Chemical composition, bioactive compounds content, and antioxidant capacities of five watermelon cultivars distributed in Egyptian local markets

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Abstract:

The present study aims to determine the chemical composition, bioactive compounds content, and antioxidant capacities of five watermelon cultivars distributed in Egyptian local markets; Giza 6 (G6W), Chilian (ChW), Seedless (SW), Yellow (YW) and Elongated (EW). Moisture content was ranged from 89.4 to 91.81%, YW recorded the highest values of moisture content and lowest values of carbohydrate (6.56 %). Protein content ranged between 0.97 and 1.15 % in all selected watermelon verities, also SW had significantly (P≤ 0.05) higher values of ash, fat and AA which recorded 0.49, 0.32 and 56.57% respectively than other samples. All red-fleshed watermelons such as SW, G6W, EW and Ch W recorded high levels of vitamin C which 8.44, 7.5, 5.55 and 4.22 mg /100g respectively. ChW was significantly (P≤ 0.05) higher values of lycopene 121.06 mg/100g, while YW had the lowest values of vitamin C (2.75 mg/100g) and lycopene (5.09mg/100g). There were significant (P≤ 0.05) differences among cultivars for total phenol ranged from 452 to 286 mg/100gfw and flavonoids content from 91.33 to 22.33 mg/100g fw. ChW has lower values of total phenol and flavonoids (P≤ 0.05) than other watermelon cultivars, while SW recorded the highest values of total phenols and antioxidant activity (452 mg/ 100g and 56.57%) respectively. In conclusion, results of this study refer to the possibility of focusing on different types of watermelon fruits as a good source of bioactive compounds such as lycopene, vitamin C, total phenol and anti-oxidant which could be beneficial to human health.

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Keywords: Citrullus lanatus L, red-fleshed watermelon, yellow-fleshed watermelon, seeded watermelon, seedless, watermelons, total phenolics, flavonoids, antioxidant activity, functional foods.

1. Introduction

Watermelon (*Citrullus lanatus* L.) is a flowering plant belongs to the *Cucurbitaceae* family. It is a very important crop in our country, as the percentage of the cultivated area in Egypt reached about 155.1 thousand acres in 2020, thus occupying the first place among summer vegetable crops at the level of the Republic. The number of exports amounted were 6815.5 tons for the same year **(Amer *et al.*, 2021)**. watermelon has over 1,000 different varieties, it is frequently consumed as a cooling and good taste summer fruit and is well regarded by customers **(Egbuonu,2015).** Fresh watermelon juice contains about 11.6 ,0.9, 0.15 and 0.61g per100 g for carbohydrate, protein, fat and fiber respectively, while vitamins content was about 12.31mg, 864.88 IU for vitamins C and A respectively **(Maoto *et al.*, 2019).**

Free radicals are very unstable ions, molecules, or atoms that interact with other molecules and impair DNA and cell membrane (**Hong *et al.*, 2015**), and could be the primary causes of the oxidative stress that living cells receive which damages macromolecules and results in diseases including cancer, asthma, diabetes, and hypertension. (**Romdhane *et al.*, 2017)**. The inclusion of watermelon in the diet could have beneficial benefits on the body since it includes enough minerals and phytochemicals like lycopene, which have been found to have antioxidant and anti-inflammatory qualities **(Lemos *et al* 2017).** Also, **(Oberoi and Sogi, 2015)** mention that lycopene was about 3.38–11.34 mg /100g in watermelon juice, which may enhance the immune system function. The supplementation of watermelon could help in the convalescence of diseases; also reduce their negative side effects (**Manivannan *et al.*, 2020).** Vitamin C is necessary for maintaining healthy skin, gums, and for preventing scurvy **(Phillips *et al.*, 2010)**. Also, it has many functions in absorption of iron, collagen formation; reduce levels of cholesterol plasma **(Byers and Perry, 1992; Kestendy et**

al., 2011), decreases oxidative stress and could help to management of physical/ emotional pressure (**Pacier and Martirosyan, 2015).**

Watermelon can provide significant levels of antioxidants to the human diet, good amount of phytochemicals such as polyphenols, flavonoids and vitamin C, which could protect food or the body from oxidative damage brought on by reactive oxygen and free radicals **(Abourashed, 2013; Elhassaneen and Abd Elhady, 2014).** Therefore, the objective of this study was to evaluate the chemical composition, bioactive compounds content and antioxidant capacities of watermelon cultivars distributed in Egyptian local markets.

2. Materials and Methods

2.1. Materials

2.1.1. Watermelon Fruits

Five watermelon cultivars, G6W, ChW, SW, YW and EW were selected (Fig 1). G6W and ChW were obtained from a local market Minia City, while SW, YW obtained from Dina farm market Cairo Alexandria Desert Road and EW from a local market Marsa Matrouh City.

2.1.2. Chemicals

Phenolic standards were from Sigmae-Aldrich Chemical Co agent, Egypt. In addition, all other chemicals and solvents were of analytical grade and purchased El-Ghomhorya Company for Trading Drugs, Chemicals and Medical Instruments Trading Co., Cairo, Egypt.

Fig.1. Watermelon cultivars

2.2. Methods

2.2.1. Physical properties

The length, major diameter, and minor diameter of watermelon fruits were measured with a measuring tape. Equations (1 and 2) were used to calculate the geometric mean diameters and the spherical coefficient **(Sadrnia et al., 2006)**.

Geometric mean diameters $= \sqrt[3]{abc}$ (1)

Spherical coefficient $= \frac{\sqrt[3]{abc}}{a}$ (2)

Where: a refers to length in centimeters of the watermelon fruits

b refers to the major diameter in centimeters

c refers to the minor diameter in centimeters

2.2.2. Preparation of samples

The outer layer of the watermelon fruit was cleaned and wiped dry before being cut into quarters longitudinally from the stem end to the blossom end at the center, with each end of the fruit. 250g of seedless flesh from a watermelon was taken, covered in aluminum, put in plastic bags, and frozen until analysis.

2.2.3. Preparation of ethanol extract

The amount of watermelon (30 g) had extracted with 95% ethanol at a percent of 3 parts of 95% ethanol: 1-part watermelon fruit W/V using a Vortex, Model B-4, Waring products Co., Winsted CONN. Filter paper No.1 used to filter the extraction with Buchner funnel and the residue was extracted twice more under the identical conditions. The filtrate samples were transferred to 500ml volumetric flask and completed with 95% ethanol, after these extracts keep in brown bottle at 4ºC until used in evaluation of flavonoid, total phenol, and antioxidant activity.

2.2.4. Chemical composition of watermelon fruits

Moisture, ash, fat, and protein were determined according to (**AOAC, 2000)** methods. TSS % (total soluble solids %) was determined using refract meter, Japan. Cole Palmer Color meter was using to evaluate color L, a, and b.

2.2.5. Determination of Vitamin C

Titrimetric method from official (**AOAC, 2000)** was used to quantified ascorbic acid and expressed as mg/100g fresh sample.

2.2.6. Determination of lycopene content

Lycopene determined according to (**Fish *et al*., 2002).** Aluminum foil must be used to wrap the glass of materials during processing and analysis in order to decrease the loss of lycopene due to photo oxidation.

2.2.7. Determination of total phenolic

Analyses were performed according to (**Singleton and Rossi, 1965)**, total phenolic concentration was expressed as mg of tannic acid equivalents via the standard curve.

2.2.8. Determination of Flavonoids

The amount of flavonoids in watermelon extract was calculated according to (**Zhishen *et al*., 1999)**.

2.2.9. Determination of Total Antioxidant Activity

Total antioxidant activity was determined according to **(Su and Silva, 200)** method.

2.2.10. Statistical analysis

GLM (General le\Linear Model) program was using to analyze the data, using statistical analysis system (**SAS, 2003**). Duncan's Multiple Test was used to compared Mean values

3. Results and discussions

3.1. Physical properties

The dimensions and spherical coefficient, in addition geometric mean diameter of G6W, ChW, SW, YW and EW fruits were shows in table (1). It could see that sample weights varied statistically significantly ($P \leq 0.05$); ChW had the highest weight (9.88 kg), while SW had the lowest weight (4.25 kg). The dimensions of watermelon fruit samples ranged from 19.25 to 23.42 cm in length, 21.23 to 31.03 cm in major diameter, and 19.66 cm in minor diameter, respectively for different cultivars of watermelon. In addition, it could notice that the high weight cultivars had the highest values of length, major diameter and minor diameter, when determining storage capacity; these dimension data are crucial (**Khater and Bhansawi, 2016)**.

The high value of geometric mean diameter was found at ChW(27.46cm) followed by G6W and YW (24.72and 22.51cm). **Khater and Bhansawi, (2016)** report that the increase of the watermelon fruits sizes led to increasing of geometric mean diameter of fruits.

Table1. Physical properties of watermelon cultivars

Watermelon cultivars	Weight (kg)	Dimensions			Spherical coefficient	Geometric mean diameter (cm)
		Length (cm)	Major diameter (cm)	Minor diameter (cm)		
G6W	7.88±0.31^{b}	25.95±0.26^{b}	24.26±0.28^{b}	23.42±0.37^{a}	0.94±0.01^{a}	24.72±0.30^{b}
ChW	9.88±0.31^{a}	32.43±1.04^{a}	31.03±0.87^{a}	20.62±0.46^{c}	0.85±0.01^{b}	27.46±0.95^{a}
SW	4.25±0.21^{e}	22.66±0.57^{c}	21.23±0.41^{c}	19.43±0.64^{d}	0.96±0.02^{a}	20.87±0.49^{d}
YW	6.00±0.5^{c}	23.86±0.43^{c}	22.4±o.43^{c}	21.78±0.16^{b}	0.96±0.01^{a}	22.51±0.32^{c}
EW	4.81±0.29^{d}	23.22±0.45^{c}	21.25±0.45^{c}	19.25±0.41^{d}	0.94±0.01^{a}	20.87±0.28^{d}

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at $p \leq 0.05$.

3.2. Color values (L, a, and b) of watermelon cultivars

Consumers usually used color to determine whether the fruit is unripe or ripe and indicator for intensity of a flavor or smell, additionally; color may affect other sensory qualities, which affect food preference, acceptance and choice **(Francis, 1995).** Table (2) shows the values of L, a, b of five cultivars watermelon, where L represents the degree of lightness, (a) refers to redness, and (b) refers to yellowness. ChW had the highest value of lightness (L) 32.29 while G6W had the lowest (19.63). Also, results show that seeded watermelons such as G6W, ChW and EW had darker red color 26.54, 24.2 and 22.96 respectively compared with the seedless and yellow watermelons (16.03 and 12.56) respectively. This might be due to that seeded watermelons contain many brown or black seeds, which could affect of the color of the flesh (**Yau *et al*., 2010).** Moreover, these cultivars content the highest levels of lycopene (Table 4). **Lopez *et al*., (2007)** report that lycopene aids in the prevention of cancer. The results indicate that the b values varied significantly (P≤ 0.05), YW had the highest level of yellowness (28.32), followed by SW (17.93).

Table2. Color values (L, a, and b) of watermelon

Watermelon cultivars	L	a	B	whiteness
G6W	19.63± 0.35[b]	26.54± 0.82[a]	14.11± 0.93[b]	14.18 ± 0.62[b]
Ch W	32.29± 1.02[a]	24.02± 0.99[ab]	5.30± 0.84[c]	27.52 ± 0.75[a]
SW	25.66± 3.84[ab]	16.03± 0.6[ab]	17.93± 3.9[b]	25.28 ± 3.31[ab]
YW	31.48± 0.56[a]	12.56±1.59[b]	28.32± 3.86[a]	24.86 ± 1.13[ab]
EW	24.05 ± 1.48[ab]	22.96± 3-84[ab]	12.97± 2.80[b]	19.41 ± 2.73[ab]

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

3.3. Chemical composition of watermelon

Proximate chemical composition of various watermelon fruits is present in table (3). As shown in the table, the content of moisture was around 89.4 - 91.81%. YW was recorded the highest values of moisture (91.81%) and the lowest values of carbohydrate (6.56 %). According to **(Sabeetha *et al*., 2017**) in complete maturity stage, watermelons become more lighter than unripe watermelons due to the higher moisture content. SW had significantly (P≤ 0.05) higher values of fat (00.32 %) than other watermelon cultivars, since all watermelon fruits are low in fat, they are regarded as part of a healthy diet that is low in sodium and cholesterol **(Jumde *et al*., 2015)**. According to the World Health Organization, consuming low-fat, fiber-rich is the best diet for everyone **(Kabel, 2014)**. Protein content ranged between 0.97 and 1.15 % in watermelon fruit samples. These results are a little higher than that reported by (Sabetha ***et al*., 2017)** for protein in red seedless, red seeded and yellow watermelons, they found that protein ranged between 0.76 to 0.81 %, also found that yellow-fleshed watermelon had the highest values of ash which disagree with our results.

Our results nearly close to (**USDA, 2003)** reported that moisture, protein, fat and carbohydrates of the flesh or pulp of watermelon fruit were as mean 95.51, 0.55, 0.43 and 6.8% respectively. The low proportion of protein, fat and carbohydrate in watermelon consequently led to low calorie and energy of fruits. According to **(Dia *et al*., 2016)** watermelon's low saturated fat and cholesterol make it a good option for those looking to lose weight.

Table3. Proximate composition of fresh watermelon fruits

Watermelon Cultivars	Moisture%	Protein%	Fat%	Ash%	Carbohydrate %	Total soluble Solids%
G6W	90.84±0.88^{ab}	1.04±0.06^{b}	0.11±0.01^{c}	0.32±0.06^{b}	7.69±0.89^{ab}	10
Ch W	89.40±0.97^{b}	0.97±0.05^{c}	0.25±0.01^{b}	0.27±0.01^{bc}	9.11±0.93^{a}	10
SW	90.53±0.91^{ab}	1.07±0.04^{ab}	0.32±0.01^{a}	0.49±0.05^{a}	7.59±0.92^{ab}	10
YW	91.81±0.13^{a}	1.15±0.02^{a}	0.13±0.01^{c}	0.37±0.005^{b}	6.56±0.16^{b}	9
EW	91.47±0.27^{a}	1.01±0.01^{bc}	0.03±0.005^{d}	0.23±0.01^{c}	7.25±0.25^{b}	10

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at $p \leq 0.05$.

3.4. Lycopene and vitamin C contents of fresh watermelon fruits

Carotenoids such as β-carotene and lycopene are responsible for the orange and red colors of fruits such as guava, red bell peppers, tomato and watermelon (**Bianchi *et al*., 2018).** The amounts of lycopene and vitamin C of the sampled watermelon cultivars are shows in table (4). Data shows statistically significant differences ($P < 0.05$) between the watermelon samples in the amount of vitamin C and lycopene. The highest value of lycopene content (121.06 mg/100g) was at ChW, while YW had the lowest values (5.09mg/100g). Lycopene content of watermelon varies according to cultivar type and growing conditions **(Soteriou *et al*., 2014)**, watermelon contains about 60% lycopene in compare with tomatoes which makes it the leader between fresh fruits **(Oberio and Sogi, 2017)**. Fruits which high content of lycopene such as watermelon has referred to as functional foods (**Soteriou *et al*., 2014).** Consumption of foods high in lycopene is linked to a lower incidence of breast, stomach, oral cavity, and colon cancer **(Kulczynski *et al*., 2017**). Lycopene has an effective effect at inhibiting free radicals, including nitrogen dioxide and cellular membrane damage (**Oberoi and Sogi, 2017)**.

Table4. Lycopene and vitamin C content of fresh watermelon fruits

Watermelon Cultivars	Lycopene content mg/100g	Vitamin C mg/100g
G6W	96.41±0.73[b]	7.5 ±0.9[a]
ChW	121.06±0.50[a]	4.22 ±0.28[c]
SW	70.17±0.16[d]	8.44± 0.62[a]
YW	5.09±0.20[e]	2.75 ±0.36[d]
EW	86.78±1.19[c]	5.55 ±0.52[b]

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at $p \leq 0.05$.

Data in the same table show that all kind of red-fleshed watermelons such as SW, G6W, EW and ChW was recorded high levels of vitamin C about (8.44, 7.5, 5.55 and 4.22 mg /100g) respectively, while the lowest was at YW (2.75 mg/100g), agree with (**Davis and Fiorotto, 2009)** report that vitamin C content in yellow-fleshed watermelon is lower than in red-fleshed watermelon. Vitamin C is probable concentrated in the outermost parts of the red-flesh watermelon, and increase in the ripe stage of fruits (**Johnson *et al*., 2012).** The varying of vitamin C content between cultivars due to harvesting, cultural practices ,handling methods after postharvest an influence vitamin C content in fruits and vegetables (**Oberio and Sogi, 2015)**. Temperature after harvesting is a basic factor to maintain vitamin C content on fruit and vegetable, which decreases at long time storage with high temperatures **(Lee and Kader, 2000)**.

Vitamin C content of all red-fleshed watermelons SW, G6W, EW and Ch W higher than those reported by **(Isabelle *et al*. ,2010)** and those by

(Jumde *et al*., 2015) report that juice of fresh watermelon contains 3.72 mg/100 g.

3.5. Total phenolic, flavonoid contents and antioxidant activity

As natural antioxidants, plants with high polyphenol content are very important. The biochemical and pharmacological actions of flavonoids include anti-inflammatory, anti-allergy, and anti-oxidant properties. **(Loke *et al*., 2008)**. Flavonoid intake has a role of reduce risk of cancer-inhibited enzymes such as prostaglandin synthase, lipoxygenase and cyclooxygenase, closely related to tumorigenesis **(Hasler, 1998; Loke *et al*., 2008)**.

Table5. Total phenols, flavonoids and antioxidant activity of watermelon fruits

Watermelon Cultivars	Total phenol mg/ 100g		Total flavonoids mg/ 100g		A A %
	Fresh	Dry	Fresh	Dry	
G6W	343.67±14.51[b]	3436. 7±140.51[b]	91.33±2.49[a]	913.3±24.9[a]	36.40±0.31[c]
Ch W	286.00±9.20[c]	2860±92.01[b]	22.33±1.25[d]	223.3±12.47[e]	55.72±2.88[a]
SW	452.00±7.26[a]	4520±72.57[a]	32.00±0.82[b]	320.0±8.16[c]	56.57±0.67[a]
YW	360.67±12.66[b]	4006.9±142.9[a]	34.00±0.82[b]	377.0±9.06[b]	40.38±1.09[b]
EW	332.67±9.98[bc]	3326.7±99.78[b]	28.67±0.0.47[c]	286.7± 4.71[d]	53.45±0.25[a]

Each value represents the mean of three replicates ±SD. Mean values with the different letters in the same column mean significantly different at p≤0.05.

Watermelon contains enough antioxidant properties which could help in prevention of some diseases like arthritis and hypertension **(Abourashed, 2013)**.

There were significant differences among samples for flavonoids content ranged from 452 to 286 mg/100gfw. ChW has lower values of total phenol and total flavonoids (P≤ 0.05) than other samples 286 and 22.33 mg/ 100g respectively (Table 5), while SW was recorded the highest values of total phenols 452 mg/ 100gfw and antioxidant activity 56.57%. The possible reason for the differences could be for factors such heat and oxidation at vegetable processing steps can lead to significant losses in carotenoid bioactivity in foods. High temperature causes a gradual decrease in flavonoids and phenolic compounds oxidase enzymatic oxidative reactions could be the main reasons of loss of phenolic compounds after harvest **(Piljac-Zegarac and Samec, 2011).** Watermelon possesses nutrients which to be useful to human health. **(Ijah *et al*., 2015)** recorded that it contains antioxidants which has potential effect to protective against carbon tetrachloride-induced toxicity, also had anti-inflammatory properties. There was no difference in the AA content between SW, ChW and EW cultivars, as they recorded the highest values at antioxidant 56.57 ,55.72 and 53.45 %respectively. Where's the lowest values were at YW, G6W 40.38 and 36.40 %.

Conclusion

The obtained results suggest that all studied watermelon fruits contain high total phenol, vitamin C and flavonoid. SW and ChW had the highest value of antioxidant activity. Therefore, watermelon fruits may be is a good source of bioactive compounds, which had important for human health. Moreover, results focus on the potential role of natural antioxidants in reducing the risk of chronic diseases.

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التركيب الكيميائي ومحتوى المركبات النشطة بيولوجيا والقدرات المضادة للأكسدة لخمسة أصناف من البطيخ منتشرة في الأسواق المحلية المصرية

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الملخص العربي:

تهدف هذه الدراسة إلى تحديد التركيب الكيميائي ومحتوى بعض المركبات النشطة بيولوجيا والقدرات المضادة للأكسدة لخمسة أصناف من البطيخ (جيزة 6 ، شيليان ، بدون بذور والبطيخ الأصفر والصحراوي). منتشرة في الأسواق المحلية المصرية.حيث سجلت النتائج محتوى من الرطوبة تراوح بين 89 و 91.81٪. كما سجل صنف البطيخ الأصفر أعلى قيم من محتوى الرطوبة (91.81٪) وأقل قيم للكربوهيدرات (6.56٪). بينما تراوح محتوى البروتين بين 0.97 و 1.15٪ في عينات ثمار البطيخ ، كما وجد أن البطيخ بدون بذر يحتوي على قيم أعلى معنويا (P≤ 0.05) من الرماد والدهون ومضادات الأكسدة بلغت 0.49 و 0.32 و 56.57٪ علي التوالي مقارنة بالأصناف الأخرى. كما شوهد ان جميع انواع البطيخ ذو اللحم الأحمروالتى تشمل جيزة 6 ، شيليان ، بدون بذور والصحراوي كانت تحتوي على مستويات عالية من فيتامين ج والتي تبلغ حوالي 8.44 و 7.5 و 5.55 و 4.22 مجم / 100جم على التوالي . أيضا .. سجل صنف بطيخ شيليان فرقا معنوياً (P≤ 0.05) ذات دلالة احصائية في محتواه من الليكوبين 121.06 مجم / 100 جرام ، بينما كان البطيخ الأصفر أقل قيم لفيتامين ج (2.75 مجم / 100 جم) والليكوبين (5.09 مجم / 100 جم). كذلك، كانت هناك فروق معنوية بين الأصناف المحتبرة فيما يتعلق بالمحتوى من اجمالى الفينولات من 286 إلى 452مجم / 100 جرام و الفلافونويد من 22.33 to 91.33مجم / 100 جم) .يحتوي البطيخ شيليان على قيم أقل من إجمالي الفينول وإجمالي مركبات الفلافونويد (P≤ 0.05) مقارنة بعينات الاصناف الاخرى ، بينما احتل البطيخ بدون بذر أعلى قيم لمجموع الفينولات ونشاط مضادات الأكسدة بلغت 452 مجم / 100 جم و 56.57٪ على التوالي. تشير نتائج هذه الدراسة إلى إمكانية التركيز على أنواع مختلفة من ثمار البطيخ كمصدر جيد للمركبات النشطة حيويا مثل الليكوبين وفيتامين ج والفينولات الكلية ومضادات الأكسدة ، والتي يمكن أن تكون مفيدة لصحة الإنسان.

الكلمات المفتاحية: Citrullus lanatus L ، بطيخ أحمر ، بطيخ أصفر ، بطيخ ببذور ، بطيخ بدون بذور، الفينولات الكلية،الفلافونويدات، الانشطة المضادة للأكسدة، أغذية وظيفية

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