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Dietary Fiber and Functional Properties in peel and seed of *Cucumis melo* L.Flour: A Review

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Agriculturally, immature or mature undersize stage of *Cucumis melo* L. (melon) has become by-products as it is thrown away to avoid nutrient competition in order to obtain a high-quality fruit. Most fruits like *Cucumis melo* L. has high content of fiber. Thus, in this article, an extensive discussion on fiber and functional properties were discussed to discover the presence of this compound and its benefits. Melon contain total dietary fibers (41.69%) and antioxidants as polyphenols and flavonoids (332 15 mg/100g extract and 95.46 mg/100g extract, respectively). The identification of the phenolic compounds of melon peels indicates that hydroxybenzoic acids and flavones constitute their main phenolic classes. 3-Hydroxybenzoic acid is the major phenolic compound in the melon peels by 33.45 mg/100g, followed by apigenin-7-glycoside (29.34 20 mg/100g). Determination of the functional properties (water and oil retention capacities) and color proves that melon peels have properties that can be used in industrial applications. Overall, from previous findings, *Cucumis melo* L. was reported to exhibit good functional properties and the fiber has a potential to be used as functional food ingredient.

Keywords: *Cucumis melo* L., melon, maazoun melon, fiber, functional properties,

INTRODUCTION

The major production of *Cucumis melo* L. in Malaysia comes from Terengganu, Kelantan, Pahang, Johor and Kedah, there are also high demand for this fruit in the area of Perak (Mallek-Ayadi et al. 2018). Melon comes from the family of Cucurbitacae and also known as *Cucumis melo* L. It is predominantly found in countries like Asia and Africa. Around 85.2% of melon farmers are found in Peninsular Malaysia alone (Sasikumar, 2011). It is mostly planted at Johor, Kedah, Kelantan, Pahang and Terengganu. Around 7.1% of agrofood land in Malaysia is planted with melons (Ismail et al. 2010). Sasikumar (2011) stated that melon has been used for centuries to treat some diseases like kidney problems, fever, urinary ulcer, fever, bile obstruction and many others.

However, in Malaysia, melon has become one of the agricultural waste because it is either thrown at immature or undersize mature stages.

Out of six fruits in tendrils of the plant, five is thrown at immature and undersize mature stage (Muhamad et al.2018). Most of these by-products or also known as underutilized fruit is rarely eaten and not familiar to many people around Malaysia. The broad spectrum of colour in seed, peel, and flesh of the underutilized fruits has many potentials that benefits human health and can be used as food ingredients because they can meet up to certain functional properties that are needed in the food industries (Ikram et al. 2009). Melon is one of the fruits that is easily perishable and deteriorates because of its short shelf life. Many melons become waste from plantations because it is plucked out to reduce nutritional competition (water, sunlight, fertilizer, and minerals) to produce best quality of fruit (Ho et al. 2017). Thus, the dried form of melon flour is made once this melon are plucked and analyzed to retain its storage stability and development of high quality melon flour that has potential to meet the potential global demand for high dietary fiber and some other compounds (Muhamad et al. 2019). The usage of melon flour as a functional ingredient in developing potential food product is highly recommended (Ho et al. 2017). To obtain a high-quality diet it is recommended with the availability of high dietary fiber in the food intake. High fiber food can prevent gastrointestinal disorders, obesity, coronary heart diseases and diabetes (Tadmor et al. 2010).Usually dietary fiber is rich in cereals. However, dietary fiber from fruit and vegetable sources could be more physiologically competent (Navarro-Gonzalez et al. 2011). Nowadays, natural ingredients are preferred over the synthetic ingredients to be used in food application. Thus, there are increasing usage of fruits and vegetables raw material to substitute the existing synthetic ingredients (Mallek-Ayadi et al.2016). Healthy by-products that come from fruits and vegetables have advantage on its economic and environmental sources (Thakur, 2015).

Thus, the functional properties of *Cucumis melo* L. is explored and studied in this article. The objective of this review paper is to study on the characterization of dietary fiber and its functional properties in *Cucumis, melo* L. Hemicellulose, oligosaccharides, gums, waxes, lignin, pectin and cellulose are parts of plant cell that is resistant human digestive enzymes (Simpson and Morris. 2014). Human small intestine does not digest these dietary fiber and the adsorption does not occur, but there will be a limited fermentation taking place in the large intestine (Bhujbal et al. 2010). Dietary fiber has multiple benefits to human. In recent years many food industries have developed high fiber food products due to its importance. These days,food researchers are trying to find new variety of natural source of fiber (Garcia-Anguilar et al. 2015). Nowadays incorporation of fiber has become a trend especially in foods such as beverages, spices, vegan cheeses, sauces, canned foods, snack foods and frozen foods (Ittiyavirah. 2013).

Cellulose is major plant cell component which is connected linearly with many glucose units that has β-1,4glucosidic bonds (Zeb, 2016). Due to its strong hydrogen bonding with micro fibrils, cellulose has great resistance to biological degradation, mechanical strength and low aqueous solubility. Strong alkali does not dissolve cellulose but it can be dissolved in acid which is that it is called "amorphous" (Ajila et al. 2010). This shows the reason behind the indigestion of cellulose in human digestive tract to any extent.

After removal of water soluble and peptic substances polysaccharides, hemicellulose can be solubilized in aqueous alkali (Atef et al. 2013). The hemicellulose is smaller in size compared to cellulose which has linkage of β-1,4glucosidic bonds as backbone. Hemicellulose also has many sugars like component such as xylose, galactose, mannose and arabinose (Simpson and Morris, 2014).

Lignin contains 40 oxygenated phenylpropane units such as sinapyl, coniferyl and coumaryl alcohols that has gone through dehydrosenarative polymerization, which shows that lignin is not a polysaccharide but it is a random complex polymer (Bahloul et al. 2014). The methoxyl content and molecular weight may differ in lignin (Ismail et al.,2010). Lignin is very inert fiber because it has carbon-carbon linkage and strong intramolecular bonding. Compared to any other natural occurring polymer, lignin has greater resistance (Morais et al. 2015).

D- Galacturonic acid is the main constituent in the complex group of pectin substances and structural components of plant cell (Atef et al. 2013). Colonic bacteria can completely metabolize pectin and are water-soluble fiber (Ittiyavirah, 2013). Pectin may affect the intestinal transit time and reduce the rate of gastric emptying due to its gelling behavior (Mallek-Ayadi et al. 2018). This attribute clearly shows that pectin has hypoglycemic properties. Pectin has a very good probable in lowering the blood cholesterol level especially low-density-lipoprotein-cholesterol fraction without affecting the amount of high-density-lipoprotein-cholesterol and triglycerides (Bidkar, 2012). Zeb (2016) stated that pectin is capable of suppressing the glucose-response curve that helps in glucose metabolis

m. Pectin is also used as a food-additive to provide gelling property in food products

(Ittiyavirah, 2013).

Gums and mucilages are secretory plant cells that are not constituted with cell wall component (Mallek-Ayadi et al. 2017). Gums and mucilage have tendency to form gel binding with water and other organic material. In response to trauma gums form sticky perspiration (i.e. gum arabic and guar gum) (Wen et al. 2015). Soluble dietary fiber gives the attribute that has the ability to undergo partial enzymatic hydrolysis (Caliskan&Polat, 2012). Guar gum comes from the seed of *Cyamopsis Tetragonolobus* (guar) which is known as galactomannans (Hoque& Iqbal, 2015). Gums express the characteristics that soluble fiber applies according to its physiological effects (Liara et al. 2014). Gum Arabic is also a complex mixture of arabinogalactan polysaccharide and glycoprotein which is obtained from acacia tree. To prevent drying of plant seed mucilages are secreted in the plant (Sasikumar, 2011).

Dietary fiber in Melon

Dietary fibers can be classified based on ways of digestion, gastrointestinal solubility, polysaccharide types, physiological categories, and its role in plants (Navarro-Gonzalez et al. 2011). The dietary fiber in *Cucumis melo* L. can be made up from both soluble and insoluble dietary fiber (Bhujbal et al. 2010). The soluble dietary fiber consists of pectin, beta glucan, and galactomannan gums, whereas the insoluble are lignin, cellulose, and hemicelluloses (Zeb, 2016). The soluble parts are mucilage, pectin and gums that can form thick gummy liquid texture when it is mixed with water, while cellulose, lignin and hemicellulose are insoluble in water (Bahloul et al. 2014). The dietary fiber concentrates consist of major component which is dietary fiber (>50%) in melon (Ajila et al., 2010). It also includes certain components like digestible proteins, minerals, lipids, carbohydrates, and small amount of water (<10% wm) in melon. Dietary fiber concentrates in melon attained by dehydrating the fruit. Dietary fiber concentrate is not similar to dietary fiber extract, because dietary fiber extract is collected by removing fiber compounds from the initial sample through chemical and enzymatic methods. Usually the dietary fiber content is greater than the dietary fiber concentrates. Using enzymatic methods, total of 41.69% dietary fiber was found in the peel, which consists of 37.58% of insoluble dietary fiber and 4.38% of soluble dietary fiber (Mallik-Ayadi et al. 2017). The flesh contains total dietary fiber of 38.32% which consists of 33.14% of insoluble dietary fiber and 5.18% of soluble dietary fiber (Mallek-Ayadi et al. 2016). The seed has a total of 22.18% insoluble dietary fiber and 3.14% of soluble dietary fiber (Zeb, 2016).

Functional properties

Different concentration of bioactive compounds was found in different parts of *Cucumis melo* L. using HPLC. The functional properties is depends on the quantitative and qualitative profile of bioactive compounds in the fruit parts (Ong et al., 2019). Apegenin-7-glycoside, vanillin, 3- hydrobenzoic acid, is-vanillic acid, lutieolin-7-glycoside, flavones, tyrosol and naringenin are the bioactive compounds that are found in *Cucumis melo* L. peel (Bahloul et al. 2014). Meanwhile, the seed of *Cucumis melo* L. has bioactive compounds such as gallic acid, 4-hydroxybenzoic acid, naringenin-7-0-glycosidase, amentoflavones, beta-tocopherol and alpha-tocopherol (Bidkar, 2012). In terms of abundance, the most predominant phenolic compound was 3-hydrobenzoic acid in *Cucumis melo* L. peel (Bahloul et al. 2014). Cardiovascular diseases and cancer can be prevented by compounds like chlorogenic and coumaric acids (Morais et al. 2015). Tyrsol and gallic acid also show excellent anti-inflammatory, anti-cancer and anti-mutagenic properties (Liara et al. 2013). Oleuropein is one of the phenolic compounds that exhibit antioxidant properties (Ismail et al.2010).

Functional properties indicate how other food ingredients affect the finished food products on its texture, taste, structure and appearances. The unique quality characteristics of food and food products are determined by studying the functional properties. From our findings, each part of melon has its functional properties. In this study functional property of melon peel, seed and flesh will be discussed.

Water holding capacity is essential to study the convenience of using water in particular food production, sensory, nutritional attributes (Caliskan and Polat, 2012) and also to study the juiciness of food such as meat products (Zeb. 2016). Recently, researchers have found that water holding capacity is necessary to determine digestion of food products that are high in fiber (Ajila et al., 2010). Oil holding capacity is needed in order to study the texture of product that potentially high in oil content, especially in meat products (Bidkar. 2012). Colour is needed to determine the effects of processing on the raw ingredients to final product, also to know if the food meets the established internal quality standards (Mallek-Ayadi et al., 2018). In this study, colour was determined using Portable calorimeter (Konica Minolta, Chroma Meter CR-410 Japan) on the basis of L*, a* and b* values for both seed and peel flour.

Functional properties of melon peel flour

Table 1 shows the functional properties of melon peel flour studied by Mallek-Ayadi et al. (2018). The water holding capacity of food is needed in order to determine the optimal addition of water to obtain desirable texture of food product (Wen et al. 2015). The water holding capacity of maazoun melon was 5.36 g water/peel. According to Al-Sayed and Ahmad (2013) the sharlyn melon peel and watermelon rind has higher value than maazoun peel which had 7.70 g water/g peel and 7.13 g water/g rind, respectively. Ahmad et al. (2013) stated that watermelon has lower water holding capacity (1.65 g oil/ g rind). The sharlyn melon has (2.4 oil/g peel) of oil holding capacity which did not differ significantly with maazoun melon peel (2.23g oil/g peel). Oil holding capacity is an important property to stabilize food with high percentage of oil emulsion or fat. Certainly, melon peel has the ability to absorb oil twice as much as its mass. This characteristic of melon peel should be explored to strengthen fat retention capacity in meat products which normally tend to lose oil retention during cooking. This is very essential in yield maintaining and flavour retention (Ghanem et al. 2012).

Colour measurement of melon peel flour

Fruit peel is an important attribute for consumer's acceptability. Table 1 shows the colour measurement in maazoun melon peel. According to Chen et al. (2015) ravi melon peel (-7,64) is lower than maazoun melon peel (-2.36). Wen et al. (2015) stated that hami melon (7.47) has lesser a* value which shows lighter in green colour than that of maazoun melon peel. The ripening and storage periods may give variety of effect on the a* value, due to the changes in chlorophyll pigments that simplifies into smaller compounds in the peel tissues of melon (Parveen et al., 2012). Hami melon peels (24.76) has lower b* value than maazoun melon peel (30.19), but both has lower b* value than ravi melon peels, where the ravi melon peel is more yellow in colour. The lightestcolour of melon peel variety is the maazoun melon peel. Ravi melon peels (35.35) has lower L* value than maazoun melon peels (68.63) and maazoun melon peel has higher L* value than ravi melon peels (66.0) (Chen et al., 2015). The cultivar, growing condition, genotype, environmental factors and other harvest conditions directly affect the pigments of peel colour in melon (Wen et al., 2015). The successions of carotenoids, flavonoids and chlorophyll affect the colour of melon peel due to pigment changes during maturation (Tadmor et al.2010).

Table 1: Functional properties and colour of maazoun variety peel flour (*Cucumis melo* L.) studied by Mallek-Ayadi et al. 2018.

Parameter	Value
Water retention capacity (g water/g peel)	5.36±0.17
Oil retention capacity (g oil/ g peel)	2.23±0.11
L*	68.63±0.98
a*	-2.36±0.04
b*	30.89±0.51

ΔL* (L* sample minus L* standard) = difference in lightness and darkness (+ = lighter, – = darker) Δa* (a* sample minus a* standard) = difference in red and green (+ = redder, – = greener) Δb* (b* sample minus b* standard) = difference in yellow and blue (+ = yellower, – = bluer)

Functional properties in melon seed flour

Table 2 shows the functional properties of maazoun seed flour investigated by Mallek-Ayadi et al. (2016). The oil holding capacity of maazoun seed is 30.08 g/oil g which is greater than seinat melon seed flour (23.67 g/ oil g). This shows that maazoun seed has the potential to be used in meat product making. The electrostatic oil repulsion can be stopped by adding protein that can function as surface emulsifying agents. An emulsifying capacity is done by mixing protein which can lower the surface tension between water and air. Siddeeg et al (2014) stated that the oil holding capacity of watermelon seed flour (18.21%) is lesser than maazoun melon seed (19.97%). From the functional properties observed, the water holding capacity and oil holding capacity has the potential to be used in meat and bakery products.

Colour measurement in melon seed flour

Table 2 also presents the CieLab coordinate values of maazoun melon seed. The L* value is 66.31± 0.18, a* (3.25± 0.01) and b* (20.63±0.04) value was found in maazoun melon seed. The L*, a* and b* value in maazoun melon seed variety is lower than of that tibish melon seed flour. This proves that maazoun melon seed has more carotenoid compounds due to its greater yellow pigments. The different colour of melon seed is due to its cultivar and storage condition. The usage of this melon seed flour may aid in colour addition to certain type of food products.

Table 2: Functional properties and colour of maazoun variety seed flour (*Cucumis melo* L.) studied by Mallek-Ayadi et al. 2016.

Parameter	Value
Bulk density(gmL^{-1})	0.65±0.03
Emulsifying capacity (%)	30.08±0.11
Oil holding capacity (%)	19.97±0.02
L*	66.31±0.18
a*	3.25±0.01
b*	20.63±0.04

ΔL* (L* sample minus L* standard) = difference in lightness and darkness (+ = lighter, – = darker) Δa* (a* sample minus a* standard) = difference in red and green (+ = redder, – = greener) Δb* (b* sample minus b* standard) = difference in yellow and blue (+ = yellower, – = bluer)

CONCLUSION

Based on this review, the functional properties of melon seed and peel flour could be learned. Melon peel contains good source of polyphenols, especially hydrobenzoic acids and flavones. The insoluble dietary fiber content was highest for the peel powder of *Cucumis melo* L. The melon peels are capable of supplying economical and adequate natural substances for food and pharmaceutical industries. Apart from that, the usage of melon by-products aids the reduction of environmental concerns that accomplices with agricultural disposal.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

MS perform and wrote the manuscript. NS, NH and ZZ supervised and reviewed the manuscript. All authors read and approved the final version.

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