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Comparative Nutritional Analysis of Zest and Pulp in Red and Yellow Grapefruit Varieties

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The global cultivation and considerable demand for citrus fruits has given them a prominent place among fruit crops. With them being known for their virtues, health benefits, and characteristic aroma and taste, grapefruits have been accepted as an important food in our diets. Indeed, they play a key role in providing the nutrients to support good health. In this context, we sought to identify the nutritional characteristics of two varieties of grapefruit (*citrus paradisi*), namely yellow and red. We therefore investigated the water, protein, fiber, total sugar, and fat contents in the zest and pulp of these two species based on international food standards. We also quantified the various saturated and unsaturated fatty acids through gas chromatography. Our results revealed an interesting richness in these grapefruit varieties in terms of factors like total sugar, proteins, and fat, particularly in the peel, as well as a high-water content and energy value. Several fatty acids were also identified, mainly palmitic, oleic, and linoleic acids, which are highly sought after for their therapeutic benefits. This nutrient density highlights the value of these fruits and demonstrates that promoting its consumption can help improve human health and quality of life. This assortment of nutrients found in our samples, as well as the abundance of phenolic compounds already noted in other research studies, highlight this fruit and show the importance of its various parts - peel and pulp - in improving quality of life and human mental and physical health.

Keywords: Citrus, nutritional value, grapefruit, gas chromatography, fatty acid.

INTRODUCTION

Among the various tree crops and their associated socioeconomic importance in the world, the cultivation of citrus crops is one of the main agricultural sectors in the international economy. It is one of the world's leading fruit products by tonnage, ahead of bananas, watermelons and apples (Statista : production mondiale des fruits par type, 2023). Moreover, the global population's demand for citrus products continues to grow due to their nutritional value (Meziane, 2013).

Epidemiological studies have linked the consumption of citrus fruits to the prevention of certain cancerous diseases in the digestive tract and cardiovascular diseases thanks to the action of several components, such as vitamin C, carotenoids, flavonoids, and limonoids (Dhuique-Mayer, 2007).

While there is an uncertain number of natural species and large areas of cultivation, the best-known examples of citrus fruits are the commercially important ones, such as oranges, lemons, limes, grapefruits, and mandarins (Liu *et al.*, 2012). The grapefruit is one of the major citrus fruits, and it contains a myriad of bioactive chemicals that make it unique among citrus fruits. What also sets the grapefruit apart from other citrus fruits is its unique taste and flavor in addition to its underlying complex chemical composition. Indeed, despite the abundance of limonene in the zest and the aroma of grapefruit juice, flavanones in conjunction with limonoids contribute to its bitter taste (Khalil *et al.*, 2022).This fruit is particularly rich in vitamin C, and B-group vitamins are well represented, notably vitamins B5 and B3, or PP; as well as provitamin A (beta-carotene) in the pink and red varieties. The pulp also contains minerals such as potassium and calcium, as well as various types of antioxidant compounds, flavonoids and carotenoids(le Figaro Santé, 2016). In addition, Grapefruit (Citrus paradisi) has been used as a folk medicine in many countries as antibacterial, anti-fungal, anti-

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inflammatory, antimicrobial, antioxidant, antiviral, astringent, and preservative. It has also been used for cancer prevention, cellular regeneration, lowering cholesterol, cleansing, detoxification, heart health maintenance, Lupus nephritis, rheumatoid arthritis and weight loss (Gupta *et al.*, 2011).

Nevertheless, few studies have exhaustively evaluated the multiple constituents and health benefits of grapefruit, so this present study focused on two varieties of grapefruit, namely red and yellow.

In this context, this study focused on two types of grapefruit: red and yellow. Its aim is to evaluate and highlight the nutritional composition of the pulp and peel of these two grapefruit species in order to explain its growing use in agro-industrial, therapeutic and cosmetic fields, and to underline its crucial role in nutrition and its importance in human health and consolidation.

MATERIALS AND METHODS

***Determination of water content*:** After the samples had been ground and homogenized, the crystallizer was dried beforehand in an oven at 103°C under a pressure of approximately 30 mbar. After an hour, it was weighed to a precision of 0.0002 g.

After cooling in the desiccator, 10 g of each sample was weighed and introduced at a precision of 0.001 g. These were then dried for 3 hours at 103°C under a pressure of 30 mbar before being weighed after cooling. The samples were dried again until two weighing taken one hour apart did not differ by more than 0.001 g.

The results were determined by calculating the water percentage according to the following formula:

$$H = 100 - \frac{M2 - M1}{M1 - M0} \times 100$$

Where: H is the humidity percentage (water content); M0 is the mass in g of the dried empty crystallizer; M1 is the mass in g of the same crystallizer containing the test sample before drying; M2 is the mass in g of the previous crystallizer after dissection. (NFV 05 105, 1974).

***Determination of fiber content*:** To determine the fiber content, 1g of the various samples were placed in a beaker in which 50ml of buffer and 100µl of termamyl were then added. The beakers were then placed in a water bath set at 100°C for 30 min, with them being stirred every 5 min. After cooling, 10ml of NaOH (0.275N) and 100µl of protease were added before the beakers were reintroduced into the water bath, now set at 60°C, for 30 min, with them again being stirred every 5 min. Some 10ml of HCl (0.325N) and 300µl of amyloglucosidase were later added after cooling. The beakers were then placed again for a third time in a water bath, still set at 60°C, for 30 min, with them also again being stirred every 5 min. After cooling, 280ml of 95% ethanol, which was preheated to 60°C, was added to the solution. Next, a filter crucible was weighed, and 0.5g of celite was placed in it. This celite was soaked with 78% ethanol to distribute it over the crucible, and the samples were vacuum filtered. Washing was performed with 20ml of 78% ethanol 3 times in a row and with 10ml of 95% ethanol twice in a row.

This was followed by two washes with acetone. The whole sample was then dried in the oven at 105°C and weighed. Finally, everything was placed in the muffle furnace at 525°C for 5 hours and then weighed. The fiber content was calculated according to the following relationships, with the results being expressed to the nearest 0.1%.

• Blank calculation:

$$B = \text{mass of dry residue} - Pb - Cb$$

Where Pb is the protein content in the sample and Cb is the ash content.

• Sample calculation:

$$TF = \frac{\text{mass of the residue} - P - A - B}{\text{mass of the test portion}} \times 100$$

Where TF is the fiber content and P is the protein content (NFV 05 105, 1974).

***Determination of Protein Content*:** In order to determine the protein content of the different samples, 25 ml of concentrated sulfuric acid was introduced into a Kjeldahl mineralization flask before 2 g of a dried and defatted sample were weighed and introduced into the flask along with a copper sulfate tablet as a catalyst. The flask was then heated gently to prevent the foam from rising into the neck of the flask or escaping. The maximum temperature was then maintained for two hours. After cooling, 50 ml of water was added in order to completely dissolve the sulfates before being swirled and allowed to cool. After placing the flask in the distiller, 100 ml of NaOH was introduced. In the recovery flask, 100 ml of boric acid 40 g/l were introduced, and to this to a few drops of Tashiro's indicator was added. The distillation was carried out in such a way as to collect 150 ml of distillate, with this being titrated with 0.1 N sulfuric acid.

The nitrogen content (T) was calculated according to the following formula in order to be able to calculate the protein content:

$$T = \frac{(V3 - V2) \times C2 \times M}{10 \times m}$$

Where: T is the nitrogen content as a percentage of the test sample; V2 is the volume in ml of the sulfuric acid used for the blank test; V3 is the volume in ml of the sulfuric acid used for the determination; M in the molar mass in g/mol of nitrogen (M=14g/mol); C2 is the concentration in mol/l of the sulfuric acid solution used for the titration; and

m is the mass in grams of the test portion.

The protein content was then calculated according to the following formula:

$$P = 6{,}25 \times T$$

Where, P is the percentage protein content of the sample being tested; T is the percentage nitrogen content of the same sample (NFV 05 105, 1974).

***Determination of fat content*:** The total percentage fat content (%MGT) was determined by extraction with

petroleum ether using a soxhlet with 5g of each powder sample being placed in a cartridge and covered with cotton before being placed in the soxhlet. Next, 200 ml of petroleum ether were introduced into the flask after weighing it. The temperature of the tank heater was set to 65°C, with the device being plugged in for 5 hours. Most of the solvent was removed using a rotavapor before the flask containing the lipids was placed in the oven for 30 min at 103°C and then in the desiccator for 2 hours prior to performing a final weighing. The results were obtained by calculating the total fat content according to the following formula:

$$\%\mathrm{MGT} = \frac{\mathrm{P1} - \mathrm{P0}}{\mathrm{A}} \times 100$$

Where: %MGT is total percentage fat content; P0 is the weight of the empty flask in g; P1 is weight of the flask containing the lipids in g; and A is the sample weight in g (NFV 05 105, 1974).

***Determination of total sugar content*:** The following describes the method for measuring total sugar content, which also includes reducing sugars, so it covers all sugars with ketone and aldehyde functions, as well as invert sugars obtained through the hydrolysis of sucrose in a slightly acidic medium.

To achieve this, 5 g of each sample were dissolved in a beaker with distilled water and then boiled for 15 min. After cooling, the solutions were poured into a 250ml flask before the volume was adjusted and the solutions were filtered. Some 50ml of the filtrate were transferred to a 100ml flask, and then 1.5ml of ferrocyanide and 1.5ml of zinc acetate were added to this. The volume was then adjusted and the mixture filtered. Next, 25ml of this filtrate was transferred to a 50ml flask, into which 1ml of concentrated HCl was added to invert the sugars, and the solution was then heated in a water bath at 70°C for 25min. After the solution had cooled, a drop of phenolphthalein was added before NaOH (36°) was slowly added drop by drop until the solution turned pink. The volume was subsequently adjusted to 50ml and then filtered. Some 20ml of the filtrate was then taken and had Fehling's solution added to it. The mixture was brought to a boil for 3 minutes while being stirred. The mixture was then left to stand in an inclined position before being filtered through a porcelain filter to recover the precipitate, which was subsequently washed with distilled water. The obtained ferric solution was then filtered until completely dissolved before being then dosed with a KMnO4 solution of known strength (i.e., the poured volume of KMnO4). The results were determined based on the quantity of copper found, which corresponds to the quantity of total sugars according to the table of Gabriel Bertrand.

Table 1. Correspondence table for invert sugars showing the correspondence between various weights of copper and invert sugar.

Sucre (en mg)	Cuivre (en mg)	Sucre (en mg)	Cuivre (en mg)	Sucre (en mg)	Cuivre (en mg)
10	20.6	41	79.5	72	132.4
11	22.6	42	81.2	73	134.0
12	24.6	43	83.0	74	135.6
13	26.5	44	84.8	75	137.2
14	28.5	45	86.5	76	138.9
15	30.5	46	88.3	77	140.5
16	32.5	47	90.1	78	142.5
17	34.5	48	91.9	79	143.7
18	36.4	49	93.6	80	145.3
19	38.4	50	95.4	81	146.9
20	40.4	51	97.1	82	148.5
21	42.3	52	98.8	83	150.0
22	44.2	53	100.6	84	151.6
23	46.1	54	102.3	85	153.2
24	48.0	55	104.0	86	154.8
25	49.8	56	105.7	87	156.4
26	51.7	57	107.4	88	157.9
27	53.6	58	109.2	89	159.5
28	55.5	59	110.9	90	161.1
29	57.4	60	112.6	91	162.6
30	59.3	61	114.3	92	164.2
31	61.1	62	115.9	93	165.7
32	63.0	63	117.6	94	167.3
33	64.8	64	119.2	95	168.8
34	66.7	65	120.9	96	170.3
35	68.5	66	122.6	97	171.9
36	70.3	67	124.2	98	173.4
37	72.2	68	125.9	99	175.0
38	74.0	69	127.5	100	176.5
39	75.9	70	129.2		
40	77.7	71	130.8		

Quantity of Cu in 100mg of the sample = nx titer of KMnO4 (Bourdon & Gielfrich, 1972).

***Determination of energy value*:** This procedure specifies the method for determining the energy value. To do this, simply calculate the quantity of macronutrients it contains and multiply them by their respective energy factor. In this way, the energy value is calculated directly from the protein, sugar and fat contents previously determined, using the following formula:

$$E = 4 \times P + 4 \times S + 9 \times M.G$$

Where: E is the energy value in Kcal/100g; P is the protein content; S is the sugar content; and M.G is the fat content (Journal officiel de l'union européenne, 2011).

***Characterization of fatty acids through gas chromatography (GC)*:** The following specifies how the fatty acids were analyzed by GC according to standard 5509 (*ISO 12966-4*, 2015). In gas chromatography (GC), the molecules to be separated are volatilized and mixed with a gas. This gas, known as the "carrier gas", forms the "mobile phase" and carries the analytes inside an analytical column whose inner wall is covered with a chemical film (or "stationary phase"). Molecules are separated in time as they migrate through the column at different speeds, the travel time of each analyte being a function of its volatility and the interactions between the molecule and the chemical film. Analytes are detected as they exit the column. Each molecule is characterized by a retention time, which corresponds to the time elapsed between the injection of the analyte and its arrival at the detector. In

terms of volatility, the principle of separation is simple: the lower a compound's boiling point, the faster it migrates down the column. The boiling point of a compound is a thermodynamic parameter which depends essentially on two factors: molecular weight and polarity. The lower the molecular weight and polarity, the more volatile the compound. Interactions between analytes and stationary phase are much more complex, and the type of chemical film to be used depends on the nature of the molecules to be separated.(Stéphane, 2009)

To do this, we weighed 0.3g and added 20ml of iso-octane and 1ml of 2Mol/l methanolic KOH solution. The mixture was then shaken vigorously for 30 seconds. After initial clouding due to the separation of glycerol, the reactive mixture became clearer.

Some 5g of sodium hydrogen sulfate were then added, and the resulting solution was stirred. After the salt had settled, the upper layer containing the methyl esters was decanted, and the samples to be used for GC were taken from this layer. The chromatographic conditions used were as follows:

- The injector temperature was 220°C.
- The column oven temperatures were as follows:
  - Initial temperature: 140°C for 20min;
  - Temperature rise: 8°C/min; and
  - Final temperature: 175°C for 80min.
- The temperature of the FID detector was 220°C.
- The capillary column used was of type BP*70 with a length of 60m, an internal diameter of 0.32mm, and a film of 0.25µm.
- The injection volume was 1µl.
- The gas flow comprised H2 (40ml/min) and air (400ml/min).

The results were expressed based on standards that correspond to the methyl esters being sought. The percentage of fatty acids was given by the following ratio:

$$\%\, AG\ = \frac{Si}{\Sigma Si} \times 100$$

Where Si is the surface of the fatty acid and ΣSi is the sum of the surfaces of the different acids

RESULTS

The nutritional value of the pulp and zest of the two grapefruit varieties is presented in Table 2.

The analysis of the grapefruit varieties revealed a high-water content for both the studied varieties, with the pulp being richer in water than the zest. More specifically, the water content for red grapefruit was 88.2% for the pulp and 78.4% for the zest, while for yellow grapefruit, it was 88.7% for the pulp and 76.6% for the zest.

Table 2. Nutritional value of the two studied grapefruit varieties.

	Red grapefruit pulp	Red grapefruit zest	Yellow grapefruit pulp	Yellow grapefruit zest
Water (%)	88.20	78.40	88.70	76.60
Protein (%)	0.92	2.35	1.08	1.65
Fiber (%)	0.00	0.00	0.00	0.00
Ashes (%)	0.70	1.10	0.40	1.10
Fats (%)	0.20	0.10	0.10	0.50
Total Carbo-hydrates (%)	10.00	18.10	9.70	20.10
Energy value (kcal/100g)	45.30	82.40	44.00	91.20

The greatest protein content was found for the peel of the red grapefruit (2.35%), while fiber was found to be absent in all the tested samples.

For all the tested samples, the fat content was found to be between 0.1% and 0.5%. More specifically, red grapefruit had a fat content of 0.2% for the pulp and 0.1% for the zest, while for yellow grapefruit, it was 0.1% for the pulp and 0.5% for the zest.

The total carbohydrate content for red grapefruit was 10% for the pulp and 18.1% for the zest, while for yellow grapefruit, it was 9.7% for the pulp and 20.1% for the zest.

The energy value for the caloric intake of each sample was calculated based on the values obtained for total sugars, proteins, and fats. This value was greater for the zests of both grapefruit varieties, with it being 82.4 kcal/100g for red grapefruit and 91.2 kcal/100g for yellow grapefruit. The caloric contribution of the pulps of both grapefruit varieties was lower, with it being 45.3 kcal/100g for red grapefruit and 44.0 kcal/100g for yellow grapefruit.

***Fatty acid characterization through GC*:** Fatty acids (FA) are part of the lipid family, and they are very abundant organic molecules that are insoluble in water. There is currently considerable research focusing on their diversity and their beneficial effects for human health. Table 3 presents the results for the FA content of the two species of grapefruit based on the gas chromatographic analysis.

The results reported in Table 3 indicate the presence of a significant number of saturated and unsaturated fatty acids in the two studied grapefruit varieties. More specifically, they show a significant presence of oleic acid in red grapefruit (39.74% in the pulp and 25.54% in the zest), followed by palmitic acid (25.33% for the pulp and 18.82% for the zest) and then stearic acid (19.58% in the pulp and 11.58% in the zest).

For the yellow grapefruit, we noted a maximal palmitic acid content for the pulp with a percentage of 28.08%, which was much higher than the zest with 10.38%. On the other hand, the oleic acid content was lower for the yellow grapefruit, with it being 12.41% for the pulp and 12.30% for the zest. The zest of this grapefruit also contained a large percentage of behenic acid (15.82%) and magraroleic acid (12.08%). Oleic

acid was also present at percentages of 15.32% and 9.74% for the pulp and zest, respectively.

Table 3. Fatty acid composition according to GC for the two studied grapefruit varieties.

Saturated and unsaturated fatty acids	Red grapefruit pulp	Red grapefruit zest	Yellow grapefruit pulp	Yellow grapefruit zest
Myristic acid	2.18%	1.04%	1.98%	4.67%
Palmitic acid	**25.33%**	**18.82%**	**28.08%**	**10.38%**
Sapienic acid	0.84%	2.39%	5.64%	4.14%
Margaric acid	0.05%	1.57%	3.19%	2.45%
Margaroleic acid	0.08%	7.01%	0.90%	**12.08%**
Stearic acid	**19.58%**	**11.58%**	**10.46%**	6.61%
Elaidic acid	0.42%	1.01%	0.74%	2.97%
Oleic acid	**39.74%**	**25.54%**	**12.41%**	**12.30%**
Linolelaidic acid	0.11%	1.57%	0.50%	1.46%
Linoleic acid	5.85%	5.66%	**15.32%**	**9.74%**
α-linolenic acid	0.41%	2.66%	1.11%	1.28%
linoleic acid	0.62%	0.24%	7.18%	1.00%
Arachidic acid	3.35%	0.65%	3.41%	7.49%
Ecosenoic acid	0.21%	**12.01%**	1.07%	4.50%
Behenic acid	1.02%	1.46%	5.30%	**15.82%**
Lignoceric acid	0.20%	6.80%	2.72%	3.11%

Other fatty acids were also noted in the various samples, including arachidic, margaric, α-linolenic acid, and many others, but the percentage contents for these did not exceed 10%.

DISCUSSION

This study has highlighted the nutritional value of two varieties of grapefruit, namely yellow and red grapefruit. The fruits tested were harvested from an exemplary farm in the Rabat-Salé-Kénitra region, in the Kenitra-Lgharb province of Morocco.

More specifically, it has evaluated the nutritional composition in the form of the water, carbohydrate, protein, fatty acids, and fiber content in the pulp and zest of the two varieties. Comparing our results with those in the literature highlights several similarities and differences in relation to other citrus fruits. Indeed, the originality of this work is rooted in the scarcity of research that has been carried out for these citrus species.

The analysis of the nutritional characteristics of these two grapefruit varieties has revealed their significant richness. A high-water content was noted for both varieties, with the pulps being richer in water than the zests. In the results of other published work, grapefruit has been found to be composed of approximately 88% water (Le Figaro Santé, 2016), and this is consistent with our work. This is significant because a high water content in fruits provides part of the environment that is necessary for the normal functioning of enzymes and general metabolic processes (Edori, 2013).

By comparing grapefruit with other citrus species, (Palangi *et al.)* showed that lemon has the greatest composition of ash and dry matter, while grapefruit of all the considered species has the lowest ash and dry matter composition (Palangi *et al.*, 2013).

In our study, fiber was absent in all the tested samples, which derived from fruit that had been collected in the fully mature phase. Previous studies have shown that dietary fiber composition and content changes with maturity, suggesting that an early harvest may result in higher dietary fiber content (Larrauri *et al.*, 1997; Liu *et al.*, 2012).

Proteins are essential components of a healthy diet for animals and humans, with their basic function being to provide adequate amounts of the amino acids necessary for survival. Indeed, protein deficiency leads to growth retardation, muscle wasting, edema, abnormal swelling of the belly, and the accumulation of fluids in the body (Perkins *et al.*, 2004).

Nevertheless, our results showed a relatively low protein content, with these being largely enzymes, including transferases, hydrolases, lyases, ligases, and oxidoreductases in different parts of the fruit, as was noted in the work of. (Liu *et al.*,2012).

Nonessential amino acids—such as alanine, arginine, asparagine, aspartic acid, glutamic acid, glycine, serine, and proline—are found in many oranges. Indeed, it has been shown that prolines are present in several varieties of oranges, lemons, and tangerines, while essential amino acids like valine, phenylalanine, threonine, leucine, methionine, and lysine are found in some oranges and grapefruits(Liu e*t al.*, 2012).

Our study showed that the lipid contents of the two grapefruit varieties varied in the samples, with it ranging from 0.1% in the zest of yellow grapefruit to 0.5% in that of yellow grapefruit.

The quantification of fatty acids for the two grapefruit varieties through gas chromatography highlighted the dominance of four fatty acids, namely palmitic, oleic, linoleic and linolenic acids. Similar results have been reported for these four fatty acids, with them constituting 74.0% of the total acids in blood orange juice (Moufida et Marzouk, 2003). Furthermore, the profile for the main fatty acids is identical for oranges and grapefruits, while lemons and limes showed a reduced level of oleic acid and high concentrations of linolenic acid in the work of.(Liu *et al.*, 2012). Thus, the fatty acid composition of citrus fruits can be used to distinguish different varieties (Liu *et al.*, 2012).

Fatty acids are major constituents of the different classes of lipids, which include triglycerides, phospholipids, and to a lesser extent, cholesterol esters. Triglycerides (TG) represent 95–98% of ingested dietary lipids, and they are made up of a glycerol molecule esterified by three fatty acids. Within the body, triglycerides are mainly located in adipose tissues and constitute the main form of energy storage (Legrand, 2007). On the other hand, saturated fatty acids (SFAs) are

synthesized by the human body, particularly in the liver, brain and adipose tissue. Along with those ingested with food, they are constituents of phospholipids (rich in C18:0 stearic acid), sphingolipids, and reserve triglycerides, and they account for a significant portion of energy expenditure. They are partly converted through desaturation into monounsaturated fatty acids.

It is very clear that not all saturated fatty acids have the same effect on metabolism. Indeed, while some seem to have no effect, others, such as palmitic acid, play a significant role in developing certain metabolic abnormalities, because they notably alter insulin sensitivity and the inflammatory response within various tissues (Walrand *et al.*, 2010).

Monounsaturated fatty acids, particularly oleic acid, are used as a source of energy. They are also esterified in all types of lipids, particularly in storage triglycerides (i.e., in adipose tissue), which they maintain in a fluid state at body temperature thanks to their mono-unsaturation. Oleic acid, a preferential substrate for ACAT (acyl-CoA-cholesterol acyltransferase), also esters cholesterol (Legrand, 2007).

The main polyunsaturated fatty acids are derived from oleic acid through a series of elongation and desaturation reactions. Note that it is appropriate to use the term "essential fatty acids" for the two precursors of linoleic acid and linolenic acid because they are essential for normal growth and the physiological functions of all tissue, yet they cannot be synthesized by humans or animals (Legrand, 2007).

Lipids, including fatty acids, fulfil various functions, such as by acting as energy sources, structural elements, and signalers (Fahy *et al.*, 2005). Indeed, like most plants, the surfaces of citrus fruits are covered with a multilayer cuticle composed mainly of cutin, a lipid whose long-chain constituents are linked by ester bonds and cross-polymerized with compounds of molecular weight that are high and intermediate in size and poorly soluble in most solvents (Fahy *et al.*, 2005) . A layer of waxy lipids, called epicuticular wax, exists on the outer surface of the cutin, and this can be easily dissolved in organic solvents (Schirra et D'hallewin, 1997). Nevertheless, the cuticle wax content in the fruit peel plays an important role in limiting moisture loss, thus protecting the fruit and maintaining its water content. This is reflected in our results for the water richness of grapefruit.

Prior studies have also demonstrated how the consumption of citrus fruits, including grapefruits, can be specifically linked to preventing certain types of cancers (Foschi *et al.*, 2010), such as cancer of the mouth, pharynx, esophagus (Chainani-Wu, 2002), stomach cancer (Bae *et al.*, 2008), and even colon cancer.

For people suffering from hypercholesterolemia, consuming two grapefruits per day can help reduce blood cholesterol and triglyceride levels (Gorinstein e*t al.*, 2004), while for obese people, consuming grapefruit as part of a balanced diet and a regime of regular physical activity can play a role in weight loss (Le Figaro Santé, 2016).

Furthermore, our sampling was limited to a single region. Of course, the nutritional composition of grapefruits can change from one region to another as a result of climate change.

The nutritional qualities of fruit and vegetables vary considerably depending on genetics and, to a lesser extent, the environment (climate, soil, terroir), Environment (climate, soil, terroir). Cultivation practices, such as fertilization and irrigation, also have an impact on micronutrient content., micronutrient content. In general, stress conditions during the growth and ripening of fruit and vegetables increase their antioxidant micronutrient content(Amiot-Carlin & Georgé, 2017) .Fruit growth and nutritional composition are determined by carbon and water inputs to the fruit. As high temperatures and water deficits can reduce these inputs at plant level, changes in fruit size and composition are to be expected under the influence of climate change. This can lead to more or less significant changes in various fruit quality characteristics, such as fruit composition and visual appearance at harvest.important changes in various fruit quality characteristics, such as fruit composition and visual appearance at harvest.(Gautier *et al.*, 2022)

There are many avenues for further research in this area, such as characterizing the minerals and vitamins in these two grapefruit species, and determining the structures and chemical properties of their phenolic compounds using analytical separation methods, which will be the subject of further research.

***Conclusion*:** Citrus fruits are widely consumed, popular fruits, and they have become an integral part of our diets. Characterized by their distinctive flavor, grapefruits, like its fellow citrus fruits, have many nutritional benefits. This study has noted the significant nutritional content of two grapefruit varieties and revealed their interesting saturated and unsaturated fatty acid profiles. This unique nutritional composition effectively proves the use of this fruit in the prevention of cardiovascular disease and many other chronic illnesses. In fact, this assortment of nutrients gives it highly sought-after preventive and therapeutic virtues for a better quality of life.

The density of nutrients in grapefruits, along with the implications these nutrients have for the prevention of chronic diseases as part of a healthy and balanced diet combined with regular exercise, mean that promoting the consumption of these fruits could have important consequences for improving human health.

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***SDG's Addressed*:** Zero Hunger, Responsible Consumption and Production, Climate Action.

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