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Research Article

ANALYSIS OF PHYSICOCHEMICAL, NUTRITIONAL, PHYTOCHEMICAL PROPERTIES AND ANTIOXIDANT CAPACITY OF THREE STRAWBERRY CULTIVARS "*FRAGACIA ×ANANASA* DUCH." FROM EASTERN OF ALGERIA AND CARACTERIZATION OF STRAWBERRY JAM

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ABSTRACT. In eastern Algeria, the predominant strawberry cultivars (*Fragaria×ananassa* Duch.) include Savana, Sabrina, and Fortuna. The aim of this study is to evaluate the physicochemical and antioxidant properties of three strawberry cultivars, as well as to characterize two types of strawberry jam. The values of compounds such as caliber, titratable acidity, total soluble solids, moisture, ash, protein, fat, carbohydrate, total phenolic and anthocyanin content, DPPH radical scavenging activity, total sugars and sensory analysis of the jam were determined. The titratable acidity and total soluble solids values demonstrated a significant variation ($p<0.05$) throughout all strawberry cultivars. The protein and lipid content of the three strawberry cultivars was less than 1%. The strawberry cultivars contain significant levels of phenolic compounds. Strawberry cultivars have a DPPH free radical scavenging activity ranging from 40.84 to 45.25%. The strawberry jam with ginger (J1) had the highest ratings for all sensory qualities, making it the greatest jam in the judges' view. These findings give useful information on the phytochemical and nutritional quality of Algerian strawberries grown in the eastern region of the country and may be utilized to enhance the nutritional content of a functional food in a healthy diet.

Keywords: *Strawberry, cultivar type, phenolic content, jam, antioxidant capacity.*

INTRODUCTION

In recent years, fruit and vegetable consumption has risen sharply as public knowledge of their health advantages has grown. Currently consumers have placed the most importance on the sensory qualities of fruit, as characterised by visual appearance, texture, flavor, and perfume. However, nowadays, people are more concerned than ever before about the nutritional value and food safety. Strawberry (*Fragaria x ananassa* Duch.) is a perennial plant belonging to the genus *Fragacia* and the *Rosaceae* family. Due to its resilience to a broad range of agroclimatic conditions, it is one of the most

commonly farmed berry species in the world [1]. The Food and Agriculture Organization of the United Nations (FAO) reports that the worldwide output of strawberries reached eight million tonnes in 2018. It is a widely prized fruit in the Mediterranean diet due to its aroma, red color, sweet flavor, and nutritional content [2]. In 2001, tiny sections of the province of Jijel (Algeria) were used to begin strawberry production (four hectares in 2001). With the gradual adoption of intensive cultivation of many strawberry cultivars under glass and tunnel, the area being farmed grew to 443.29 hectares in 2020. The main cultivars were Sabrina, Savana, and Fortuna. However, the nutritional value, phytochemical composition, and antioxidant capacity of strawberry fruits cultivated in eastern Algeria are undetermined. Strawberry is mostly made up of water (90%) and dry matter (10%), but it also contains carbohydrates, lipids, proteins, minerals (124 mg/100 g potassium), and vitamins (58 mg/100 g Vitamin C) [4, 5]. This composition differs according to the variety, production techniques, climate and location of production, cultivar, harvest period, and maturity level. Consequently, several factors may significantly impact the nutritional content of strawberries [4]. When it comes to how hot temperatures affect the growth of fruit, for example, temperatures around 30 improve and stimulate antioxidant activity [6]. Strawberries are one of the richest fruits in phytochemicals, mostly phenolics, and flavonoids are the phenolic compounds that provide the most antioxidant and anti-inflammatory properties of strawberries, in addition to being responsible for their red colour [7]. All of these phenolic compounds may help prevent certain diseases because they are antioxidants and don't make inflammation worse [8]. Strawberry production is abundant in the wilaya of Jijel (eastern Algeria); however, their shelf life is short due to their high-water content. Consequently, the valorisation of this fruit by transforming it into jam might offer a real economic and social potential that is dependable, sustainable, and market-specific.

In the original investigation, strawberry cultivars (cv. "Sabrina", cv. "Savana", and cv." Fortuna") grown in eastern Algeria (Jijel) were evaluated for their physicochemical, nutritional, phytochemical (polyphenol and anthocyanin content), and antioxidant capacity (DPPH scavenging activity) qualities, and the cultivar with the highest quality was selected for the industrial manufacture of strawberry jam with and without ginger. The physicochemical and sensory properties of both jams were analysed in order to choose the most appetising jam formulation for the customer. Consequently, this study provides significant information on the quality of Algerian strawberry varieties.

MATERIALS AND METHODS

Sample preparation

Three strawberry cultivars (*Fragaria× ananassa* Duch.) (cv. "Sabrina", cv. "Fortuna", and cv." "Savana") were collected from the El Ouana fruit farm in the Jijel area (Algeria). When growers selected strawberries, they considered growing circumstances such as maturity (80% red color) and the absence of lesions. Strawberry harvesting and transportation to the laboratory totaled 5 kg of strawberries. Strawberries that were not used right away were wrapped in polyethylene film and kept at 4 °C and 90% relative humidity for no more than 12 h before being analyzed.

Analysis of physicochemical properties

For physical properties, digital Calipers (ProPanal-HD, USA) were used to estimate the caliber and the height of the strawberries. Additionally, twenty strawberries from each cultivar were weighed [9].

Titratable acidity

The titratable acidity was determined using the procedure reported in [10], with some modifications: To achieve a 1:1 solution, 25 g of strawberry pulp was mixed with 25 g of distilled water. Titrations were performed using a sodium hydroxide solution, NaOH (0.1N) (Carlo ERBA, Val de Reuil, France), since a pH of 8.1 was attained in the presence of a few drops of phenolphthalein (Riedel-de Haen, Germany).

Total soluble solids (TSS)

A refractometer (Model ATAGO HSR-500, Japan) was used to measure the soluble solid content of the strawberries. Four strawberries of each variety were blended and filtered. Each sample was applied as a drop to the refractometer plate. At the intersection of the light and dark fringe limits of the refractometer, the result was directly read on the scale. Brix is used to express the result [11].

Analysis of proximate composition

We determined the following parameters (moisture, ash, protein, fat, and carbohydrate): Moisture was determined by drying 10 g of strawberry samples in an oven at 70 °C to obtain a constant mass, then the dry residue is weighed [9]. To determine the amount of ash, the samples were heated in a Thermolyne F48010-33 Muffle Furnace (ColeParmer, VernonHills, USA) at 600 °C [4]. The protein content was determined through the Kjeldhal procedure (N ×6.25) in accordance with AOAC 920.152. The Soxhlet approach is used to assess the lipid content in accordance with AOAC 963.15. Carbohydrates were calculated by difference as follows [11]:100–(g Moisture+g Protein+g Fat+g Ash).

Analysis of antioxidant properties
Total polyphenol content

The total phenolic content was determined by the method of [12] with some modifications, which is based on the Folin-Ciocalteu method using gallic acid as a standard.

Extraction

2.5g of pulp of each strawberry variety was macerated in 25 ml of pure methanol (Fluka, Almaty, Kazakhstan) under agitation in an orbital shaker for 24 h (Infors AGCH-4103, Bottmingen, Switzerland). The extract was then filtered and evaporated with a rotavapor at 65 °C. The residue was recovered with 3 ml of methanol then stored in the refrigerator until analysis.

Total phenolics determination

250 µL of methanolic extract was then mixed with 250 µL of Folin-Ciocalteu reagent (Sigma- Aldrich, Taufkirchen, Germany), 500 µL of sodium carbonate Na_2CO_3 (20%) (Sigma-Aldrich) and 5 Ml of distilled water. We kept the mixture at room temperature for 30 min, and the mixture's absorbance was determined at 750 nm by a spectrophotometer (Model Ultrospec 100 pro, SHIMADZU, Germany). The results are given in milligrammes of gallic acid equivalents (mg GAE) per 100 grammes of strawberries.

Anthocyanin content

pH difference was used to assess the anthocyanin content of strawberry cultivars. 2.5 mL of strawberry samples were combined with 5 mL of two buffers with pH values of 1.0 (0.2 M potassium chloride (Fluka) adjusted with chloric acid (Sigma-Aldrich)) and 4.6 (0.2 M acetate of sodium (Fluka) adjusted with acetic acid (Fluka)). Both strawberry samples with a pH of 1.0 and 4.6 were incubated at room temperature for 30 min. The absorbance difference between the two buffers at 530 nm is related to their anthocyanin concentration. Additionally, absorbance data at 700 nm was used to compensate for the presence of interfering chemicals. The following equations [Eq.1, Eq.2] reflect the findings in mg cyanidin-3-glucoside per 100 g strawberry fruit [13].

The absorbance corresponding to the anthocyanins is calculated as follows:

$$\text{Anthocyanin concentration} = \Delta A.\, MW\ \text{average}\ FD\ 1000/\varepsilon.\, L \quad \text{(Eqn.1)}$$

$$\Delta A = (A530 - A700)\ \text{pH: } 1. - (A53 - A700)\ \text{pH: } 4.5 \quad \text{(Eqn.2)}$$

Where: MW average is the molecular mass of cyanidin-3-glucoside (449.2 g/mol); FD is the dilution factor; ε is the molar extinction coefficient of cyanidin-3-glucoside (26,900 cm/M); L is the optical path (cm); and 1000 is the milligrams conversion factor.

Antioxidant activity (DPPH radical scavenging activity)

The DPPH scavenging activity was measured using the approach described by [14]. 50 µL of sample/standard was incubated for 1 h in the dark at room temperature with 150 µL of DPPH solution (150 mol/L). Subsequently, the absorbance at 517 nm was determined. Inhibition was represented as a percentage of radical scavenging activity (% RSA).

Manufacturing process of strawberry jam with ginger and without ginger

Two types of strawberry jams were made using the Sabrina cultivar: J1 jam with ginger and J2 jam without ginger. Sorting, trimming, washing and blanching (95-100 °C) for 3min were the preliminary treatments of the strawberry. All ingredients were weighed separately: strawberry (1 kg), sugar (600 g), ginger (15 g) (peeled and grated) and citric acid (1 g). The strawberry pulp was combined with sugar and ginger. Slowly, with frequent stirring, the mixture was heated until it reached the desired thickness. In order to avoid excessive hydrolysis of the sugar, citric acid was introduced later in the process. Hot jam was poured into clean, sterile, and dry glass bottles, which were then sealed and kept in a cold location.

Sensory analysis of the jam

The strawberry jam without ginger (J1) and with ginger (J2) were subjected to a sensory assessment. A group of 10 judges that were very familiar with jam, 5 men and 5 women aged between 20 and 40 years old, used a nine-point hedonic scale to rate the product on its color, flavor, sweetness, texture, taste, and overall acceptability. 1=I don't like it exceedingly, to 9=I like it tremendously. The judges then gave each parameter a score, and the average of those scores was found [15].

Determination of moisture content

Each sample of strawberry jam weighing 100 g was put in a porcelain crucible and oven-dried at 80 °C until the weight remained consistent [16].

Determination of total sugars

The total sugar content was assessed using the technique of Dubois [17]: 0.125 g of jam was combined with 5ml of sulphuric acid (0.5M) (Sigma-Aldrich), and the combination was heated at 105 °C for 3h. The solution was poured into a flask and topped it up with 500 mL of distilled water. After that, the solution was filtered and divided into three equal dilutions. In tubes, 1ml of each dilution was placed, and then 1mL of phenol (Fluka) and 5Ml of sulphuric acid were added to each tube (98%). We kept the tubes in the oven at 105 °C for 5 min and in the dark for 30 min. Finally, the optical density was measured using a spectrophotometer at 485 nm.

Determination of total soluble solids and titratable acidity

The total soluble solids and titratable acidity of jam were measured using the same procedures as for strawberry analysis.

Statistical analysis

Analysis of variance was used to compare the results of three replicates (ANOVA: Analysis of Variance) with SPSS (version 20.0) [SPSS Inc., France]. The difference between strawberry cultivars and strawberry jam was significant when the $p<0.05$.

RESULTS AND DISCUSSION

Physicochemical determinations

The values of calibre, height and weight (Table1) shown no significant difference in all strawberry cultivars ($p>0.05$). Cv. "Savana" weighed 21.54 g on average, followed by cv. "Sabrina" with 20.68 g and cv." Fortuna" with 17.99 g. In terms of fruit length, we found that the cv. "Savana" averaged 45.19 mm in length, followed by the cv. "Fortuna" with 43.41 mm and the cv. "Sabrina" with 39.30 mm. Both Savana and Fortuna cultivars had lengths more than 10 mm longer than the cultivars used in [18] research, which had an average length of 31.6 mm. [19] reported a length of 35.6 mm, which is less than the lengths recorded for the three cultivars evaluated. Additionally, [20] found that the average length was 47.7 mm, which is greater than the lengths seen in the three cultivars investigated. The calibre of the three strawberry cultivars was comparable: cv. "Fortuna" (32.94 mm), cv. "Savana" (31.89 mm) and cv. "Sabrina " (28.86 mm). Our findings are

much lower than those obtained from cultivars cv. "Primoris" (48.9 mm), cv. "Portola" (42.2 mm) and cv. "Endurance" (41.7mm) cultivated in Portugal's western area [11]. They are, however, comparable in calibre to the North American Pacific cultivars cv. "Totem" (29.13 mm) and cv. "Puget Reliance" (30.5 6mm) [9]. As a result of our research, we have discovered that the three strawberry cultivars Savana, Sabrina, and Fortuna cultivated in the wilaya of Jijel have excellent physical features that make them appealing to consumers.

Table 1. *Dimension and weight of strawberry cultivars (cv. "Sabrina", cv."Fortuna", cv."Savana").*

Cultivars	Calibre (mm)	Height (mm)	Weight (g)
cv."Sabrina"	28.26±1.47[a]	39.30±1.26[a]	17.99±1.54[a]
cv."Fortuna"	32.94±1.49[a]	43.41±1.04[a]	20.68±1.61[a]
cv."Savana"	31.89±1.18[a]	45.19±1.53[a]	21.54±1.54[a]

Data are expressed as means± standard deviation of three measurements. a-c Means followed by a different letter in the same column are significantly different p<0.05 between Strawberry cultivars.

The titratable acidity and total soluble solids values (Table 2) demonstrated a significant variation ($p<0.05$) throughout all strawberry cultivars. The cv. "Sabrina" had the greatest titratable acidity value (0.612±0.012) g citric acid/100g, followed by the cv. "Fortuna" with a value of (0.514±0.008) g citric acid/100g and the cv. "Savana" with a value of (0.315±0.055) g citric acid/100 g. According to [11], strawberry cultivars Primoris (0.809 g citric acid/100g) and Endurance (0.739 g citric acid/100 g) grown in Portugal had the greatest titratable acidity values compared to the strawberry cultivars "Sabrina", "Fortuna", and "Savana". Additionally, it demonstrates that strawberries grown on a local farm in China had a lower titratable acidity (0.68 g citric acid/100 g) than our strawberry cultivars [21]. However, the titratable acidity of cv. "Sabrina" and cv. "Fortuna" is greater than that of strawberry fruit grown in Columbia, averaging 0.490 g citric acid/100 g [10]. Maximum citric acid content of 0.8 percent to ensure an adequate taste, stating that less acidic fruits are preferable for fresh consumption, so those with a greater citric acid concentration may be utilized to produce better-quality processed products [22,23]. Changes in strawberry cultivars' titratable acidity may occur as a result of differences in harvest ripeness, growing circumstances, and environmental influences [24]. The acids found in fruits are used over time during the respiration process, making way for new molecules, which justifies their decline throughout the fruit ripening [25].

Table 2. *Physicochemical properties (titratable acidity and soluble solid content) of the studied strawberry cultivars.*

Physicochemical Properties	cv."Sabrina"	cv."Fortuna"	cv."Savana"
Titratable acidity (g citric acid/100g)	0.612±0.012[a]	0.514±0.008[a]	0.315±0.055[c]
Soluble Solide Content (°Brix)	9.54±0.47[a]	8.23±0.44[a]	6.94±0.35[b]

Data are expressed as means± standard deviation of three measurements. [a-c] Means followed by a different letter in the same line are significantly different P <0.05 between Strawberry cultivars.

Cv. "Sabrina" had the greatest value of total soluble solids, 9.54 (°Brix), whereas cv." Savana" had the lowest value 6.94 (°Brix). These values are greater than those reported on the cultivars Primoris and Portola, which indicated values of 6.82 (°Brix) and 4.89 (°Brix), respectively [11]. Nevertheless, the result as reported by cv "Sabrina" is comparable to that of cv. "Totem" 9.02 (°Brix) but much less than that of the cv."Puget Reliance" 12.33 (°Brix) growing in the United States' North Pacific [9]. According to [26], total soluble solids in strawberry fruit varies from 7-12 %, depending on the cultivar. A modern data with seven distinct types substantiates this assertion, since the authors demonstrated notable variations between seven different strawberry cultivars grown in relatively comparable locations of the state [27]. Organic acids and sugar are the major elements of fruit's total soluble solids [28]. Carbohydrates are converted to sugars and other soluble molecules during the early metabolic phase in strawberries, increasing the overall quantity of soluble solids. Sucrose hydrolysis, which lowers sugars, was used to determine the soluble solid content [21]. Strawberry total soluble solids are regulated by a multitude of variables, particularly genetics, environment, and agricultural runoff [29].

Proximate compositions

Except for ash and protein levels, there were no significant differences ($P>0.05$) in the proximate composition of the strawberry varieties. (Table 3). The sample of the cv. "Savana" has the most minerals at 0.660%, followed by the two samples of cv. "Fortuna" at 0.460% and cv. "Sabrina" at 0.260%. These results are lower than those reported by [30] and [32], who reported 2.82%, 1.71%, and 0.860%, respectively. Variation in the mineral content of fruits may be explained by the geographical origin of the samples, the meteorological conditions, and the soil edaphic features. Also, these differences could be caused by different environmental conditions, the age of the plant, where it is in its life cycle, or even its genes. The protein content of the three strawberry cultivars was less than 1% and the highest value was recorded with cv. "Fortuna" (0.895%), while the lowest value was recorded with cv. "Sabrina" (0.575%). Similarly, for the lipid content, the three strawberry cultivars cv. "Sabrina", cv. "Fortuna", and cv. "Savana" recorded low values in the order of 0.150%, 0.130%, and 0.120%, respectively. Several parameters influence the lipid content, such as particle size, moisture, nature of the solvent, and the extraction method used. The highest moisture content was (83.93 % in cv. "Fortuna", while the lowest was 81.23%) in cv. "Sabrina". Our findings are lower than those published by [9], who reported values of 88.26% and 86.39% for the cv. "Totem" and cv. "Puget Reliance", respectively. Similarly, strawberry cultivars cv. "Portola" (89.8%) and cv. "Endurance" (88.2%) were shown to be very productive [11]. All mineral salts, carbohydrates, enzymes, and other substances found in fruit are dissolved in water. The following variables may affect the moisture content of a plant: the plant's age, the vegetative cycle duration, the degree of maturity, and genetic factors. This fluctuation in moisture content may also be attributed to a variety of environmental factors, including exposure to a variety of soil and meteorological conditions and geographic dispersion [31]. Carbohydrate content varied between 14.585% and 17.785%, with no significant variation between the three strawberry varieties ($p>0.05$). In general, the nutritional profile of strawberries grown in the Jijel area of Algeria influences the dietary choices of people trying to incorporate safe, healthy, and nutritious foods into their diet.

Table 3. *Proximate compositions of strawberry cultivars (cv. "Sabrina", cv."Fortuna", cv."Savana").*

Components [%]	cv."Sabrina"	cv."Fortuna"	cv."Savana"
Moisture	81.23±0.91^{a}	83.93±3.20^{a}	82±1.05^{a}
Ash	0.260±0.011^{c}	0.460±0.013^{b}	0.660±0.008^{a}
Crude Protein	0.575±0.034^{b}	0.895±0.021^{a}	0.865±0.054^{a}
Crude Fat	0.150±0.008^{a}	0.130±0.003^{a}	0.120±0.011^{a}
Carbohydrates	17.785±1.35^{a}	14.585±1.58^{a}	16.355±1.94^{a}

Data are expressed as means± standard deviation of three measurements. $^{a-c}$ Means followed by a different letter in the same line are significantly different $p<0.05$ between Strawberry cultivars.

Antioxidant properties

The strawberry cultivars exhibited significant differences in phytochemical composition ($p<0.05$) but not in antioxidant capacity ($p>0.05$) (Table 4). Strawberry is a phytoconstituent fruit that has mostly been linked to a lower risk of getting sick because of its phenolic content. Anthocyanin is one of the most studied polyphenol chemicals in strawberry fruits [5] because of its health advantages and association with red color, which are the primary traits used to estimate strawberry quality [32, 33]. We observed that all three strawberry cultivars evaluated contained significant levels of phenolic compounds: 1115 mg GAE/100 g for cv. "Sabrina", 854 mg GAE/100 g for cv. "Fortuna" and 740 mg GAE/100 g for cv. "Savana". Our findings are consistent with those of [11] and [34].

Polyphenols are very good antimutagens and anticarcinogens, particularly in relation to one of their properties, which is that they are extremely powerful antioxidants. [35]. Polyphenols could exert antioxidant protection in the digestive tract, where they are present in high concentrations and in their native forms. They could thus actively fight against oxidation, which can occur in the stomach [36]. The quality and quantity of polyphenols that exist in fruits are influenced by the type of variety, environment and soil type [37].

In red or purple fruits, cyanidin glycosides are the most abundant anthocyanins, followed by delphinidin glycosides [38, 39] demonstrated that the presence of cyanidin-3-glucoside in Rubus ulmifolius contributes significantly to the fruit's antioxidant activity. The concentration of anthocyanin expressed as cyanidin-3-glucoside was found to be substantially different ($p<0.05$) in cv. "Sabrina" (2.85 mg/100 g) when compared to cv. "Fortuna" (1.40 mg/100 g) and cv. "Savana" (1.10 mg/100 g). In this study, all three strawberry cultivars showed a correlation between anthocyanin content and phenolic content. However, the anthocyanin level of the examined strawberry cultivars was greater than that of Fragaria chiloensis Mill, also known as Chilean strawberry, which had a lower anthocyanin content of 1.10 mg/100 g, according to [40]. Anthocyanidins (aglycone form) are unstable and sensitive to light, pH and temperature variations. These anthocyanins vary in number of hydroxyl groups, degree of methylation of these hydroxyl groups, type and quantity of sugars, and location and quantity of aliphatic or aromatic acids linked to the sugar [41]. According to research conducted by [42], the content of anthocyanins and their antioxidant effects varies significantly across fruit species and varieties. Strawberries have been demonstrated to be a great natural source of anthocyanins, which have been linked to health benefits [43].

Strawberry cultivars have a DPPH free radical scavenging activity ranging from 40.84 to 45.25. The present research found that the values were typically greater than those reported by Wang, Wang, Ye, Vanga, and Raghavan [44] for the strawberry cultivar "Seascape" following postharvest high-intensity ultrasound therapy before juice processing. According to [45], strawberry fruits' antioxidant content expanded across the postharvest stage, from immature to a completely ripened maturity phase. Additionally, environmental circumstances (mostly higher temperatures) also cause berry fruits to have a large increase in the amount of antioxidant potential that they contain [46].

Table 4. Antioxidant properties *(total phenolic component, anthocyanin content and antioxidant capacity (DPPH radical scavenging activity) of the studied strawberry cultivars.*

	cv."Sabrina"	**cv."Fortuna"**	**cv."Savana"**
Phytochemical			
Total phenolic component (mg gallic acid equivalent (GAE)/100g)	1115±29[a]	854±34[b]	740±25[b]
Anthocyanin content (mg/100g)	2.85±0.04[a]	1.40±0.02[b]	1.10±0.05[b]
Antioxidant capacity			
DPPH radical scavenging activity (RSA, %)	45.25±2.12[a]	43.81±1.54[a]	40.84±3.45[a]

Data are expressed as means± standard deviation of three measurements. a-c Means followed by a different letter in the same line are significantly different P <0.05 between Strawberry cultivars.

Strawberry jam characteristics

Sensory attributes

Fig.1 shows the means of sensory evaluation of jam. The color score was 7.60 on the 9-point hedonic scale, suggesting that the color of strawberry jam with ginger (J1) was moderately liked, and on strawberry jam without ginger (J2), it was 6.70, indicating that it was slightly liked. The flavor had a rating of between 5.10 and 5.95, suggesting that it was neither particularly liked nor disliked. This is because the appealing strawberry flavor was lost during the high temperature heating process used to make the gel. Sweetness was assigned a score of 6.60-6.90, suggesting that the two strawberry jam is liked slightly. J1 had an 8.20 texture characteristic, suggesting that gel formation was excellent. While J2 received the lowest mark (5.5). The flavor of the jam received an 8.30 rating in J1, indicating that it was highly liked, while it received a 7.30 rating in J2, indicating that it was somewhat appreciated. The overall acceptability of the jam received an 8.50 rating for J1, meaning that it was highly regarded, and a 7.50 rating for J2, indicating that it was liked moderately. According to the findings in Figure 1, strawberry jam with ginger (J1) had the highest ratings for all sensory qualities, ranging between 5.95 and 8.50, making it the greatest jam in the judges' view.

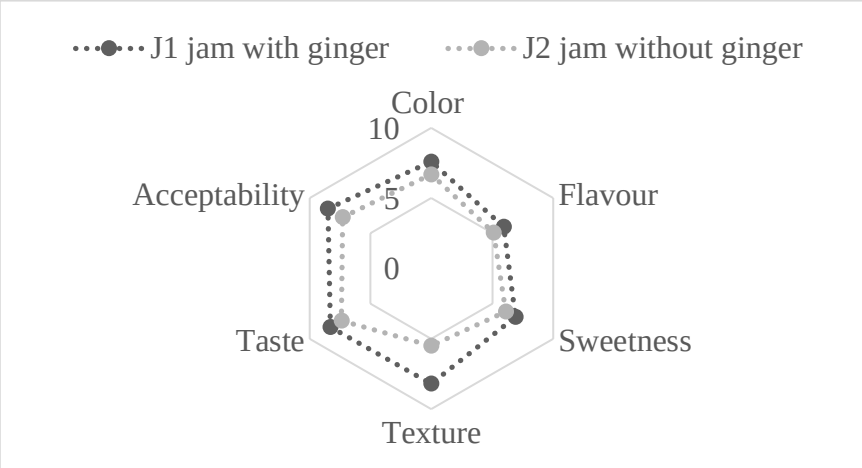

Fig. 1. *Sensory quality of jams:((J1) with ginger and (J2) without ginger.*

Physicochemical characteristics

A physicochemical study of strawberry jam revealed no significant differences ($p>0.05$) with the exception of titratable acidity (Table 5). Strawberry jam with ginger recorded the highest values for titratable acidity at 0.85%, total soluble solid at 66.25%, and moisture at 32.12% compared to strawberry jam without ginger at 0.542%, 64.34%, and 31.12%, respectively. The strawberry jam without ginger had the most sugar at 44.85%, while the strawberry jam with ginger had the least at 43.42%. Our total soluble solids values were lower than the 72.7° Brix reported by [47, 48] for strawberry jam. The word "acidity" refers to the concentration of organic acids (citric, malic, tartaric, etc.). The acidity of a jam closely correlates with its customer acceptability and storage stability.[49] observed strawberry jam concentrations of between 0.6 and 1.2 g/100 g. These values are higher than those obtained in the present study. On the other hand, the studies carried out by [50] gave higher values than our results, where the acidity found was 0.82%. From our results, it can be seen that the moisture contents of both jams are in accordance with the standards which require a moisture content below 40% [51]. Similarly, [52] reports that the moisture content of the jam varies between 30 and 40%. The amount of carbohydrates in fruits and their derivatives is important because it affects how they taste and how well they keep [53].

Table 5. *Moisture, total soluble solid (TSS), titratable acidity, and total sugar of strawberry jam with ginger and without ginger.*

Jam samples	Moisture (%)	TSS (°Brix)	Titratable acidity (%)	Total Sugar (%)
Strawberry jam with ginger (J1)	32.25±1.25^{a}	66.25±1.84^{a}	0.852±0.012^{a}	43.42±1.39^{a}
Strawberry jam without ginger (J2)	31.12±2.12^{a}	64.34±1.63^{a}	0.542±0.035^{b}	44.85±2.45^{a}

Data are expressed as means± standard deviation of three measurements. $^{a-c}$ Means followed by a different letter in the same column are significantly different $P<0.05$ between jam.

CONCLUSION

In this research, the most relevant strawberry cultivars (Sabrina, Savana, and Sabrina) grown in the eastern part of Algeria were characterized. All of the examined strawberry cultivars included a natural supply of health-promoting characteristics, as determined by phytochemical and antioxidant analysis and nutritional value testing. The "Sabrina" strawberry cultivar had the greatest concentration of antioxidant compounds. In addition, cv. Sabrina satisfies all physical and physicochemical criteria for processing, making it an ideal cultivar for the processing industry. Considering the sensory assessment and physio-chemical investigation, the most popular strawberry jam is the one containing ginger. In addition, these results will be significant for boosting the dietary pattern and for consumers who prefer to eat high-quality, antioxidant-rich foods regularly.

Conflict of Interest. The author declared that there is no conflict of interest.

Authorship Contributions. Concept: A.B., M.T.B., Design: A.B., M.T.B., Data Collection or Processing: A.B., M.T.B., M.I., W.B., Analysis or Interpretation: A.B., M.T.B., M.I., W.B., Literature Search: A.B., M.T.B., Writing: A.B., M.T.B.

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