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Physico-chemical Evaluation of White and Pink Grapefruit (*Citrus paradisi*) Juice

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Abstract:

Two grapefruits juices from white and pink cultivars were studied to evaluate some physical properties, chemical, antioxidantive components, antioxidant activity, as well as, minerals and some vitamins. The results showed that the white juice was higher in TSS, pH, TSS/Acid ratio with values 12.00%, 3.51, 10.61compared to 11.60%, 3.45 and 6.04 for pink juice; respectively. Phosphorus was the predominant mineral present in white, pink juices fruits, followed by sodium and calcium with values of 93.31, 89.32; 57.81, 72.07; 48.65 and 21.59 mg/100ml, respectively. The amounts of total carbohydrates, crude fiber, total dietary fibers in white and pink juices were found to be (8.09 and 8.47g/100ml); (1.82 and 1.21 g/100g D.W); (4.40 and 6.60 g/100g D.W); respectively. The pink juice had a high antioxidant activity 88.86% when compared with white juice 81.00%, as a result of increasing in antioxidants components in pink juice. The two varieties of grapefruit juice contained high percentage of vitamin C. The vitamin C, vitamin B1 contents were in white juice were 39.23, 0.50 comparing with 38.82 mg/100ml and 0.65 mg/100 ml for white one. The grapefruit juice has the potential to be further developed into a nutritionally interesting raw material for food and beverage applications.

Keywords: *Citrus paradisi, Phenolics, Flavonoids, pink and minerals.*

Introduction

The grapefruit is a subtropical citrus tree of the family *Rutacae* grown for its fruit, which is also known as grapefruit. Grapefruit got its name because it commonly grows in clusters on the tree just like grapes. The most popular varieties cultivated presently are red, white and pink. Double-red flesh grapefruit varieties are also popular in the USA, Israel, Europe, Mexico and are increasing in Asia. It has high vitamin C content and is therefore valuable to the immune system and it helps protect against colds flue and it has a very positive effect on obesity and also has diuretic properties, helping to remove excess water from the body (Uckoo, *et al.* 2012; Sicari *et al.* 2018).

Grapefruit enhance appetite and is employed for its digestive, stomachic, antiseptic and diuretic properties. Similarly, fresh grapefruit (white and pink) tended to have higher nutrient density scores when compared to some commonly consumed fresh fruit such as apples, bananas, and peaches. It is an excellent source of many nutrients and phytochemicals that contribute to a healthy diet. Grapefruit extract has been claimed to have strong antimicrobial properties. Grapefruit juice is relatively rich in nutrients, including vitamins and minerals, and has fewer calories than other many juices (Rampersaud *et al.* 2012; Hung *et al.* 2017).

Grapefruit is an excellent source of antioxidant-promoting vitamin A and vitamin C. It is also a good source of heart-healthy dietary fiber and potassium as well as energy-producing vitamin B1 and vitamin B5. Grapefruit also contains phytochemicals including liminoids and lycopene. Grapefruit (*Citrus paradisi)* has been used as a folk medicine in many countries as antibacterial, anti-fungal, anti-inflammatory, antimicrobial, antioxidant, antiviral, preventing diabetes, astringent and preservative. It has also been used for cancer prevention, cellular regeneration, lowering cholesterol, cleansing, detoxification, heart health maintenance, arthritis and weight loss (Behera and Yadev, 2013; Imran *et al.* 2013).

Pectin is a gelling biopolymer originating from plants, and as an essential component in initial cell growth as well as in the ripening process. The major sources of commercial pectin's are citrus wastes (pulp and peel), and apple pomace, while some specific products may be extracted from sugar –beet pulp**.** The pectin content in grapefruit ranging from 3.30 to 4.50% (FW). Dietary fiber consists of non-digestible carbohydrates and lignin that are intrinsic and intact in plants; and functional fiber consists of isolated, non-digestible carbohydrates that have beneficial physiological effects in humans**.** These carbohydrates may be fermented in the large intestine, although some resistant fibers, such as purified cellulose, escape any fermentation, whereas other fibers, such as inulin or pectin, are completed broken down by bacteria in the colon (Lan *et al.* 2012; Lundberg *et al.* 2014).

Dietary fiber is listed on the Nutrition Facts panel and 25 g of dietary fiber is the recommended amount in a 2000-kcal diet. Manufacturers are allowed to call a food a "good source of fiber" if it contains 10% of the recommended amount (2.5 g/serving) and an "excellent source of fiber" if the food contains 20% of the recommended amount (5 g/serving). Dietary fiber on food labels includes both dietary fiber and functional fiber. One half of a piece of grapefruit has more dietary fiber than many other popular fruits including, bananas, apples and strawberries. Low fat diets high in fruits and vegetables containing dietary fiber have been shown to a variety of health benefits, especially in the reduction of risk of cardiovascular disease and cancer (Kranz *et al.* 2012; Rampersaud, 2012).

Phenols are very important plant constituents because of their scavenging ability on free radicals due to their hydroxyl groups**.** It is known that phenolic compounds are carriers of antioxidant activity in plant extracts. Several studies showed a good correlation between the phenols and antioxidant activity**.** Phenolic compounds are hydroxylated derivatives of benzoic and cinnamic acids and contribute to the overall antioxidant activity in the plants. It is well known that the antioxidant action is related to the amount of phenolic compounds**.** Carotenoids are responsible for the orange colour in the fruit**.** β-Carotene is very important in the prevention of certain human diseases such as cancer. The reason that carotenoids prevent cancer is related to the antioxidant activity that deactivates free radicals generated in tissues Castro *et al. (*2008).

Vitamins are organic substances present in very small quantities in food, but necessary for metabolism. They are grouped together not because they are chemically related or have similar physiological functions, but because they are vital factors in the diet and they all were discovered in connection with the diseases that cause its lack**.** Most fruit juices are excellent sources of vitamin C, several are good sources of carotene and many contain moderate amounts of pyridoxine, inositol, folic acid and biotin**.** All fruits contain more or less of the vitamin C. Most of them are good sources and several others are very rich in the vitamin (Latham, 2002).

Ascorbic acid plays an important role in human nutrition, including growth and maintenance of tissues, the production of neurotransmitters, hormones and immune system responses. Vitamin C is an important dietary antioxidant, since it reduces the adverse effects of reactive oxygen and reactive nitrogen that can cause damage to macromolecules such as lipids, DNA and proteins, which are related to cardiovascular disease, cancer and neurodegenerative diseases. Vitamin A plays a crucial role in the growth and development of young people is important for cellular differentiation, including the hematologic system, lysosomal membrane stabilization, maintenance of epithelial tissue integrity and has an immune stimulatory effect (Naidu, 2003; Ombwara *et al.* 2005).

The aim of this investigation was to evaluate some physical properties, chemical, antioxidantive components, antioxidant activity, as well as, minerals and some vitamins of juices extracted from two grapefruit cultivars namely white and pink.

Materials and Methods

Materials:

Samples. Fruits of two grapefruit cultivars (white and pink) were obtained from botanical farm of Faculty of Agriculture, Assiut University on December 2017. The fruit was kept in the refrigerator until use.

Methods:

Preparation of grapefruit juice:

The grapefruits were squeezed mechanically by a blender and the natural juice was sieved using a wire mesh to remove seeds and cellular materials. The juice was also filtered twice using a cloth filter to ensure removal of cellular material and result into clear natural juice. The juice was then packing in polyethylene bags and stored in freezer at -18 °C.

Physical properties

Total Soluble solids (brix). Total soluble solids (TSS) in grapefruit juice was measured using Abbe refractometer (A. Kruss, Germany) calibrated against sucrose and the results were expressed as Brix by (AOAC, 2005).

Total Acidity and pH value. Total acidity was determined by titration with 0.1 N sodium hydroxide solution using phenolphthalein as an indicator, while pH values of grapefruit juice were measured using an AQUA LYTIC pH meter (at 20ºC) as described by Habash *et al.* (1990).

Maturity or Ripeness index (T. S. S/Acidity). The ripeness index (RI or MI) was measured using the TSS/Acid ratio, which is a useful index to classify the grapefruit varieties as sweet, sour, or sweet sour Hernandez *et al.* (1999).

Chemical composition

Minerals determination. Sodium and potassium were determined using a Flame Photometer 410as described in AOAC (1995). Calcium, phosphorus, magnesium, manganese, copper, iron and zinc were determined using Thermos Scientific ICAp 6200 Inductivelty coupled plasma (ICP) as described in AOAC (2007).

Total carbohydrates. Total carbohydrates content of grapefruit juice was determined according to AOAC (2005).

Determination of Dietary fiber. Total dietary fiber, soluble and insoluble dietary fibers were determined as described by Prosky *et al.* (1988).

Determination of Pectin. Pectin was determined as described by Ranganna (1977).

Determination of sugars. The sugars fractions analysis was carried out as described by Zielinski *et al.* (2014).

Bioactive compounds determination and antioxidant activity assay:

Determination of Total phenolics content. The total phenolics content was measured according Folin-Ciocalteu reagent method as described by Gutfinger (1981) and Koksal *et al.* (2011). Briefly, 0.5 ml of appropriately diluted samples or standard solutions of gallic acid was pipetted into test tube, along with 5 ml of distilled water, 0.5 ml of Folin-Ciocalteu reagent, and the mixture was allowed to react for 3 min. 1 ml of 20% Na_2CO_3 solution was added and mixed well then left to stand for 1 h at room temperature for color development. Absorbance was measured at 725 nm and the total phenolic content was calculated by the comparison with the gallic acid standard curve. The total phenolics measurement was carried out in triplicate for all samples using a Shimadzu 1240 MINI UV-VIS spectrophotometer.

Total flavonoids content. The total flavonoid content of the samples was measured as described by Marinova *et al.* (2005). The total flavonoid content was expressed as Catechin equivalents (CE) per 100 g of grapefruit juice using a calibration curve.

Total carotenoids content. Total carotenoids content of grapefruit juice was determined as described by Lee and Castle (2001).

Antioxidant activity assay. The diphenyl picrylhydrazyl (DPPH) radical scavenging activity assay was performed as described by Silva *et al.* (2005).

Determination of lycopene. Lycopene pigments were determined as described by Sadler *et al.* (1990).

Vitamins analysis. Vitamin C was determined using HPLC as described by Romeu-Nadal *et al.* (2006). Vitamin B1& B2 contents of grapefruit juice were determined using HPLC as described by Batifoulier *et al.* (2005).

Vitamin A was determined by HPLC as described by NÖll, (1996). Vitamin E was determined by HPLC according to the method of Pyke and Sliwiok, (2001).

Results and Discussion:

Physical properties of white and pink grapefruit Juice

The physical properties of white and pink grapefruit juice are recorded in Table 1. The results showed the white juice was higher in TSS, pH, TSS/Acid ratio with values 12.00%, 3.51, 10.61compared to 11.60%, 3.45 and 6.04 for pink juice, respectively. While pink juice was highest in TTA (1.92 mg citric acid/100ml). The physical properties in the fruit pulp play an important role in flavor promotion as well as a preservation factor. These results are agreement with Faid *et al.* (2017).

Table 1. Physical properties of white and pink grapefruit juice.

Analysis	Sample	
	White grapefruit juice	Pink grapefruit juice
T.S.S%	12.00	11.60
T.T.A(mg citric acid/100ml)	1.13	1.92
pH	3.51	3.45
T.S.S/T.T.A ratio	10.61	6.04

Minerals composition of white and pink grapefruit Juice

The nutritional elements are essential or required for the normal functioning of the body and are classified according to their relative amounts or requirements: Magnesium (Mg), Calcium (Ca), Potassium (K), Sodium (Na) and Phosphorus (P) are classified as macronutrients, while the Iron (Fe), copper (Cu), Manganese (Mn) and Zinc (Zn), for example, are considered as micronutrients (Szefer and Nriagu, 2007). The minerals contents of white and pink grapefruit juices are presented in Table 2. The results revealed that Phosphorus was the predominant mineral present in white, pink juices fruits, followed by sodium, calcium with values 93.31, 89.32; 57.81, 72.07; 48.65 and 21.59 mg/100ml, respectively.

Magnesium, Iron contents was ranging from 15.31-33.84, 20.31-39.72 mg/100ml in the white and the pink juices, respectively. Copper, Zinc was found in lower contents in the two juices under study with values 0.03, 0.10; 0.15, 0.36 mg/100ml for white and pink, respectively. The results for minerals are in a good agreement with Chuku and Chinaka (2014).

Table 2. Mineral composition of white and pink grapefruit juice(mg/100ml).

Mineral	Sample	
	White grapefruit juice	Pink grapefruit juice
Phosphorus (P)	93.31	89.32
Magnesium (Mg)	15.31	33.84
Calcium (Ca)	48.65	21.59
Potassium (k)	0.11	0.56
Sodium(Na)	57.81	72.07
Iron(Fe)	20.31	39.72
Copper (Cu)	0.034	0.097
Zinc (Zn)	0.15	0.36
Manganese (Mn)	15.31	33.84

Total carbohydrates, crude fiber, dietary fibers fractions in white and pink grapefruit juice:

The contents of total carbohydrates, crude fiber and dietary fibers fractions in the grapefruit juice of two varieties are shown in Table 3. The amounts of total carbohydrates, crude fiber, total dietary fibers in white and pink juices were found to be 8.09, 8.47g/100ml; 1.82, 1.21 g/100g D.W.; 4.40, 6.60 g/100g D.W.; respectively.

For dietary fibers fractions: soluble fraction content was higher than insoluble one in both white, pink juices recording 2.30, 3.80; 2.10, 2.80 g/100g D.W.; respectively. While cellulose and hemicellulose were found in small amounts in the studied juices. The studied juices contained small amounts of (0.39-0.12, 0.12-0.12). The data revealed that pink juice had more pectin (1.33 g/100g D.W) than white one. A high percentage of pectin works to prevent heart disease and atherosclerosis and also works to strengthen the immune system. The previous results are in accordance with Aadil *et al.,* (2013) and Wang *et al.,* (2015).

Table 3. Total carbohydrates, crude fiber, dietary fibers fractions of white and pink grapefruit juice

Analysis		Sample	
		White grapefruit juice	Pink grapefruit juice
	Total carbohydrates (g/100ml)	8.09	8.47
	Crude fiber	1.82	1.21
Dietary fiber fractions (g/100g D.W.)	Total dietary fiber (TDF)	4.40	6.60
	Soluble dietary fiber (SDF)	2.30	3.80
	Insoluble dietary fiber (IDF)	2.10	2.80
	Cellulose	0.39	0.12
	Hemicellulose	0.12	0.12
	Pectin	0.11	1.33

Antioxidative components, antioxidant activity, vitamins contents of white and pink grapefruit juice

Table 4 shows the antioxidative components, antioxidant activity, vitamins contents in white and pink grapefruit juices. The total phenolics, total flavonoids, and total carotenoids contents were higher in pink juice: 1407.98, 25.13, 0.48 than white juice: 776.06 mg GAE/100ml, 19.52 mg catechin/100ml and 0.01 mg/100ml, respectively. The lycopene content of pink juice was found to be 0.016 mg lycopene/100ml, while this pigment was not detected in white juice. So, the pink juice had a high antioxidant activity 88.86% when compared with white juice 81.00%, as a result of increasing in antioxidants components in pink juice.

Table 4. Antioxidative components, antioxidant activity, vitamins content of white and pink grapefruit juice.

Analysis	Sample	
	White grapefruit juice	Pink grapefruit juice
Total phenolics (mg GAE/100ml)	776.06	1407.98
Total flavonoids (mg catechin/100ml)	19.52	25.13
Total Carotenoids (mg/l)	0.01	0.48
Antioxidant Activity (DPPH)%	81.00	88.86
Lycopene (mg lycopene/100ml)	N.D*	0.016
Ascorbic acid (C)mg/100ml	39.23	38.82
Thiamine(B1)mg/100ml	0.50	0.65
Riboflavin(B2)mg/100ml	0.057	0.042
Vit(A) B.carotene µg/100g	N.D*	17.4
Vit(E)αTocophyrol mg/100g	0.04	N.D*

*N.D. not detected.

As shown in Tale 4 the results revealed that contents of ascorbic acid, thiamine, riboflavin were similar both in white and pink juices. The vitamin C, vitamin B1 contents were in white juice were 39.23, 0.50 comparing with 38.82 mg/100ml and 0.65 mg/100 ml for white one. Vitamin A which determined as µg beta carotene/100ml was found just in pink juice (17.40), on the contrary vitamin E which determined as mg alpha tocopherol/100ml was found in the white one (0.04). Our results for antioxidants and vitamins are in consistent with Makkawi (2007) and Aadil *et al.* (2013).

Conclusion

Grapefruit juice contains several different compounds that can exert beneficial effects on human health based on the results of chemical composition and antioxidant components of grapefruit juices under study. Grapefruit juice can be considered to be a good dietary source of nutrients and antioxidant compounds, especially flavonoids and phenolics. Grapefruit juices can be used for their health properties in food products; in fact, they can be applied as a source of functional compounds, or as natural preservatives. In conclusion. Grapefruit juice has the potential to be further developed into a nutritionally interesting raw material for food and beverage applications.

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التقييم الفيزيائي والكيميائي لعصير الجريب فروت الابيض والقرنفلي

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الملخص

تهدف هذة الدراسه الي دراسه بعض الخواص الفيزيائيه والتقييم الكيميائي لصنفين من عصير الجريب فروت (الصنف ذو اللب الابيض والصنف ذو اللب القرنفلي) حيث محتواها من مضادات الاكسده والنشاط المضاد للأكسده وكذالك المعادن وبعض الفيتامينات. أظهرت النتائج أن العصير ذو اللب الأبيض كان أعلى في نسبة TSS و pH و TSS/Acid وكانت قيمتهم كالاتي ١٢,٠٠٪ و ٣,٥١ و ١٠,٦١ مقارنة بـ ١١,٦٠٪ و ٣,٤٥ و ٦,٠٤ للعصير ذو اللب القرنفلي على التوالي.

وتم تقدير العناصر المعدنيه حيث كان الفوسفور هو العنصر السائد الموجود في الصنفين، يليه الصوديوم والكالسيوم وكانت النسب كالتالي ٩٣,٣١ و ٨٩,٣٢ ؛ ٥٧,٨١ ، ٧٢,٠٧ ؛ ٤٨,٦٥ و ٢١,٥٩ ملجم / ١٠٠ مل، على التوالي. وكان إجمالي الكربوهيدرات والألياف الخام والألياف الغذائية الكلية في الصنف الابيض والقرنفلي كالتالي ٨,٠٩ ، ٨,٤٧ جم / ١٠٠ مل ؛ ١,٨٢ ، ١,٢١ جم / ١٠٠ جم D.W ؛ ٤,٤٠ ، ٦,٦٠ جم / ١٠٠ جم ، على التوالي. أحتوي العصير ذو اللب القرنفلي علي قيمه أعلي من النشاط المضاد للأكسدة بنسبة ٨٨,٨٦ ٪ بالمقارنة مع العصير ذو اللب الأبيض بنسبه ٨١,٠٠ ٪. وكان محتوي كلا من عصير الجريب فروت ذو اللب الابيض وعصير الجريب فروت ذو اللب القرنفلي على نسبة عالية من فيتامين ج. حيث كان محتوي صنف العصير ذو اللب الابيض من فيتامين ج وب١ كالتالي ٣٩,٢٣ ، ٠,٥٠ملجم/١٠٠مل مقارنة بـ ٣٨,٨٢ ملجم / ١٠٠ مل و ٠,٦٥ ملجم / ١٠٠ مل للصنف ذو اللب القرنفلي.

يعتبر عصير الجريب فروت له فائدة صحيه وقيمه تغذويه جيده لذا يصبح مادة خام جديرة للاهتمام من الناحية الغذائية في مجال الأغذية والمشروبات.