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Nutritional Characterization, Bioactive Compounds and Antioxidant Activity of Brazilian Roses *(Rosa spp)*

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ABSTRACT

The aim of this study was to evaluate thirteen cultivars of roses for nutritional composition, bioactive compounds and total antioxidant activity. Attaché cultivar had the highest amounts of proteins and total fiber. Regarding color, Avalanche presented values for internal cromacity around 7 fold higher than Attaché cultivar. The results showed that the evaluated roses presented means of bioactive compounds as ascorbic acid (70.47 mg 100 g^{-1}), yellow flavonoids (35.25 mg 100 g^{-1}) and total anthocyanins (150.40 mg 100 g^{-1}). The evaluated roses presented relatively low content of total carotenoids (1.25 mg 100 g^{-1}), and high content of total polyphenols (1565 mg 100 g^{-1}) and antioxidant capacity (260 µM trolox g^{-1}). Avalanche, Prima Donna, Dolce Vita, Salmone, and Elisa cultivar presented the minor Euclidean distance. The petals of the evaluated roses are excellent sources of nutritional compounds and antioxidants.

Keywords: Carotenoids, Minerals, Petals, Phenolics, Roses.

INTRODUCTION

Flower is an important part of plant which contains a great variety of natural antioxidants, such as phenolic acids, flavonoids, anthocyanins, and other components of nutritional value as minerals (Kaisoon *et al.*, 2012; Rop *et al.*, 2012). Rose petals have been consumed in many cultures for many years, especially as jams, teas, cakes, and flavor extracts. They were also used in medicinal practices for remedy of various illnesses (Cutler, 2003). In the last few years, there is a growing interest in flowers as edible fresh crops (Kelley *et al.*, 2002; Burfield, 2005) and roses with their multitude colors and fragrance are excellent candidates for commercialization as fresh edible crops.

Proximate composition of flowers indicate that the main component of edible flowers is more than 80% of water and their protein and fat contents are considered to be low, with different amounts of total carbohydrates, dietary fiber and minerals according to the kind of flower (Mlcek and Rop, 2011; Rop *et al.*, 2012; Lara-Cortés, 2013). Other properties of flowers are related to the content of bioactive compounds like carotenoids and essential oils, which provide a wide range of functional properties (Navarro-González *et al.*, 2015; Loizzo *et al.*, 2015; Kucekova *et al.*, 2013). Rose petals are known to contain high levels of antioxidants, and in water infusions prepared from petals of Rosa de Castillo, the levels were the highest amongst 30 medicinal plants (VanderJagt *et al.*,

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2002). Vinokur *et al.* (2006) showed that the levels of antioxidants in infusion prepared from several cultivars of *Rosa spp*. were similar to that found in green tea. The main criteria for evaluation of edible flower quality are their sensory characteristics such as color, taste, and aroma (Kelley *et al.,* 2002). The colors of flowers are predetermined due mainly to the carotenoids and flavonoids, which provide antioxidant capacity and protect against the damage induced by free radicals (Song *et al.,* 2011).

In Thailand, many flowers have been eaten since ancient times, and some have medicinal properties as well as nutritional value (Wongwattanasathien *et al.,* 2010; Kucekova *et al.,* 2013; López-García *et al.,* 2013; Loizzo *et al.,* 2015). However, studies specifically with roses focusing on their nutritional characteristics or health-promoting components are scarce in Brazil and the world. The gastronomic culture in Brazil has not encouraged its use, and these "foods", found in exotic culinary, are sold at a high cost. One of the reasons of low stimulus can be associated with lack of knowledge of the physico-chemical, chemical, biochemical, and toxicological properties of roses. So, the objective of this research was to provide quantitative information on the nutritional composition, bioactive compounds, and total antioxidant activity of thirteen rose cultivars in order to provide a scientific basis for its use in food, aiming to shed light on their potential health benefits that could be useful for consumers.

MATERIALS AND METHODS

Plant Material

Roses (*Rosa spp*) were harvested from commercial growing field of CeaRosa Ltda., in the mountain region of Ibiapaba located at São Benedito-CE, Brazil (04° 07’ S, 40° 53’ W). The climate of this region is tropical rainy, with rainfall around 1,000 mm^3. Thirteen cultivars of Brazilian roses cultivated were studied, namely: Ambiance, Attaché, Avalanche, Carola, New Fashion, Elisa, Gold Strike, Tresor, Prima Donna, Salmone, Dolce Vita, Soutine e Rover (Figure 1). The roses had removed the petals, weighted and crushed with distilled water (1:1 p/v) using an omnimixer (Ultra-turrax IKA®, Germany). Thereafter, all samples were stored at -80ºC for further analysis.

Nutritional Composition

Organic Compounds

Lipids contents (LP) were obtained by Soxhlet extraction using hexane as solvent according to IAL (2005). Total Protein content (PT) and Nitrogen content (N) were determined by the micro-Kjeldahl method. The conversion factor of 6.25 was used to covert nitrogen into protein, as recommended by AOAC (2005), and results were expressed as mg 100 g^{-1}. The Total Fiber content (TF) was determined on the basis of the acid digestion of defatted dry material, and then drying at 105°C for 2 hours followed by calcination (IAL, 2005). The determination was performed by difference between the weight of dry sample and the weight of the calcined sample and was expressed in percentage (%). Reducing Sugars (RSs) were determined by DNS method according Miller (1959) and results were expressed as g 100 g^{-1}. Total soluble Sugars (TSs) were determined according Antrona method (Yemn and Willis, 1954), then the reading was performed in a spectrophotometer (Spectronic Genesys 2®, USA) at 620 nm and results were expressed as mg 100 g^{-1}. Total Pectin (TP) and Soluble Pectin (SP) contents were measured according to the methodology described by McCready and McComb (1952). The absorbance of samples was read at 520 nm. Both results for pectin (total and soluble) were expressed as mg 100 g^{-1}. Total Carbohydrate (TC) was determined by formula: 100 - (moisture + ash+ protein+ lipids + total dietary fiber) in 100 g of petals.

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Figure 1. Thirteen rose cultivars cultivated at Ceará-Brazil, selected as candidates for edible flowers.

The ash determination was made by gravimetry after incineration at 600ºC until constant weight according to IAL (2005).

Mineral Content

Initially, samples of the roses were dried to a constant weigh at a temperature of 65-70°C for 48 hours. Then, acid digestion was performed using 0.5 g of dry sample with 8 mL of concentrated acid (3:1) [HNO_3 65% (v/v) and $HClO_4$ 72% (v/v)] during 4 hours. We took the tubes to the block digester and the material was heated slowly to 120°C, maintaining this temperature until interruption of release of a brown smoke. Then, the temperature was raised to 200°C, and maintained this temperature to defer the release of white smoke. The minerals Calcium (Ca), iron (Fe), Zinc (Zn), Manganese (Mn), Copper (Cu) and Magnesium (Mg) were determined by atomic absorption spectrophotometry (Perkin Elmer AAnalyst 300®, USA). The minerals including sodium (Na) and potassium (K) were determined by flame photometry using a flame photometer. Phosphorus (P) and Sulfur (S) were determined using a spectrophotometer at a wavelength of 660 nm for phosphorus and 420 nm for sulfur. All these minerals were determined following the method described by Silva (1999) and measurements were performed in triplicate with results reported as mg 100 g^{-1} of Fresh Weight (FW).

Bioactive Compounds

Color and Associated Bioactive Compounds

Color was determined using a chromameter (Minolta® CR-300 equipped with D_{65} illuminant, Japan) with the

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cylindrical coordinate system and the color space for lightness, chroma and hue angle by averaging two readings from the inner face and outer face of the two reading petals at points approximately equidistant and reported as Luminosity (inner facer and outer face), Chromaticity (inner facer and outer face) and Hue angle (inner facer and outer face).

The Total Phenolics Contents (TPCs) were measured according to the method described by Obanda *et al.* (1997), while extracts were prepared as described by Larrauri *et al.* (1997). Samples (20 to 30 g depending on the cultivar), were homogenized in 4 mL methanol [50% (v/v)] and kept in the dark at room conditions for 1 hour, before centrifugation at 4,000×*g* for 30 minutes at 4°C. The precipitate was extracted with 4 mL acetone [70% (v/v)] under similar conditions as previously described. After centrifugation, supernatants were joined and total volume was raised to 10 mL with distilled water. Extracts (100 µL) were added to 100 µL Folin Ciocalteau, 1 mL Na_2CO_3 (20%) and 100 µL of distilled water and allowed to stand for 30 minutes in the dark. Absorbance was measured at 700 nm and results were expressed as Gallic Acid Equivalents (GAEs) mg 100 g^{-1} FW.

Total Anthocyanin (TAN) and Yellow Flavonoids (YF) were evaluated as described by Francis (1975). One gram of samples was homogenized with 15 mL of extracting solvent (95% ethanol/1.5N HCl, 85:15), for 5 minutes, and allowed to stand overnight (13 hours) in the dark, at 4°C. Afterwards, the absorbance was measured at 535 nm for the total anthocyanin content using an absorption coefficient of 98.2 mol cm^{-1} and at 374 nm for the yellow flavonoid content using an absorption coefficient of 76.6 mol cm^{-1}. Both results were expressed as mg 100 g^{-1}.

Total carotenoids content were extracted and determined as described by Higby (1962). Ten grams of samples were homogenized in 15 mL of isopropyl alcohol and 5 mL of hexane (v/v). The content was transferred to a separation funnel of 125 mL and diluted with distilled water; then, it was allowed to rest for three 30-minute periods followed by three subsequent filtrations with anhydrous sodium sulfate. Absorbance was measured at 450 nm, and the results were expressed as mg 100 g^{-1} FW.

The Total Chlorophylls (TCLs) were determined according to Bruinsma (1963). One gram of samples was homogenized using Omni Mixer (Ultra-turrax IKA®, Germany) with 1 mL of acetone 80% (v/v) during 5 min until complete discoloration of tissues. The absorbance of filtrate was measured at 652 nm. The results are expressed in mg 100 g^{-1} following the equation:
[(Xabsorbance×1000×V)/(1000×w)/3.4]×100 (Engel and Poggiani, 1991).

Vitamin C

The total Vitamin C (VC) was determined by titration with a 0.02% 2,6-Dichloro-indophenol solution (DFI) (Strohecker and Henning, 1967). One gram of pulp was diluted to 50 mL of 0.5% oxalic acid, homogenized and, then, 2 mL of this solution was diluted to 50 mL with distilled water and titrated. Results were expressed as mg 100 g^{-1} FW.

Total Antioxidant Activity (TAA)

The Total Antioxidant Activity (TAA) was determined according to Re *et al.* (1999). Samples were subjected to a similar extraction procedure as described for total phenol content (Larrauri *et al.,* 1997). Once the radical was formed, reaction was started by adding 30 µL of the extract in 3 mL of radical solution; after 6 minutes, absorbance was measured at 734 nm. A calibration curve was prepared with standard trolox solutions ranging from 100 to 2.000 µM. Antioxidant activity was expressed as Trolox Equivalent Antioxidant Capacity (TEAC), µM trolox g^{-1} FW.

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Statistical Analysis

Statistical analyses were conducted using M-STATC and Genes software and values were expressed as means, standard deviation, confidence level at 95% ($P< 0.05$) for all cultivars. Pearson's correlations (1 and 5%) and Clusters were applied to display related characteristics for all cultivars.

RESULTS AND DISCUSSION

Nutritional and Mineral Composition

The nutritional composition of the roses is shown in Table 1. The lipids differ widely among the cultivars of roses evaluated, such that the minimum value observed was 0.60 mg 100 g^{-1} and the maximum was 1.35 mg 100 g^{-1}. Attaché cultivar had the highest amounts of Proteins (PT) and Total Fiber (TF) reaching 33.30 and 20.74 mg 100 g^{-1}, respectively (Table 1). In the case of Reducing Sugar (RS), Prima donna contained 2.80 mg 100 g^{-1}. Also, PT showed negative correlation with total carbohydrates (r^2= -0.75, P> 0.01), while TF presented negative correlation with TC (r^2= -0.80, P> 0.01).

The mineral composition of the roses, expressed on a fresh weight basis, is shown in Table 2. The macro-minerals including N, P, and K considered as essential for development of plants, presented low variation among cultivars analyzed in this study. Concerning the humans health, nitrogen is important for protein synthesis, phosphorus is found in nucleic acids, ATP, and phospholipids; bone formation; buffers; metabolism of sugars, and potassium is important for nerve and muscle action, protein synthesis or as principal positive ion in cells (Uma-Maheswari et al., 2012). The most abundant mineral elements in Rover cultivar were zinc, copper, manganese, and potassium. The values for magnesium mineral were 1.58 to 2.85 mg 100 g^{-1}, with Carola reaching the highest value (2.35 mg 100 g^{-1}). These values were ~39 fold higher than that found in edible flowers such as *Tagetes erecta and Spilanthes oleracea*

Table 1. Nutritional composition including total carbohydrate (mg 100 g^{-1}) and ash (g 100 g^{-1}) in fresh weight of the studied rose cultivars.

Cultivar	LP [a]	PT [b]	TF [c]	RS [d]	TS [e]	SP [f]	TC [g]	Ash [h]
Carola	0.60	30.33	14.69	2.16	2.31	0.05	0.07	0.96
Avalanche	0.63	30.64	15.91	2.67	2.70	0.05	0.06	0.96
Salmone	0.74	30.26	16.15	2.73	2.77	0.05	0.06	0.97
Prima Donna	0.84	31.42	17.72	2.80	3.00	0.05	0.06	0.97
Elisa	1.04	32.03	19.14	2.66	2.94	0.04	0.06	0.97
Attaché	1.16	33.30	20.74	2.68	2.98	0.02	0.05	0.97
Gold Strike	1.09	31.39	19.45	2.63	3.07	0.03	0.07	0.97
Ambiance	1.05	29.68	16.79	2.62	3.39	0.04	0.09	0.96
Soutine	0.97	27.94	15.15	2.33	3.64	0.04	0.11	0.94
Dolce Vita	1.03	30.13	13.50	2.37	3.50	0.04	0.10	0.96
Tresor	1.08	32.48	15.01	2.20	3.12	0.03	0.10	0.98
New Fashion	1.24	34.70	16.62	2.25	2.76	0.03	0.09	0.98
Rover	1.35	34.53	19.11	2.35	2.87	0.03	0.08	0.99
Mean	1.34	32.96	19.40	2.75	2.89	0.04	0.07	1.00
IC_{95} (±) [i]	0.15	0.95	1.81	0.32	0.28	0.01	0.01	0.94
Maximum	2.76	39.86	38.68	4.49	5.26	0.08	0.15	0.97
Minimum	0.60	27.62	8.05	1.05	1.72	0.01	0.03	0.00
CV% [j]	34.16	8.92	28.77	35.31	29.52	46.55	42.34	1.43

[a] Lipids; [b] Proteins; [c] Total Fiber; [d] Reducing Sugars; [e] Total Sugars; [f] Soluble pectin; [g] Total Carbohydrate; [i] Confidence level at 95% of probability, [j] Coefficient of Variation, [h] mineral compounds.

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Table 2. Mineral content (mg 100 g^{-1}) in fresh weight of the studied rose cultivars.[a]

Cultivar	N [a]	P [b]	K [c]	Ca [d]	Mg [e]	Na [f]	S [g]	Cu [h]	Fe [i]	Zn [j]	Mn [k]
Carola	15.40	1.18	18.25	1.80	2.35	0.64	2.18	4.05	39.00	23.10	21.15
Avalanche	15.55	1.23	18.53	1.82	2.26	0.68	2.09	4.60	42.80	22.63	21.53
Salmone	15.38	1.24	18.98	1.86	2.28	0.62	2.04	4.57	47.60	23.13	21.27
Prima Donna	15.97	1.28	18.72	1.87	2.14	0.45	2.09	6.00	68.68	30.37	21.65
Elisa	16.29	1.28	18.37	1.83	2.08	0.26	2.24	6.83	90.10	36.68	21.98
Attaché	16.93	1.26	17.80	1.91	1.98	0.12	2.14	7.77	100.65	39.80	22.32
Gold Strike	15.95	1.17	17.92	2.04	1.91	0.14	1.95	7.82	89.82	33.08	21.93
Ambiance	15.25	1.15	18.20	2.07	1.83	0.14	1.92	7.35	69.13	23.77	21.72
Soutine	14.34	1.10	18.03	2.13	1.85	0.14	2.08	7.38	56.72	21.87	21.57
Dolce Vita	15.48	1.21	17.97	2.10	2.03	0.14	2.26	7.77	57.38	21.27	21.93
Tresor	16.51	1.31	18.08	2.28	2.17	0.14	2.07	8.73	67.12	24.22	22.30
New Fashion	17.66	1.50	19.72	2.26	2.27	0.14	2.04	9.10	72.37	22.23	22.15
Rover	17.58	1.50	20.07	2.24	2.18	0.15	2.14	9.63	78.00	40.15	22.52
Mean	16.76	1.31	18.77	2.07	2.12	0.29	2.67	9.27	85.76	35.20	22.06
IC95 (±) [l]	0.49	0.06	0.56	0.13	0.10	0.09	0.20	0.85	10.03	4.39	1.65
Maximum	20.37	1.65	23.20	3.05	2.85	0.78	3.96	15.35	165.05	78.90	39.70
Minimum	14.22	1.01	15.95	1.38	1.58	0.07	1.65	4.05	39.00	13.15	14.65
CV% [m]	8.99	14.08	9.12	18.87	13.83	91.85	22.94	28.16	36.10	38.46	23.02

[a] Nitrogen; [b] Phosporus; [c] Potassium; [d] Calcium; [e] Magnesium, [f] Sodium; [g] Sulfur; [h] Copper; [i] Iron; [j] Zinc, [k] Manganese. [l] Confidence level at 95% of probability, [m] Coefficient of Variation.

(Navarro-González *et al.*, 2015). Magnesium is required by many enzymes; we can also find this element in bones and teeth, too (Uma-Maheswari *et al*., 2012). Regarding the trace minerals evaluated, iron (100.65 mg 100 g^{-1}) and sulfur (2.26 mg 100 g^{-1}) were the minerals more abundant in Attaché and Dolce Vita. The results found for iron in this study were higher than that observed in eleven tropical fruits cultivated in the northwest of the Brazil (Almeida *et al.*, 2009). The manganese showed a little variation among the evaluated rose cultivars. From a nutritional point of view, it is noteworthy that the rose cultivars showed higher concentrations of potassium than sodium; however, the calcium concentration was very low in the roses, especially in Carola (1.80 mg 100 g^{-1}). In short, the mineral composition of these roses were higher than that of other roses (Navarro-González *et al.*, 2015), edible flowers (Kaisoon *et al.*, 2012; Zeng *et al.*, 2014), herbs such as yellow Camellia (Song *et al.*, 2011), vegetables, such as *Spinacea oleracea* (Kruger *et al.*, 1998), tropical fruits (Almeida *et al.*, 2009), and edible wild green vegetables (Martins *et al.*, 2011).

Color and Associated Variables, Vitamin C, and Antioxidant Activity

Roses (*Rosa sp.*) are one of cut flowers which attract many people, and are often used as an ornamental flower, herbal remedy, or exotic food. Besides the beauty of rose color, the plant also contains bioactive compounds such as pigments and efficacious antioxidant (Garz'on *et al.*, 2009). Colors in the diet are affecting the quality of food products, can make the product more attractive, and affect consumer acceptance. The internal and external measures of rose petals are considered. In this study, the color mesures in the internal and external faces of petals was regarded as a manner of reproduce the overall color of rose. once the pigments are present in different shades in the area of rose petal. In this study, internal and external color of roses is expressed as luminosity, chromacity and Hue angle, as presented in Table 3. New Fashion cultivar presented highest external (112.18) and internal (117.68) luminosity. The cromacity describes the saturation of the

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Table 3. Color of the studied rose cultivars, which were selected as candidates for edible flowers.[a]

Cultivar	EL [a]	IL [b]	Ec [c]	Ic [d]	EH [e]	IH [f]
Carola	34.05	25.74	49.64	62.25	28.10	36.30
Avalanche	35.60	27.25	50.11	63.59	27.45	38.98
Salmone	34.18	27.11	48.18	63.05	27.42	39.65
Prima Donna	49.42	44.97	35.08	45.75	53.78	65.33
Elisa	62.13	58.79	20.92	26.67	82.77	87.47
Attaché	77.22	73.32	8.61	8.50	107.47	110.67
Gold Strike	72.86	66.90	15.12	21.41	84.65	87.68
Ambiance	70.18	62.39	24.33	34.42	59.37	66.95
Soutine	66.35	58.86	32.96	48.78	38.78	45.32
Dolce Vita	81.49	77.48	34.06	44.65	46.90	57.75
Tresor	96.48	98.00	34.90	41.54	54.77	69.85
New Fashion	112.18	117.68	35.40	37.22	61.63	82.48
Rover	108.10	114.37	41.19	38.47	42.00	56.78
Mean	71.79	77.34	40.41	35.79	54.05	60.98
IC95 (±) [g]	8.43	7.23	5.82	6.08	11.96	12.05
Maximum	112.24	118.84	64.16	66.00	113.75	113.35
Minimum	27.12	25.74	7.38	7.45	2.55	3.00
CV% [h]	36.24	28.85	44.47	52.43	68.28	60.94

[a] External Luminosity; [b] Internal Luminosity; [c] External chromacity; [d] Internal chromacity; [e] External Hue angle, [f] Internal Hue angle; [g] Confidence level at 95% of probability, [h] Coefficient of Variation.

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color, a measure of how far from the grey tone the color is. High values of chromaticity demonstrate the saturation of the color. In this study, Avalanche cultivar (white rose) presented values for internal cromacity around ~7 fold higher (rose color more saturated) than Attaché (pink rose). The parameter hue, describes the color tonalities (red, green, yellow, etc.). For Hue angle, Attaché (pink rose) presented internal (110.67º) and external (107.47º) values ~4 fold higher than Carola cultivar (red rose) (Table 3). Bintory *et al.* (2015) evaluating the color of dried Dutch Rose flowers using a colorimeter found the highest hue angle for Avalanche cultivar (97.02°). Besides the beauty of rose color, the plant also contains bioactive compounds such as pigments (anthocyanins and flavonoids) and efficacious antioxidant that can even be used as a natural remedy (Garz'on *et al.*, 2009).

Bioactive compounds associated with color of the thirteen cultivars of rose are presented in Table 4 on fresh weight basis. Among the phenolics, anthocyanins and flavonoids yellow are primarily responsible for the pigmentation of flowers and fruit to attract pollinators and seed disseminators. As for Yellow Flavonoids (YF), Total Anthocyanins (TAN) contents differ widely among the evaluated cultivars of rose. Rover presented high contents of TAN (250 mg 100 g^{-1}) (Table 4). This cultivar presented more YF than found in "CCP 76" ripe cashew apples (Lopes *et al.*, 2012). Salmone presented more TAN (250 mg 100 g^{-1}) than found in "Florida sweet" acerola (Souza *et al.*, 2014) (Table 4). Schmitzer *et al.* (2009) reported that two predominant anthocyanic pigments present in rose petals are pelargonidin-3,5-di-*O*-glucoside and cyanidin-3,5-di-*O*-glucoside. The internal Hue angle presented correlation with total carotenoids (r^2= 0.57, P< 0.05). Anthocyanins have been categorized as the largest group of water-soluble pigments present in flowers. These natural pigments are of great interest in the food industry, due to their attractive colors and beneficial health effects, including anti-inflammatory, anticancer, antidiabetic, and antioxidant activities. Humans consume considerable amount of anthocyanins from plant-based food sources in daily life (Clifford, 2000).

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Table 4. Bioactive compounds (mg $100g^{-1}$) and antioxidant activity (μM Trolox.g^{-1}) in fresh weight of the studied rose cultivars. [a]

Cultivar	VC [a]	TP [b]	TAN [c]	YF [d]	TCA [e]	TCL [f]	TAA [g]
Carola	64.63	425.45	28.66	74.59	0.04	2260.92	119.90
Avalanche	64.65	431.98	27.40	75.12	0.03	2218.71	93.20
Salmone	67.33	419.45	27.46	78.98	0.03	2203.64	115.60
Prima Donna	72.94	952.15	20.07	54.67	0.03	4641.67	167.40
Elisa	72.05	1492.33	13.48	30.00	0.02	7199.99	177.40
Attaché	65.62	1966.66	8.10	1.37	0.01	9401.90	92.50
Gold Strike	56.70	2078.40	17.01	6.66	0.01	10642.36	47.40
Ambiance	54.38	2242.06	24.70	11.38	0.01	12218.59	136.20
Soutine	54.85	2435.36	30.92	16.55	0.02	13742.83	69.00
Dolce Vita	57.70	2289.98	100.28	13.96	0.23	12282.21	222.20
Tresor	63.24	2216.74	168.84	11.79	0.42	10872.62	66.70
New Fashion	75.80	2147.37	248.15	9.73	0.58	9700.62	38.10
Rover	75.75	2178.78	250.11	14.27	0.48	9768.90	88.10
Mean	70.47	1565.46	154.40	35.25	1.25	7555.42	260.30
IC95 (±) [h]	5.20	205.30	33.62	13.39	0.57	1039.40	35.70
Maximum	99.86	2550.03	358.80	173.25	6.17	14580.14	110.30
Minimum	36.64	394.40	6.35	0.79	0.00	2173.50	17.94
CV% [i]	22.76	40.46	67.16	117.17	140.40	42.44	50.17

[a] Vitamin C; [b] Total Phenolics; [c] Total Anthocyanins; [d] Yellow Flavonoids; [e] Total Carotenoids; [f] Total Chlorophyll, [g] Total Antioxidant Activity; [h] Confidence level at 95% of probability, [i] Coefficient of Variation.

The TPs differed widely among the evaluated rose cultivars, and the minimum and maximum values were 419.45 and 2435.36 mg^{-1} EAG 100 g^{-1} for Salmone and Soutine cultivar, respectively (Table 4). Rufino *et al.* (2010), evaluating the bioactive compounds in eighteen Brazilian fruit species, found 1176.3 mg^{-1} GAE 100 g^{-1} for Camu-camu, which is considered a fruit very rich in polyphenols. Phenolic compounds are known to modulate human physiology and cell transduction pathways. They can also stimulate immune response, specifically to recognize and destroy cancer cells as well as to inhibit angiogenesis, which is necessary for tumor growth (Newell *et al.*, 2010). In this study, the internal luminosity presented positive correlation with TP (r^2= 0.55, P< 0.05) and TAN (r^2= 0.67, P< 0.05), suggesting that when more luminosity are the roses, more pigments and phenolics are present. Total Carotenoids (TCAs) are not only important precursors of vitamin A, but exhibit a considerable degree of antioxidant activity. Smaller amounts of TCA were detected for varieties Avalanche and Soutine that are roses of white color, and the biggest amount for New Fashion (0.58 mg 100 g^{-1}), which has an orange pink color (Table 4). Clinical study has shown that consumption of a carotenoid-rich diet contributes to improvement of the vitamin A status (Gouado *et al.*, 2007). The beneficial effects of carotenoids are thought to be due to their role as antioxidants, and the carotenoids that have been most studied in this regard are β-carotene, lycopene, lutein, and zeaxanthin (Clifford, 2000). Positive correlation was observed among internal Hue angle and TCA (r^2= 0.57, P< 0.05). Total chlorophyll differed widely among the studied rose cultivars, and was present in minor amount in Salmone cultivar (2203.64 mg 100 g^{-1}). TC values were correlated positively with TP (r^2= 0.97, P< 0.01). As to total Vitamin C (VC), the mean value of the samples was 70.47 mg 100 g^{-1} (Table 4) and the maximum value was found for the New Fashion cultivar (75.80 mg $100g^{-1}$), considered a good content in comparison with pineapple (George *et al.*, 2016) and mandarin peel power (Ojha *et al.*, 2016).

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On the basis of the increase in the consumption of flowers, researchers have intensified their studies to assess the phytochemical profile and bioactivity with particular reference to antioxidant properties. The Total Activity Antioxidant (TAA) expressed on a fresh weight basis is presented in Table 4. According to Navarro-González *et al.* (2015), who evaluated nutritional composition and antioxidant capacity in edible flowers, the maximum antioxidant capacity by ABTS method belonged to Dolce Vita cultivar (222.27 μM Trolox g^{-1} FW), a value around 3.5 times more than that found for *Tagetes erecta* (66.22 μM Trolox g^{-1} FW).

Phytochemicals are a large group of plant-derived compounds hypothesized to be responsible for much of the disease protection conferred from diets. Among them, phenolic compounds are attracting the attention of scientists because of their antioxidant, anti-inflammatory, antimutagenic, and anticarcinogenic properties and their capacity to modulate some key cellular enzyme functions (Tempesta, 2012). In short, the phytochemical of these roses is not too different from that of other fruits (Rufino *et al.*, 2010; Lopes *et al.*, 2012; Souza *et al.*, 2014), edible flowers (Loizzo *et al.*, 2015) and *Myrciaria dubia* as Camu-camu (Neves *et al.*, 2015). Kaisoon *et al.* (2012) investigated the flowers largely used in Thailand for tea and salads including *Antigonon leptopus*, *Bougainvillea glabra*, *Cosmos sulphurous*, and *Tagetes erecta*, and showed that the extract of *T. erecta* show a promising cellular antioxidant activity and total reducing capacity, and the extract of *A. leptopus* demonstrated a more potent radical-scavenging ability. In a study that included 19 Chinese edible flowers used as tea, *Paeonia lactiflora, Paeonia suffruticosa*, and *Rosa rugosa* exhibited stronger antioxidant activity; according to the authors, this was probably due to their high polyphenolic contents (Zeng *et al.*, 2014).

Considering all the observed and evaluated variables, seven groups were identified using the cluster analysis done by optimizing Tocher, based on the average Euclidean distance. The group I included Avalanche, Prima Donna, Dolce Vita, Salmone and Elisa cultivars. Dendrogram of dissimilarity of the cultivars showed that the physical and chemical variables which contributed most to the discrimination of cultivars were magnesium, sodium, sulfur, iron, zinc manganese, total fiber, lipids, proteins, chlorophyll, total pectin, total anthocyanins, total carotenoids, antioxidant activity, and color parameters such as *EC*, *IC*, and *EH* (Table 5, Figures 1 and 2).

CONCLUSIONS

Due to the content of nutrients, minerals, phytochemicals and antioxidant activity, the petals of the studied roses can be regarded as excellent candidates for edible flowers. Therefore, we suggest further studies involving determination of pesticides, determination of anti-nutritional factors, sensory analysis, and evaluation of cultivars whose cultivation is organic, as well as *in vivo* studies.

Table 5. Grouping of 13 rose cultivars by the Tocher optimization method based on average Euclidean distance evaluated for 36 descriptors.

Groups	Cultivar
1	Avalanche. Prima Donna. Dolce Vita. Salmone and Elisa
2	Rover. New Fashion and Carola
3	Tresor
4	Soutine
5	Ambiance
6	Gold Strike
7	Attaché

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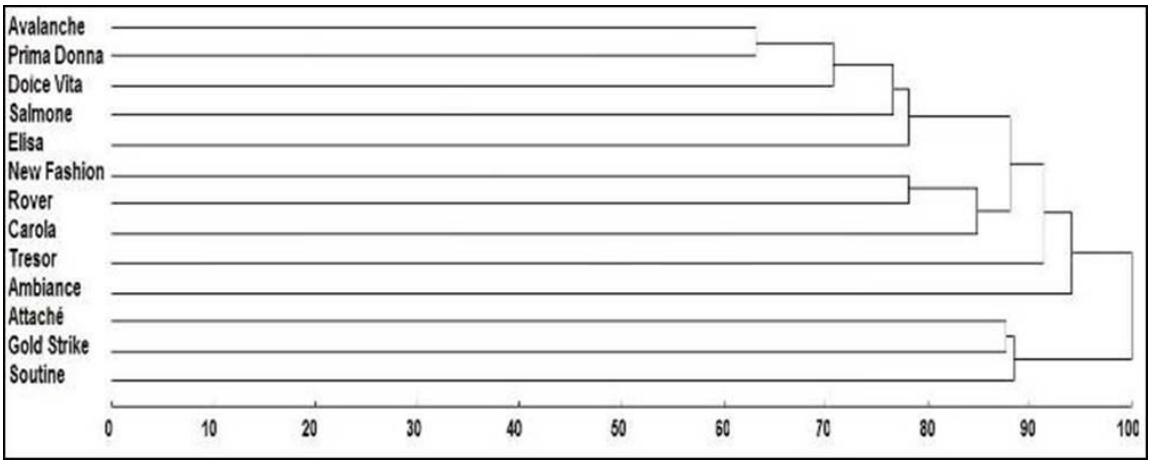

Figure 2. UPGMA dendrogram of 13 rose cultivars using Euclidean distance for 36 descriptors for all variables.

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ویژگی های تغذیه ای، مواد زیست فعال، و فعالیت آنتی اکسیدانی رز های برزیلی (*Rosa spp*)

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چکیده

هدف این پژوهش ارزیابی ۱۳ کولتیوار رز از نظر ترکیبات تغذیه ای، مواد زیست فعال و فعالیت آنتی اکسیدانی کل بود. در میان کولتیوارهای مطالعه شده، کولتیوار Attaché بیشترین مقدار پروتئین و فیبر

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کل را داشت. از نظر رنگ، کروماسیته (cromacity) کولتیوار Avalanche تقریبا هفت برابرکولتیوار Attaché بود. نتایج نشان داد که میانگین مواد زیست فعال این گل ها شامل اسکربیک اسید ($70.47\ mg\ 100g^{-1}$)، فلاونوئید های زرد($35.25\ mg\ 100g^{-1}$)، و آنتوسیانین ها ($150.40\ mg\ 100g^{-1}$) بود. مقدار کاروتینوید ($1.25\ mg\ 100g^{-1}$) در رزهای ارزیابی شده نسبتا کم بود ولی مقدار فنل های کل ($1565\ mg\ 100g^{-1}$) و ظرفیت آنتی اکسیدانی ($260\ \mu M\ trolox.g^{-1}$) زیادی داشتند. کولتیوارهای Avalanche، Prima Donna، Dolce Vita، Salmone، و Elisa فاصله اقلیدسی جزیی نشان دادند. بر اساس نتایج به دست آمده، گلبرگ های رزهای ارزیابی شده در این پژوهش منابعی غنی برای مواد غذایی و آنتی اکسیدان ها هستند.

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