour, texture, and flavour, it is considered one of the most diverse species in the genus Cucumis [26]. Naudin developed a classification system for C. melo L. in 1859, subdividing it into ten varieties.

Table 1. Taxonomic classification of Cucumis melo L. [21]

Rank	Scientific name
Kingdom	***Plantae***
Subkingdom	Viridiplantae
Superdivision	Embryophyta
Division	Tracheophyta
Class	Magnoliopsida
Superorder	Rosanae
Order	Cucurbitales
Family	Cucurbitaceae
Genus	Cucumis
Species	Cucumis melo L

Table 2. Centesimal Composition, Dietary Fiber, and Energy Value of Cantaloupe (Cucumis melo L. var. reticulatus) melon seed flour.[11]

Components	% on a wet basis
Moisture	*2.64 (0.34)**
Ash	*4.12 (0.12)**
Lipids	*30.43 (0.45)**
Proteins	*17.64 (0.93)**
Dietary Fiber	*35.48 (0.8)**
Carbohydrates	*9.70*
Caloric Value	*(Kcal/100 g) 425.41*

*Average and standard deviation

According to Table 2, the moisture content in MSF was low (2.64 percent), which contributes to the preservation of organoleptic properties and microbiological quality, in addition to meeting the specific requirements for flours, cereal starch, and sharps, which set a maximum quantity equivalent to 15.0 percent [7]. Furthermore, the seeds' inherent low humidity, which is associated with the drying process to which they were subjected, allows for the concentration and preservation of nutrients, reducing perishability and promoting long-term use [3, 25].

Moisture, ash, and carbohydrate results are comparable to those obtained in studies by Petkova and Antova [46], in which the authors investigated the centesimal composition of seeds from three different species of Cucumis melo L. melon from Bulgaria (Honeydew Dessert 5 and Hybrid1), as well as Umar et al. [46], which investigated the physicochemical composition of Citrullus ecirrhosus melon seeds.

Based on the centesimal composition and dietary fiber analysis results, the raw material extracted from melon seeds is an ideal alternative source of functional food to promote health due to the high protein (17.64), lipid (30.43), and fiber content (30.43). [27] examined the dry seeds of Cucumis melo melon and discovered lipid values (37.17 percent) similar to those found in this study, though the dietary fiber values were lower. [41] demonstrated in a review study that the protein levels in Cucumis melo L. melon seeds ranged from 15% to 36%. Cantaloupe melon seeds contained the following nutrients in 100g of sample, according to Moura Rolim et al. [29]. 3.1g moisture; 22.06g protein; 24.56g lipids; and 15.4g total fiber.

The fiber content obtained in the MSF analysis (35%) stands out as a result of the current study. A product is considered a source of dietary fiber if it contains at least 6% of this nutrient. In addition to providing a significant amount of this nutrient, it was discovered that melon seed flour is high in lipids and protein, making it ideal for use as an ingredient in the production of any food [6].

Table 3. Values of minerals in Cantaloupe melon (Cucumis melo L. var. reticulatus) seed flour.[11]

Minerals	Values (mg/100 g)	Standard Deviation (SD)
Calcium	36.54	0.041
Copper	1.61	0.003
Total Chromium	0.01	0.000
Iron	5.42	0.003
Total Phosphorous	1507.62	0.523
Magnesium	504.03	0.171
Manganese	4.43	0.002
Total Nickel	0.08	0.000
Potassium	957.35	0.414
Selenium	0.00	0.000
Sodium	18.50	0.121
Zinc	8.38	0.003

The Dietary Reference Intakes—DRI's[25] for minerals for men and women aged 19–70 years are as follows: Cr (35 106 and 25 106 mg/d), Mg (400–420 and 310–320 mg/d), P (700 mg/d, both genders), and Zn (11 and 8 mg/d) intakes should not exceed K (4,700 mg/d) and Na (1,500 mg/d).

The minerals found in this study (P, K, Mg) were similar to those found by Pimentel et al. [12]. Furthermore, Azhari et al. [17] discovered corresponding calcium (Ca) and copper (Cu) results while revealing higher potassium (9,548.33 mg/100 g), sodium (386.13 mg/100 g), zinc (44.03 mg/100 g), iron (81.17 mg/100 g), magnesium (3,299.27 mg/100 g), and manganese (15.20mg/100 g) concentrations in the oil extracted from Cucumis melon.

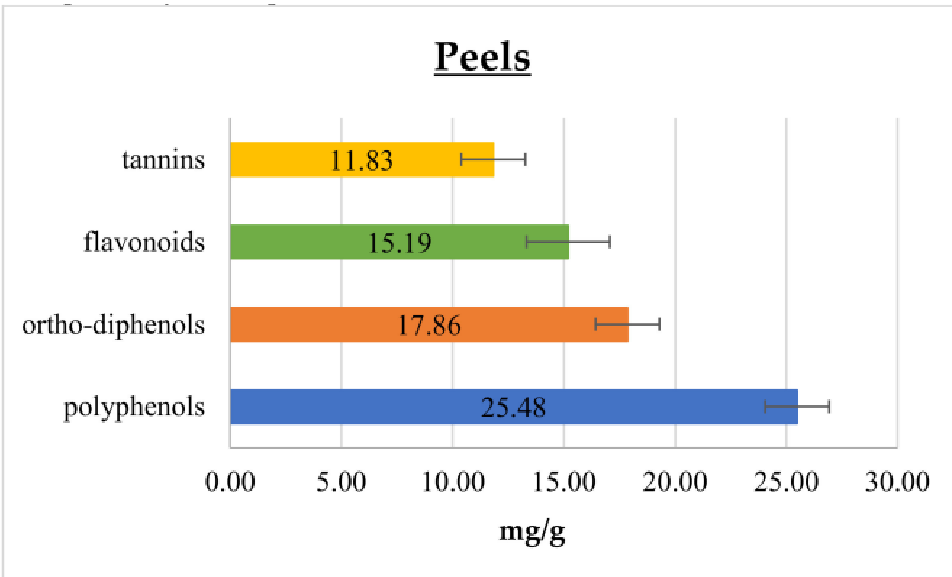

Figure 1. Polyphenol, ortho-diphenol, flavonoid and tannin content in cantaloupe peels

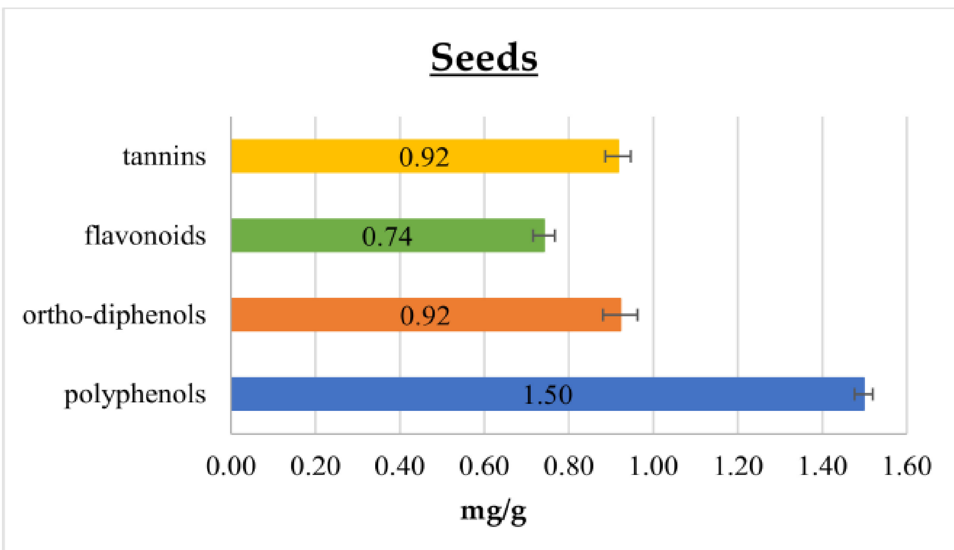

Figure 2. Polyphenol, ortho-diphenol, flavonoid and tannin content in cantaloupe seeds.

The polyphenol content in peels was 25.48 ± 1.44 mg GAE/g, which is 6 and 8 fold higher than that reported by Isamil et al. [8] and Mallek-Ayadi et al. [42], respectively. This disparity could be attributed to a variety of factors, including cultivar, degree of ripening, and environmental elements such as climatic conditions and geographical origin [30,27,44]. Conversely, the polyphenol content of cantaloupe seeds was 1.50 ± 0.02 mg GAE/g, which corresponds to the range reported in the literature [8,42].

Polyphenols are found in both edible and non-edible plant parts and are necessary for plant growth and reproduction. They also play a significant role in modulating the defence response against insects, pathogens, and microorganisms. Furthermore, they play an active role in the colour, flavour, taste, and appearance of fruits. Ortho-diphenols are the most important phenolics in terms of antioxidant activity because they can improve radical stability by forming an intra-molecular hydrogen bond between the hydrogen and phenoxyl radicals.

According to Figures 1 and 2, the ortho-diphenols content in peels and seeds was 17.86 ± 1.43 and 0.92 ± 0.04 mg CAE/g, respectively. To the best of our knowledge, data on ortho-diphenols in cantaloupe have never been reported. Flavonoids are the most common and widely distributed group of plant phenolics, and they are very effective antioxidants [13]. As shown in Figures 1 and 2, cantaloupe peels had the highest flavonoid content of 15.19 1.88 mg CE/g, while seeds had 0.74 ± 0.03 mg CE/g.

Furthermore, these components had higher content values for total phenolic compounds than those reported in the literature [8,42]. Furthermore, flavonoid content, like polyphenols, is subject to many sources of variation, including genotype, fruit ripening, plant phenotypic state, and pedoclimatic conditions [30,27,44]. Tannins have long been thought to be beneficial to human health due to their anti-carcinogenic and anti-mutagenic properties, as well as antimicrobial, antioxidant, and antiradical properties.

Tannin content was higher in peels than in seeds in this study, with 11.83 ± 1.44 and 0.92 ± 0.03 mg GAE/g, respectively. Many studies [46,8,42] compare the polyphenolic and flavonoid contents of different parts of cantaloupe, but tannins were never assessed. Because phenolic compounds are known to protect cellular components from free radicals, the antioxidant properties of cantaloupe peels and seed extracts were assessed using the FRAP assay and the DPPH radical scavenging activity.

The FRAP assay, described by Benzie and Strain [27], measures the reduction of a ferric 2,4,6-tripyridyl-s-triazine complex (Fe3+-TPTZ) to the ferrous form (Fe2+-TPTZ) in the presence of an antioxidant compound. The antioxidant ability of peels was higher than that of seeds, as measured by the FRAP assay, with values of 12.27 ± 1.22 mg AAE/g and 0.31 ± 0.02 mg AAE/g, respectively.

Table 4. Antioxidants content and activity in cantaloupe peels and seeds. Antioxidant Power (mg AAE/g)[19,20]

	*Antioxidant Power (mg AAE/g) **	*EC50 (mg/mL) ***
Peels	12.27 ± 1.22	6.65
Seed	0.31 ± 0.02	55.03

*The antioxidant power was measured by FRAP assay; EC50 was calculated by DPPH assay.**

The DPPH assay was used to assess the scavenging activity, which was based on the reduction of the DPPH radical to hydrazine as a result of the extracts' antiradical activity. Similarly, to the FRAP assay results, scavenging activity in peel extracts was higher, with an EC50 after 15 minutes of 6.65 mg/mL, whereas seed extracts had an EC50 of 55.03 mg/mL, indicating a lower antioxidant activity of this latter cantaloupe by-product. These findings were consistent with previous research: in particular, the cantaloupe peel extract in our study proved to be 1.4 times more active than the results published by Isamil et al. [18,20].

In contrast, seed extract demonstrated half the activity observed and reported by Isamil et al. [18,20]. The DPPH assay results indicate that extracts are capable of scavenging free radicals via electron or hydrogen-donating mechanisms. Furthermore, the DPPH activity of these cantaloupe by-products exhibited similar behaviour to the polyphenols, ortho-diphenols, flavonoids, and tannins content, indicating that the amount of phenolic compounds is related to the amount of radical scavenging activity of cantaloupe peels and seeds extracts.

Morphological analysis

SEM micrographs revealed some spherical particles of varying diameters (Fig 4), the majority of which had smooth surfaces (Fig 4D, 4E, and 4F), homogeneous size, granular appearance, and the formation of structural groupings. The presence of hemicellulose and lignin (the main components) was linked to the presence of dietary fibers and cell wall constituents (cellulose), which involved spherical particles (Fig 4B) [29, 27]. The melon seed is divided into three distinct layers: tegument, endosperm cells (middle seed layer), and perisperm (inner seed layer).

The integument can be defined as the wall of the seed, also called the endocarp. The resistance to digestion, even after the treatment methods, indicated an external layer consisting of fibrous, mostly insoluble, filaments (Fig 4C, 4D and 4F), protecting the embryo and the endosperm (Fig 4A and 4B), allowed for the storage of proteins and lipids [27]. The protein presence in melon seed flour, involving starch grits, may be responsible for restricting their contact with digestive enzymes. Thus, it is believed that proteins act as a physical barrier that limits the access of these enzymes [46]. The representation of a structured arrangement with a strong tegumentary presence reflects the permanence of seed peel remnants, reaffirming the high concentration of dietary fiber [37].

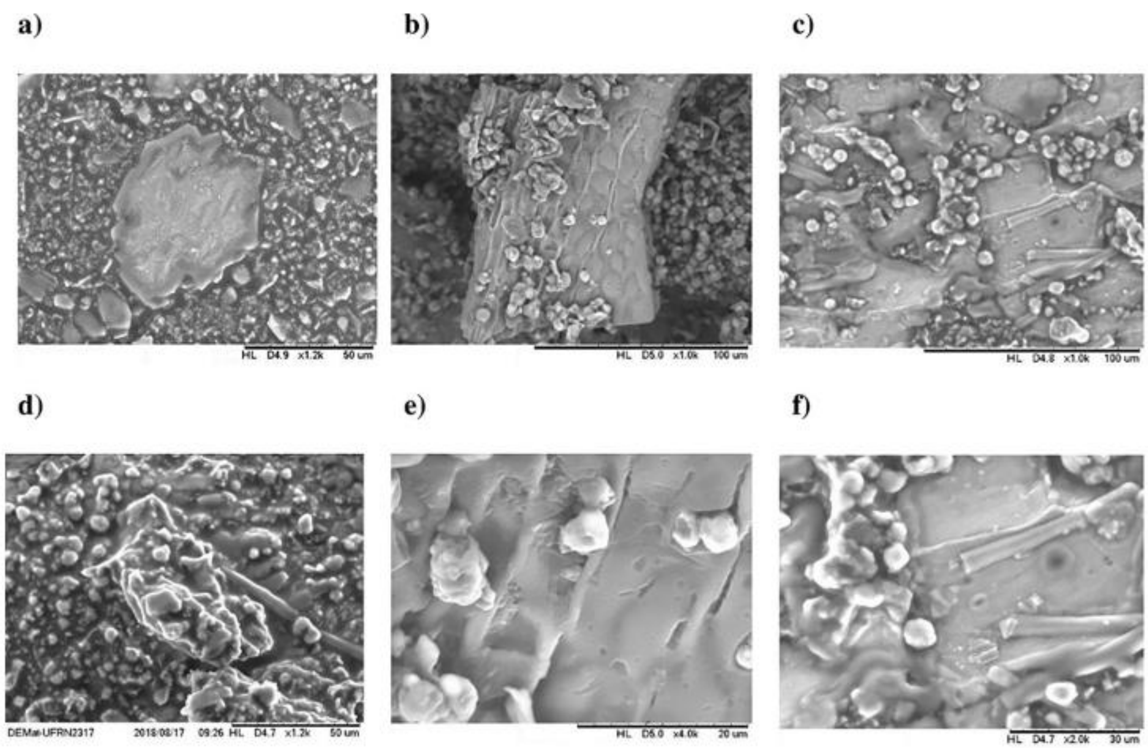

Figure 4. Scanning electron microscopy of cantaloupe melon (curcumis melo l. Var. Reticulatus) seed flour; (a) 1,2 k, (b)1,0 k, (c) 1.0 k, (d) 1,2 k, and 4,0 k and (f) 2,0 k. Fig 4 e represents two configurations: the heaviest particle indicates a higher atomic number; therefore it has a stronger glow (clearest picture). In contrast, the lighter elements (lower atomic numbers), stand out because they are darker.

Activities by Cantaloupe Seeds

1. Antiulcer activity

The antiulcer activity of methanolic extracts of C. melo L. [14] was investigated using three models: pyloric ligation, water immersion stress, and indomethacin-induced ulcer models. On a rotary evaporator, the methanolic extracts were evaporated and concentrated. The concentrated filtrate was partitioned with hexane after suspension in distilled water, and its aqueous phase was separated and concentrated in a water bath. For an 8-day period, melon seed extracts were given at concentrations of 150 and 300 mg/kg. The authors reported ulcer inhibition percentages of 41.0 percent and 57.6 percent for the pyloric ligation model at concentrations of 150 and 300 mg/kg, respectively.

In the water immersion stress model, melon seed extracts inhibited ulcers by 52.3 percent and 67.6 percent at doses of 150 and 300 mg/kg, respectively. Finally, extracts from C. melo seeds inhibited indomethacin-induced ulcers by 51.3 and 61.9 percent at 150 and 300 mg/kg doses, respectively [14]. These findings suggest that C. melo seed extracts have antiulcer activity [14]. This activity has been linked to decreased vascular permeability, free radical generation, lipid peroxidation, and mucosal barrier strengthening. The presence of triterpenoids and sterols may be responsible for these actions [14].

2. Anti-inflammatory and analgesic activity

The analgesic potential of C. melo L. seeds was assessed using tail and tail immersion methods [16]. Melon seed methanolic extract inhibited the formation of free radicals produced during pain stimulation, implying analgesic properties. The carrageenan-induced rat paw edoema assay was also used to investigate the anti-inflammatory effect. Under reduced pressure, the methanolic extracts were evaporated and concentrated. The filtrate was then suspended in distilled water and partitioned with hexane in stages. After that, the aqueous layer was concentrated in a water bath.

The authors gave carrageenan-induced paw edoema rats the final extract of C. melo seeds orally and found that doses of 200 and 300 mg/kg reduced paw edoema by 43.4 percent and 56.6 percent, respectively. A suspension of carrageenan (1%) was administered subcutaneously to induce edoema, and diclofenac sodium was used as the standard drug [16].

Rats were given orally extracts of C. melo var. agrestis seeds [4]. The melon seeds were extracted in methanol and three doses (100, 200, and 300 mg/kg) were tested after the solvent was removed. The authors discovered that the most concentrated extract inhibited edoema by 61.6 percent after 3 hours. These findings show that melon seed extracts have anti-inflammatory activity [4].

3. Antidiabetic activity

Type 2 diabetes is distinguished by a rapid rise in blood glucose levels caused by starch hydrolysis (pancreatic -amylase) and glucose absorption in the small intestine (-glucosidase). This can be controlled in part by inhibiting the activities of these two enzymes involved in carbohydrate digestion [23]. [9] The inhibitory effect of C. melo L. on -glucosidase and -amylase was investigated. Hexane extracts of oriental melon seeds inhibited both enzymes with a 61.8 percent inhibitory effect for amylase and 35.3 percent inhibitory effect for glucosidase. [9] The effect of melon seed roasting temperature on glucosidase and amylase inhibition ability was investigated.

Hexane extracts were prepared from raw seeds and subjected to various roasting temperatures before being re-dissolved in DMSO. The extracts of raw seeds subjected to various roasting temperatures (150 °C, 200 °C, 250 °C, and 300 °C) inhibited amylase by 61.8, 60.9, 50.5, 72.0, and 45.7 percent, respectively. In terms of glucosidase inhibition, the extract of melon seeds subjected to a roasting temperature of 250 °C demonstrated the highest percentage of inhibition [10].

4. Anti-hypothyroidism effects

Studies with the influence of extracts of mango, watermelon and melon peels on serum levels of thyroid hormones (T3 and T4) [37], in healthy normal and propylthiouracil hypothyroid rats. The extracts were obtained using methanol as extraction solvent at 30 °C. After filtration, the filtrate was dried under vacuum. The three extracts increased serum T3 and T4 concentrations, indicating that they have thyroid stimulating activity, however only when administered individually [37].

5. Antibacterial activity

Antibacterial activity of C. melo L. seeds essential oil against Gram-positive bacteria (Streptococcus pyogenes, Staphylococcus aureus, and Bacillus subtilis) and Gram-negative bacteria (Salmonella typhimurium, Shigella dysenterae, and Escherichia coli) [38]. According to the findings, the essential oil has the highest antibacterial inhibition against S. aureus and is more effective against Gram-positive bacteria [38].

6. Antioxidant activity

The antioxidant power attributed to melon by-products is essentially due to the presence of specific compounds, namely polyphenols and flavonoids. Determination of the 2,2-diphenyl-1-picrylhydrazylradical (DPPH) inhibition and the hydroxyl radical scavenging ability of methanolic extracts obtained from different parts (skin, leaf, stem, flesh and seed) of cantaloupe melon [18,20].

The methanolic extracts were subjected twice to the extraction procedure and, after that, the methanol was removed from the filtrates under reduced pressure. An IC 50 value for melon skin of 9.58 ± 0.37 mg/mL was found for the DPPH inhibition assay. For the hydroxyl radical scavenging activity, a value of 39.11 ± 2.921 g dimethyl sulphoxide (DMSO) equivalents/g extract was found [18,20]. In an other study, exposed methanolic extracts of C. melo var. agrestis seeds to hydrogen peroxide radical action and DPPH [4]. The methanolic extracts showed a radical inhibition of 75.59% at a concentration of 300 µg/mL. For hydrogen peroxide scavenging activity, the methanolic extracts achieved 69.86% at a concentration of 400 µg/mL [4].

Potential and current applications

After salting or roasting, melon seeds are consumed directly by humans in Arab countries as snacks. They are dried and used to flavour dishes and desserts in India.

Furthermore, melon seed oil is used as a cooking oil in some African and Middle Eastern countries [26][25].

A beverage made from melon seeds was created and tested by a panel of tasters to determine its nutritional value and acceptability [21]. According to the findings of this study, this drink is a good source of minerals (magnesium and iron) and protein, and it was well received by the panel of tasters as an alternative drink.

The effects of adding different concentrations of melon seed protein concentrate and isolate to wheat flour on the physical properties and chemical composition of bread fortified with melon seed proteins were studied [39].

They came to the conclusion that 15% wheat flour supplemented with melon seeds protein concentrate and isolate can be used to make bread without affecting its sensory properties. They discovered an increase in protein composition, fibre, and amino acids, making melon seeds an appealing ingredient for bread and other baked goods [39]. [38] The authors combined melon seed oil with peanut oil and assessed its influence on physicochemical composition, oxidative stability index, and organoleptic properties of the oils and their blends.

The obtained results revealed a high degree of similarity between that mixture and other edible oils. Furthermore, combining the beneficial properties of two oils into one can help to improve the nutritional and functional qualities of the oil [38]. [2] have created a new cake formulation and production using sharlyn melon peel and watermelon rinds. When compared to a cake made entirely of wheat flour, the newly formulated cake batter contained more bioactive components. The authors also suggested a 5% substitution of wheat flour for the production of an acceptable cake [2].

The nutritional composition of Musk melon seeds has revealed that they are potential sources of energy, protein, fat, and carbohydrates. They were found to be high in calcium, magnesium, phosphorus, and potassium. Musk melon seeds are high in valuable bioactive compounds and have the potential to be used as nutraceuticals. The seeds have the potential to be developed into medicines, cosmetics, value-added products, and dietary supplements. Musk melon seed oil was discovered to be high in unsaturated fatty acids, which may have health benefits.

Conclusion and future perspectives

Melon by-products are a potential source of natural food ingredients that can be used to enrich and create novel foods with health and well-being promoting properties. Melon seed oil has piqued the interest of many people due to its similarity to some of the most commonly used vegetable oils, such as soybean and sunflower oils. Melon seeds, based on their chemical composition, can be considered a good source of important nutrients and can be used as a dietary supplement in relevant applications. The use of melon by-products is also an important aspect of food waste management and can help several industries produce more sustainably (e.g. food, cosmetics).

To achieve this, it is necessary to continue research on new bioactive compounds, optimise environmentally friendly extraction techniques, and investigate the sensory aspects of new food products containing melon byproducts, such as functional foods. It is also critical to implement strategies that ensure the viability of the processes used in order to scale up to the industrial level and ensure the valorisation of the nutritional and functional potential of melon by-products as well as the sustainability of the final product.

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