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Chemical composition and bioactive compounds of *Cucumis melo* L. seeds: Potential source for new trends of plant oils

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ABSTRACT

Studies were conducted on the chemical composition of melon (*Cucumis melo* L.) seeds, Maazoun variety. Melon seeds were found to contain (on a dry weight basis): moisture (7.16%), oil (30.65%), protein (27.41%), ash (4.83%), carbohydrate (29.96%), fibers (25.32%) and considerable amounts of antioxidant substances as phenolic compounds. The major mineral elements were: potassium, magnesium and calcium. The chemical composition of oil extracted from melon seeds was investigated. The main fatty acids of melon seed oil were linoleic acid and oleic acid. The chromatographic analysis of phenolic compounds showed that flavonoids were the most important group with predominance of amentoflavone (32.80 μg/g). Besides, melon seed oil presented considerable amounts of phytosterols in which β-sitosterol was the major sterol accounting for 206.42 mg/100 g. The seed oil was also found to be rich in tocopherols with a predominance of β+γ-tocopherol fraction. The obtained results revealed that melon seeds presented an alternative source of plant oil which may serve as raw material for food applications.

1. Introduction

There is a worldwide concern regarding fruits by-products, which are annually generated in great volumes by fruit-processing industries. Fruits by-products are made up of peels, rinds, seeds, and unused flesh, that have normally no further usage and they are commonly wasted or discarded. These agro-industrial residues represent a serious problem and need to be managed. Fruits have been recognized as natural sources of bioactive compounds such as vitamins, phenolic compounds, dietary fibers and carotenoids (Silva et al., 2014; Mallek-Ayadi et al., 2017). Fruit seeds are often considered as waste products but in recent years they have received growing interest due to the important nutritional and medicinal properties of their bioactive components. In addition, seeds could be considered as renewable resources from which several useful products can be derived. Indeed, due to the growing trend of replacing fats from animal origin with those of vegetables, some industries nowadays are returning to the use of natural raw materials for the production of oil. Thus, fruit seeds can be used for the extraction of plant oils which contain a great number of valuable biocomponents and natural antioxidants (Górnaś et al., 2015; Górnaś and Rudzińska, 2016).

The *Curcurbitaceae* family, also referred to as cucurbits, is a group of fruit producing plants which is interesting because of the extensive range of medicinal properties they have been reported to exhibit (Dhiman et al., 2012). Melon (*Cucumis melo* L.) belongs to the *Cucurbitaceae* family which is a medium-sized plant family found in warm regions of the world. Melon presents high potential for consumption due to the exceptional taste of the flesh. During processing of melon fruit, large quantities of by-products are generated. Much of these materials are composed by melon seeds which are generally discarded. In fact, the amount of melon seeds recovered from fruit processing industry has been estimated to 738 thousands of tons, based on the data of fruit production (FAOSTAT, 2015). However, melon seeds could have a potential use as a source of nutrients and bioactive compounds. In fact, melon seeds are excellent sources of protein and oil and they are utilized directly for human consumption as snacks after salting and roasting in Arabian countries (Al-Khalifa, 1996). They are usually dried and used to add flavor to Indian dishes and desserts (Maran and

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Priya, 2015). Melon seeds are also a good source of natural antioxidants and may serve as food ingredients for maintaining shelf life (Zeb, 2016). Moreover, melon seed oil is frequently used as cooking oil in some countries in Africa and the Middle East (Hemavathy, 1992). In this respect, a study of the biologically active compounds of melon seed oil is of capital importance and should be undertaken to valorize agricultural by-products.

The present paper aims to study the chemical composition of melon seeds and to investigate the bioactive compounds of melon seed oil including fatty acids, polyphenols, phytosterols and tocopherols. Obtained results could promote the potential applications of melon processing by-products.

2. Material and methods

2.1. Chemicals and standards

Ethanol (≥99.9%), methanol (99.0%), heptane (99.0%) and chloroform (99.1%) were purchased from Riedel-de Haën (Steinhein, Germany). Diethyl ether (≥99.7%), *n*-hexane (99.0%) and acetonitrile (99.9%) were supplied by Merck (Darmstadt, Germany). Hydrogen peroxide (H_2O_2) and potassium hydroxide (88.5%) were obtained from Sigma-Aldrich (Sternheim, Germany). Folin Ciocalteu reagent and sodium carbonate (Na_2CO_3) were purchased from Sigma Chemical (Co., St. Louis, MO, USA). Aluminium trichloride ($AlCl_3$) was acquired from Merck (Darmstadt, Germany). The standards of fatty acids methyl esters (>99.0%) and sulphuric acid (H_2SO_4) were obtained from Sigma-Aldrich (St. Louis, MO, USA). Phenolic compound standards of *p*-hydroxyphenyl acid, gallic acid, *p*-coumaric acid, *m*-coumaric acid, 3-hydroxybenzoic acid, 4-hydroxybenzoic acid, caffeic acid, cinnamic acid, syringic acid, vanillic acid, isovanillic acid, ferulic acid, protocatechuic acid, chlorogenic acid, rosameric acid, phenyl acetate, catechol, resorsinol, pinoresinol, naringenin, 2.4-D pestanal, quercetin and flavone were acquired from Sigma-Aldrich (St. Louis, MO, USA). Catechin acetate, catechin hydrate, rutin, oleuropein, verbascoside, tyrosol, hydroxytyrosol, luteolin, luteolin-7-glucoside, and apigenin-7-glucoside standards were purchased from Extrasynthèse (Genay, France). Phytosterol standards (>95% of purity) were acquired from Sigma-Aldrich (St. Louis, MO, USA). Standards of α-, β-, γ-, and δ-tocopherols with degrees of purity of 99.9, 98.0, 99.4, and 99.6%, respectively were purchased from Sigma Chemical (Co., St. Louis, MO, USA).

2.2. Seed material

Mature fruits of melon (*C. melo* L.) Maazoun cultivar were obtained from plants in the same locality, Skhira, 80 Km far from governorate of Sfax in south of Tunisia (geographical location: lalitude 38°94′N; longitude 9°21′E), during the summer season. The melon fruits were immediately peeled and seeds were carefully separated by hand from the pulp, cleaned and washed of any adhering residue. Then, damaged seeds were removed, and the remaining seeds were oven-dried at 40 °C for 24 h. Dried seeds were grounded in a mill (Moulinex, France). The seed powder was preserved in hermetic bags at −20 °C until analyses and oil extraction.

2.3. Chemical composition of melon seeds

Moisture, water activity, fat, protein, carbohydrates, fibers, ashes and minerals contents, as well as functional properties of melon seeds samples were determined in triplicate.

2.3.1. Moisture content and water activity

Moisture was determined according to the AOAC 930.15 (1997) (AOAC, 1997); the results are expressed in percentage. The water activity (a_w) of melon seeds was directly measured using a "NOVASINA" apparatus (AW Sprint TH-500) at 25 °C.

2.3.2. Fat content

The fat content of the melon seeds was determined using a Soxhlet extraction apparatus with hexane for 8 h (AOAC, 1997). The solvent was then removed using a rotary evaporator under reduced pressure.

2.3.3. Protein content

Total protein of melon seeds was determined by the Kjeldahl method (AOAC, 1997). Protein was calculated using the general factor (6.25) (Ortiz et al., 2006). Data were expressed as percentenge of dry weight.

2.3.4. Carbohydrate content

Carbohydrate content of the melon seeds was estimated by difference of mean values: 100-(sum of percentages of moisture, ash, protein and lipids) (Lima et al., 2014).

2.3.5. Dietary fibers

Insoluble and soluble dietary fibers were obtained according to the AOAC enzymatic-gravimetric method of Prosky et al. (1988). Total dietary fiber was determined by summing the total amount of both insoluble dietary fiber and soluble dietary fiber. Dietary fibers were expressed as percentage of dry weight.

2.3.6. Ash and mineral contents

Ash and mineral contents were determined by carbon removal from about 2 g powdered seed which was ignited and incinerated in a muffle furnace at about 550 °C for 4 h (AOAC, 1997). The flask was removed from heat and left to cool. Two milliliters of H_2O_2 were added and the flask was put back in the muffle furnace for further incineration over 1 h. Total ash was expressed as percentage of dry weight. The mineral constituents (K, Mg, Ca, Na, Fe, Zn, Mn and Cu) present in *C. melo* seed were analyzed, using an atomic absorption spectrophotometer (Analytikjena AAS Zeenit 700) (AOAC, 1984).

2.4. Functional properties

The water retention capacity and oil retention capacity measurements were performed for melon seeds powders. All samples were milled and sifted through 1 mm mesh screen.

2.4.1. Water retention capacity

The water retention capacity was measured following the method of Garau et al. (2007). Ground samples of melon seeds (±0.5 g) were hydrated in excess during 24 h in a 50 mL tube, prior to centrifugation at 2000 × g for 25 min. Excess supernatant was decanted. Water retention was recorded in terms of g water/g dry sample.