ISSN 0100-2945 DOI: http://dx.doi.org /10.1590/0100-29452021918
Revista Brasileira de Fruticultura

Processing

Physicochemical and antioxidant characterization of Andean blackberry with and without prickles cultivated in Risaralda, Colombia

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Abstract - Approximately 55% of the *Rubus glaucus* Benth (Andean blackberry) produced in Colombia is sold fresh and 10% is used in agroindustry. There are two types of cultivars for this species: Andean blackberries with prickles and ones without prickles. The investigations carried out in the Department of Risaralda are focused on finding the best genetic materials; however, studies on the bioprospecting that can generate an added value to these fruits are lacking. Therefore, soil fertility analysis, physicochemical characterization, and evaluation of the total phenolic content and antioxidant activity of Andean blackberries with and without prickles were carried out. The parameters evaluated for soil analysis were pH, organic matter, minor elements, phosphorus, nitrogen, aluminum, and texture, and the parameters evaluated for physicochemical characterization were titratable acidity, ash, dietary fiber, fat, moisture, maturity index, protein, and soluble solids. The total phenolic content and antioxidant activity were evaluated with the Folin–Ciocalteu and DPPH methods, respectively. Statistical analysis showed significant differences in the content of fat, proteins, total soluble solids, titratable acidity, acidity index, and ash between the materials with and without prickles. The ash content and soluble solids are highlighted: they presented differences by study municipality, The ash content and soluble solids are highlighted; in addition, a high content of phenolic compounds was observed in fruits from plants without prickles. The diagnosis of blackberry crops by the materials planted and place of cultivation in the Department of Risaralda showed that the materials without prickles are more widely distributed in the department due to their ease of handling. According to the results of the soil analysis, most Castilla blackberry crops in the Santa Rosa, Santuario, and Pereira municipalities are within the recommended parameters for blackberry production at the national level.
Index terms: antioxidants, nutritional analysis, secondary metabolites, *Rubus glaucus* Benth.

Caracterização físico-química e antioxidante de amora Andina com e sem espinhos cultivada em Risaralda, Colômbia

Resumo - Na Colômbia, aproximadamente 55% da produção de *Rubus glaucus* Benth (Amora de castilla) é vendida fresca e 10% é utilizada na agroindústria. Para esta espécie, existem dois tipos de cultivares: amora de castilla com e sem espinhos. Os trabalhos de pesquisa realizados no departamento de Risaralda, estão focados na busca pelos melhores materiais genéticos, no entanto, não há estudos sobre a bioprospecção que possam gerar um valor agregado a esses frutos. Para tanto, foram realizadas análises de fertilidade do solo, caracterização físico-química e avaliação do conteúdo fenólico total e da atividade antioxidante de framboesas andinas com e sem espinho. Os parâmetros avaliados para análise do solo foram pH, matéria orgânica, elementos minoritários, fósforo, nitrogênio, alumínio e textura, e os parâmetros avaliados para caracterização físico-química foram acidez titulável, cinzas, fibra alimentar, graxa, umidade, índice de maturidade, proteína e sólidos solúveis. O conteúdo fenólico total e a atividade antioxidante também foram avaliados com os métodos Folin-Ciocalteu e DDPH, respectivamente. Concluiu-se de acordo com a análise estatística diferenças significativas nos teores de gordura, proteínas, sólidos solúveis totais, acidez titulável, índice de acidez e cinzas entre os materiais com espinhos e sem espinhos. Destacaram-se os teores de cinzas e sólidos solúveis, que apresentaram diferenças por município de estudo; além disso, um alto teor de compostos fenólicos foi observado em frutos sem espinhos. O diagnóstico das lavouras de amora-preta pelo local de plantio e cultivo de materiais no departamento de Risaralda, mostrou que os materiais sem espinhos são mais amplamente distribuídos no departamento devido à facilidade de manuseio. De acordo com os resultados da análise de solo, a maioria das lavouras de amora-preta em Castilla nos municípios de Santa Rosa, Santuário e Pereira está dentro dos parâmetros recomendados para a produção de amora-preta em nível nacional.
Termos para indexação: antioxidantes, análise nutricional, metabolismo secundário, *Rubus glaucus* Benth.

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Received: June 23, 2021
Accepted: August 16, 2021

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Introduction

The species of the *Rubus* family are considered an important source of phytochemicals with high nutraceutical value and several health benefits (MILOSEVIC et al., 2012). Its fruits are consumed fresh, frozen, or commercially processed in a wide variety of foods and products, such as jellies, wine, tea, dyes, fruit peels, and medicines (MILOSEVIC et al., 2012). They are rich in carbohydrates, dietary fiber, vitamins, and minerals (GÜNDOĞDU et al., 2016), as well as in phenolic compounds, including phenolic acids, tannins, stilbenes, lignans, and flavonoids (anthocyanins, flavanols or catechins, flavonols, flavones, flavanones, and isoflavonoids) (KHAN et al., 2019). Several types of biological activity are attributed to these compounds, such as antibacterial (AFIF-CHAOUCHE et al., 2015), anti-inflammatory, antioxidant (LI et al., 2015), anti-neurodegenerative (ABU-BAKAR et al., 2016), anticancer (GEORGE et al., 2017), and anti-Alzheimer activity (LI et al., 2015). These health benefits have boosted the rapid growth of production of these blackberries for the fresh, processed, and nutraceutical markets.

To satisfy the expanding world market, countries with the highest production, such as Serbia, have devoted themselves to bioprospecting their materials to find different characteristics that satisfy the demands of the markets for fresh and processed products. Phytochemical studies on fresh blackberries have shown that genetic factors, geographical region, weather and environmental conditions, the type of cultivar, ripeness, exposure to UV light, soil, cultural practices, harvest method, and post-harvest treatment play an important role in fruit composition (LABANCA et al., 2017). Substantial variation in the total phenolic content and antioxidant capacity is found among blackberry cultivars, which is an indication of the possible diversification of uses for both fresh consumption and processed products, among other breeding programs (MILOSEVIC et al., 2012).

According to information provided by the Food and Agriculture Organization of the United Nations, in recent years, the world production of raspberries has increased slightly from 975,017 tons and 119,456 hectares in 2009 to 1,027,408 tons and 136,056 hectares in 2013, with countries in the Asian continent standing out as the largest producers with 52.4% of the total, and New Guinea (16%), Iran (15%), and Vietnam (11%) standing out regarding the harvest area (MADR, 2016). The area used for growing blackberries in Colombia is in accordance with the Strategic Plan for Science, Technology, and Innovation of the Agricultural Sector of the Ministry of Agriculture. For the year 2019, blackberry production in the country was approximately 140,000 tons with an increase of 28%, of which exports correspond to approximately 1%. Between 2015 and 2019, the planted area also reached 15,649 hectares and the harvested areas showed an increase of 9.3%. The main blackberry cultivator departments are Cundinamarca (21%), Santander (20%), Nariño (9%), and Huila, which represent 8.8% of the cultivated areas of the country, followed by the departments of Boyacá (8.6%), Antioquia (7.2%), and Caldas (5%), and Risaralda which is the department with the second-highest productivity at the national level, with 13 annual average tons per planted hectare (SIOC, 2020). The demand for this crop has increased in the local and international markets, so there is great interest in satisfying the agroindustry and increasing the commercial supply as its fruits are considered an important source of compounds with nutritional and antioxidant properties, and they are consumed raw and processed in the form of jellies, jams, pastries, juices, concentrates, and wines (CARRILLO-PERDOMO et al., 2015).

The blackberry species *Rubus glaucus* Benth. (Andean blackberry) belongs to the order Rosales, family Rosaceae, genus *Rubus* (IOPI-GPC, 2010). Reports show that there is morphological variability in the berries grown in Colombia (ESPINOSA et al., 2016). There are two types of Andean blackberry cultivar: with prickles and without prickles (MARULANDA et al., 2011). The latter has been classified as *Rubus glaucus* because it closely matches the description of this species, and since it also has several advantages compared to the fruit from plants with prickles in terms of agronomic management, harvest, processing (ESPINOSA et al., 2009), greater productivity, and ease of vegetative propagation (LÓPEZ-VÁSQUEZ et al., 2009).

Investigations carried out on Andean blackberries in the Department of Risaralda have sought the best genetic materials and have allowed the blackberry farming sector to have planting materials of excellent phytosanitary and productive quality (MARULANDA et al., 2011). However, there are no bioprospecting studies of the secondary metabolites such as phenols, anthocyanins, and flavonoids, among others, mentioned above due to the health benefits they present. In this context, this study included a physicochemical characterization and an evaluation of the total phenolic content and antioxidant activity of fruits of the Andean blackberry with and without prickles, as well as evaluating and comparing the quality attributes of materials manufactured from blackberries in the Department of Risaralda.

Material and methods

The study was carried out in three of the municipalities (Pereira, Santa Rosa de Cabal, and Santuario) with the highest production in the Department of Risaralda; samples were taken from three farms within each municipality, and each of them was sampled five times. A totally random block design was carried out. Fruits of *Rubus glaucus* Benth. (Andean blackberry) of two commercial types – with and without prickles – were collected at ripeness stages 5 and 6, according to the classification established in the Colombian standard NTC 4106 (ICONTEC, 1997). Table 1 shows the georeferencing for each farm sampled by municipality.

Table 1. Georeferencing for *Rubus glaucus* Benth. crops sampled in three municipalities of Risaralda department.

Municipality	Farm	Georeferencing
Pereira	El Edén	N: 04° 45' 57.8" W: 075° 38' 20.9" altitude: 1839 ± 3 m
	La Carmelita	N: 04° 45' 56.8" W: 075° 30' 23.7" altitude: 1828 ± 3 m
	Los Alpes	N: 04° 45' 49.1" W: 075° 38' 32.4" altitude: 1804 ± 3 m
Santa Rosa de Cabal	Los Pinos	N: 04° 54' 97" W: 075° 34' 29.9" altitude: 2013 ± 3 m
	El Rubí	N: 04° 53' 24.1" W: 075° 33' 44.0" altitude: 2085 ± 3 m
	Canoas	N: 04° 52' 37.2" W: 075° 32' 31.1" altitude: 2244 ± 4 m
Santuario	La Teresita	N: 05° 07' 25.2" W: 076° 00' 01.2" altitude: 2114 ± 3 m
	San Antonio	N: 05° 07' 16.8" W: 076° 00' 15.0" altitude: 2128 ± 4 m
	San Cayetano	N: 05° 06' 44.5" W: 075° 59' 36.9" altitude: 2075 ± 3 m

For the soil fertility analysis, the following parameters were evaluated: pH, organic matter, minor elements (K, Ca, Mg, and Na), and phosphorus (P), according to Colombian Technical Standards NTC 5264 (ICONTEC, 2018), NTC 5403 (ICONTEC, 2013), NTC 5349 (ICONTEC, 2016a), and NTC 5350 (ICONTEC, 2016b) respectively. In addition, the nitrogen content was calculated based on the organic matter content, aluminum using the KCl IM-EAA volumetric technique, and texture using the Bouyoucos method with sodium pyrophosphate and the USDA triangular classification diagram.

Physicochemical characteristics of *Rubus glaucus* Benth. fruits were analyzed as described by the AOAC. The following tests were performed: titratable acidity, humidity, ash, and crude fiber by gravimetric method according to AOAC methods 497.05, 934.06, 940.26, and 962.09/90 respectively. Ripeness index was determined following the procedure established by the AOAC (2005). Determination of fats was done according to the Soxhlet extraction method and to AOAC method 963.15, protein with the Kjeldahl method according to AOAC method 920.152, and total soluble solids with the refractometric method according to AOAC method 932.12 (AOAC, 2005).

Determination of the total phenolic content and antioxidant analysis was done with the extract obtained from frozen fruits ground in an electric blade grinder with liquid nitrogen. The pulverized material was extracted using methanol according to modifications made to the methodology proposed by Milosevic et al. (2012).

The Folin–Ciocalteu method for total phenolic content analysis was implemented in accordance with the modifications made to the methodology described by Waterhouse (2002). In brief, 50 µL of the extract and 250 µL of Folin–Ciocalteu reagent were mixed in a 5 mL flask at a 1:1 ratio. After 1 min, 750 µL of 20% sodium carbonate was added and diluted with distilled water. This solution was then incubated at room temperature for 30 min, absorbance was measured at 760 nm, a calibration curve was standardized using gallic acid as the standard, and the results were expressed in milligrams of gallic acid equivalents per gram of sample (mg GAE g^{-1} sample).

Antioxidant activity was evaluated by spectrophotometric method based on the extinction and absorption of 2,2-diphenyl-1-picrylhydrazyl radical (DPPH). In brief, 30 µL of the extract was added to 2 mL of 50.7 µM (20 mg L^{-1}) methanolic DPPH solution. This solution was then incubated at room temperature for 30 min, and the absorbance was measured at 517 nm. A calibration curve was standardized using ascorbic acid as the standard, and the results were expressed in millimoles of ascorbic acid equivalent per 100 grams of sample (mmol AAE g^{-1} sample) (MILOSEVIC et al., 2012).

All data were expressed as the mean ± standard deviation. Analysis of variance (ANOVA) was performed, in addition to the Shapiro–Wilk specific tests and the Tukey comparison test, to establish significant differences between the samples, and a cluster analysis using the 2011 version of InfoStat statistical software.

Results and discussion

In Colombia, *R. glaucus* has altitude adaptation from 1200 to 3500 m, but commercially it is cultivated between 1800 and 2400 m (CARDONA; BOLAÑOS-BENAVIDES, 2019). The Andean blackberry crops with and without prickles evaluated in this investigation were located at an altitude between 1804 ± 3 and 2244 ± 4 m above sea level, in the western and central mountain range of the Department of Risaralda.

Soils suitable for establishing blackberry crops are those that present loamy textures with a high content of organic matter, which allows water storage, greater fertility, and natural drainage (MORALES; VILLEGA, 2012). The soil fertility results for the Pereira, Santa Rosa de Cabal, and Santuario municipalities are shown in Table 2.

Table 2. Soil fertility results for the municipalities in Risaralda department.

Parameters evaluated	Municipality					
	Pereira		Santa Rosa de Cabal		Santuario	
	Material with prickles	Material without prickles	Material with prickles	Material without prickles	Material with prickles	Material without prickles
pH	5.35 ± 0.78 ^{aA}	4.75 ± 0.07 ^{aA}	5.90 ± 0.42 ^{aB}	5.45 ± 0.21 ^{aB}	5.40 ± 0.20 ^{aAB}	5.40 ± 0.10 ^{aAB}
N (%)	0.39 ± 0.09 ^{aA}	0.51 ± 0.08 ^{aA}	0.38 ± 0.07 ^{Aa}	0.44 ± 0.01 ^{aA}	0.65 ± 0.08 ^{aB}	0.57 ± 0.10 ^{aB}
MO (%)	9.45 ± 2.76 ^{aA}	11.95 ± 0.78 ^{aA}	9.35 ± 2.05 ^{aA}	11.15 ± 0.49 ^{aA}	19.10 ± 0.70 ^{aB}	15.93 ± 3.74 ^{aB}
K (meq 100 g^{-1} soil)	0.32 ± 0.06 ^{aA}	0.27 ± 0.01 ^{aA}	0.57 ± 0.40 ^{aA}	0.44 ± 0.22 ^{aA}	0.69 ± 0.22 ^{aA}	0.46 ± 0.22 ^{aA}
Ca (meq 100 g^{-1} soil)	3.00 ± 2.26 ^{aA}	1.48 ± 0.11 ^{aA}	7.65 ± 5.16 ^{aB}	4.71 ± 1.00 ^{aB}	5.90 ± 0.11 ^{aAB}	3.92 ± 1.78 ^{aAB}
Mg (meq 100 g^{-1} soil)	1.00 ± 0.85 ^{aA}	0.45 ± 0.07 ^{aA}	1.90 ± 1.13 ^{aA}	1.42 ± 0.45 ^{aA}	2.00 ± 0.70 ^{aA}	1.49 ± 0.78 ^{aA}
Ca/Mg	3.00	3.29	4.03	3.32	2.95	2.63
Ca/K	9.38	5.48	13.42	10.70	8.55	8.52
Mg/K	3.13	1.67	3.33	3.23	2.90	3.24
Al (meq 100 g^{-1} soil)	0.45 ± 0.64	0.90 ± 0.00	---	---	---	---
P (mg kg^{-1} soil)	5.00 ± 0.00 ^{aA}	17.5 ± 3.54 ^{bA}	3.60 ± 3.54 ^{aA}	9.50 ± 4.95 ^{bA}	12.00 ± 3.54 ^{aA}	10.00 ± 5.80 ^{bA}
Texture	Clay loam	Clay loam	Loam	Sandy clay loam	Silt	Silt loam

Averages with a common letter in the same row are not significantly different according to the Tukey test ($p \geq 0.05$). Uppercase letters indicate differences between municipalities and lowercase letters differences between material with and without prickles.

According to the results obtained, the Pereira and Santa Rosa de Cabal municipalities present loamy and clay-loam soils for blackberry crops both with and without prickles, while Santuario presents silty soils for material with prickles and silty-loam soil for material without prickles.

Some soils have pH values between 5.4 and 6.2. Blackberry has been found to adapt well to acidic soils with pH values between 5.2 and 6.7 (MORALES; VILLEGA, 2012). According to the Instituto Colombiano Agropecuario (ICA, 1992), these soils are classified as strongly acidic and suitable, with the exception of that in Pereira municipality for the material without prickles, which is considered very strongly acidic. Therefore, for this last zone mentioned there is a low concentration of exchangeable bases (Ca^{2+}, Mg^{2+}, and K^{+}) in relation to the other soils evaluated. This is mainly due to pH determining the availability of nutrients since depend on soil solubility (OSORIO, 2012). At all sampling places, organic matter was present at medium (5.1% to 10%) to high concentrations (> 10.1%) (ICA, 1992).

The previous results allow us to establish that the soils are suitable for blackberry cultivation. Most of the soils have a clay-loam texture, which ensures moisture content. An important aspect in blackberry cultivation is the ability to retain moisture in the soil because adequate humidity allows a constant productive and vegetative plant growth (CASTRO; CERDAS, 2005).

The results obtained for titratable acidity, ash, crude fiber, fat, humidity, ripeness index, protein, and total soluble solids for the fruits of Andean blackberry with and without prickles are presented in Table 3.

Table 3. Physicochemical parameters of *Rubus glaucus* Benth. fruits from plants with and without prickles.

Parameters evaluated	Municipality					
	Pereira		Santa Rosa de Cabal		Santuario	
	Material with prickles	Material without prickles	Material with prickles	Material without prickles	Material with prickles	Material without prickles
Humidity (g 100 g^{-1} sample)	83.17 ± 0.06 ^{aA}	86.87 ± 1.33 ^{aA}	86.33 ± 0.58 ^{aA}	85.11 ± 0.53 ^{aA}	86.63 ± 0.01 ^{aA}	85.82 ± 1.02 ^{aA}
Dietary fiber (g 100 g $^{-1}$ sample)	32.17 ± 0.12 ^{aA}	32.03 ± 1.27 ^{aA}	26.73 ± 0.06 ^{aA}	32.50 ± 2.77 ^{aA}	38.80 ± 0.17 ^{aB}	38.53 ± 0.47 ^{aB}
Fat (g 100 g^{-1} sample)	0.11 ± 0.01 ^{aA}	0.35 ± 0.14 ^{bA}	0.05 ± 0.01 ^{aA}	0.14 ± 0.08 ^{bA}	0.07 ± 0.01 ^{aA}	0.15 ± 0.13 ^{bA}
Protein (g 100 g^{-1} sample)	0.73 ± 0.01 ^{aA}	1.23 ± 0.14 ^{bA}	1.07 ± 0.01 ^{aAB}	1.91 ± 0.70 ^{bAB}	1.64 ± 0.01 ^{aB}	1.65 ± 0.23 ^{bB}
Ash (g 100 g $^{-1}$ sample)	0.45 ± 0.01 ^{aA}	0.39 ± 1.33 ^{bA}	0.75 ± 0.01 ^{aB}	0.58 ± 0.05 ^{bB}	0.57 ± 0.01 ^{aC}	0.51 ± 0.07 ^{bC}
Total soluble solids (°Brix)	4.13 ± 0.06 ^{aA}	4.87 ± 0.98 ^{bA}	5.07 ± 0.11 ^{aB}	6.87 ± 0.46 ^{bB}	7.23 ± 0.06 ^{aC}	6.80 ± 0.40 ^{bC}
Titratable acidity (g malic acid 100 g^{-1} sample)	3.08 ± 0.02 ^{aA}	2.13 ± 0.08 ^{bA}	2.67 ± 0.03 ^{aA}	2.42 ± 0.06 ^{bA}	3.20 ± 0.02 ^{aB}	2.65 ± 0.19 ^{bB}
Ripeness index	1.34 ± 0.03 ^{aA}	2.30 ± 0.55 ^{bA}	1.90 ± 0.06 ^{aB}	2.84 ± 0.11 ^{bB}	2.27 ± 0.02 ^{aB}	2.82 ± 0.24 ^{bB}

Averages with a common letter in the same row are not significantly different according to the Tukey test ($p \geq 0.05$). Uppercase letters indicate differences between municipalities and lowercase letters differences between material from plants with and without prickles.

According to statistical analysis of the parameters in Table 3, significant differences were found for fat, proteins, total soluble solids (° Brix), titratable acidity, ripeness index, and ash content between the fruit from plants with and without prickles. The fat and protein content were higher in the fruits from plants without prickles, while ash content and titratable acidity were significantly higher in those from plants with prickles. The ash and soluble solids content are highlighted; they showed differences by study municipality, the ash content being higher in Santa Rosa and the total soluble solids content in Santuario.

In addition, there were no significant differences between the fruits from plants with and without prickles in terms of humidity and dietary fiber. However, Santuario presented a higher dietary fiber content in relation to Pereira and Santa Rosa de Cabal. The high dietary fiber content of 38.80 ± 0.17 g 100 g^{-1} sample is very significant considering food applications and human nutrition, providing an added value to the fruits grown in Risaralda department.

A high humidity content was detected in the two *R. glaucus* materials assessed; this value is close to the range determined by other authors who established values of 86.42–94.1 g 100 g^{-1} sample for the same fruit (AYALA et al., 2013a; CARRILLO-PERDOMO et al., 2015).

The ash content of the fruits from plants with prickles (0.45 ± 0.01 to 0.75 ± 0.01 g 100 g^{-1} sample) was significantly different between municipalities; that of the fruits from plant without thorns (0.39 ± 1.33 to 0.58 ± 0.05 g 100 g^{-1} sample) was significantly lower and there were also significant differences between municipalities. This ash content is like that reported (0.515 g 100 g^{-1} sample) for the same species by Leterme et al. (2006) and close to the range established for other species of raspberries, blackberries, and bilberries, which is between 0.25 ± 0.004 and 0.54 ± 0.03 g 100 g^{-1} sample (STAJČIĆ et al., 2012).

Regarding the soluble solids content, the fruits from plants with and without prickles were significantly different, as were the municipalities sampled, the values found being between 4.13 ± 0.06 and 7.23 ± 0.06 °Brix for material from plants with prickles and between 4.87 ± 0.98 and 6.87 ± 0.46 °Brix for material from plants without prickles. This variation is possibly associated with environmental factors, cultivation practices, and weather conditions which affect the plant's development and have a strong influence on the sugars present in fruits.

As shown in Table 3, according to the ANOVA, the titratable acidity and ripeness index of the Andean blackberry fruit from plants with and without prickles were significantly different. Acidity for the fruits from plants with prickles was greater than that of ones from plants without prickles, while the ripeness index was higher for the fruits from plants without prickles. These results may affect the selection of materials according to the food or industrial application because less acidic fruits are desired for their use in the elaboration of jams, juices, yogurt, concentrates, frozen pulp, preserves, and confectionery.

The ripeness index is associated with the state of development of the fruits and their quality, and the results for the fruits from plants without prickles matches those obtained by several authors including Ayala et al. (2013b) and Sora et al. (2006) for Andean blackberries grown in other regions of Colombia. However, this index was slightly lower for fruits from plants with prickles. The values obtained for this characteristic for the fruits from plants without prickles grown in the Department of Risaralda guarantees their competitiveness at the national level since, according to the industrial requirements for fruit processing, this index must be 2.2 (GÓMEZ, 2004).

The results for antioxidant activity and total phenolic content are shown in Figures 1 and 2, respectively.

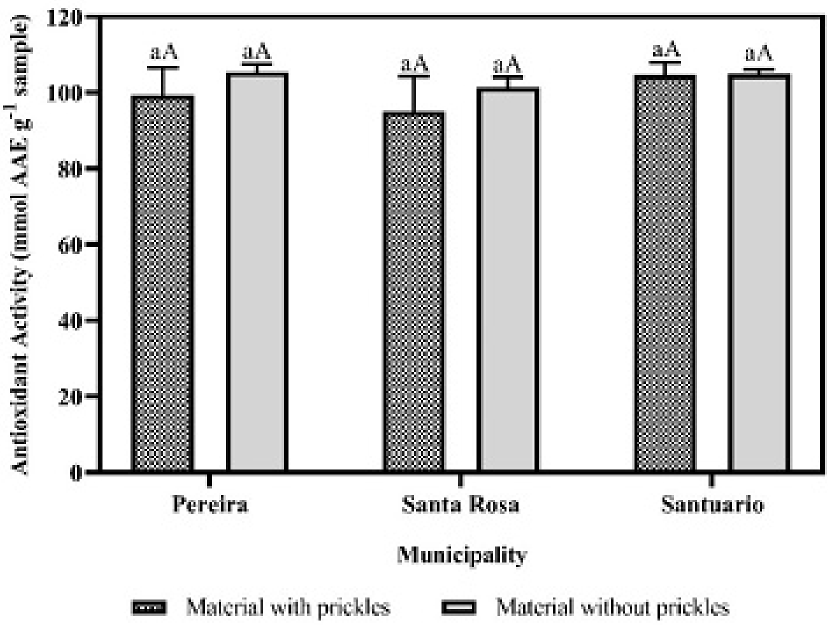

Figure 1. Antioxidant activity of *Rubus glaucus* Benth. fruits from plants with and without prickles. Averages with a common letter are not significantly different according to the Tukey test (p ≥ 0.005). Uppercase letters indicate differences between municipalities and lowercase letters differences between material from plants with and without prickles.

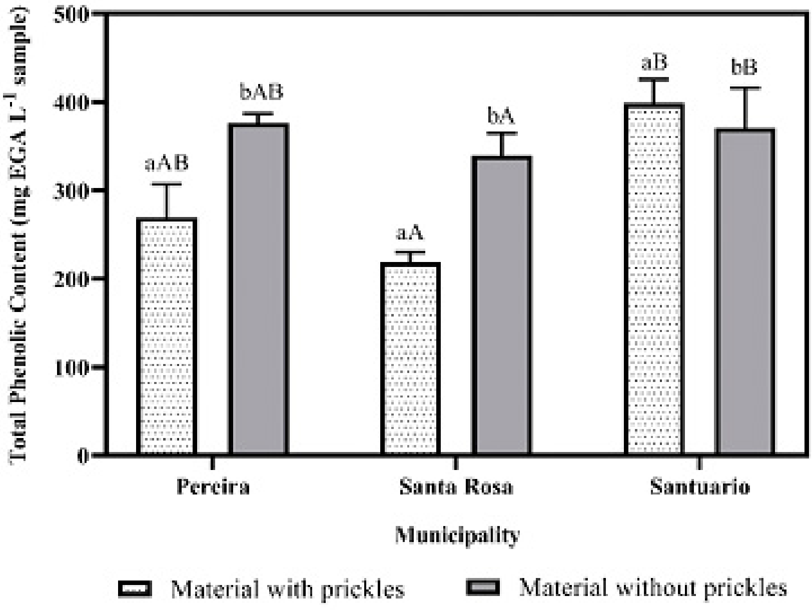

Figure 2. Total phenolic content of *Rubus glaucus* Benth. fruits from plants with and without prickles. Averages with a common letter are not significantly different according to the Tukey test ($p \geq 0.005$). Uppercase letters indicate differences between municipalities and lowercase letters differences between material from plants with and without prickles.

For the total phenolic content, values of 218.75 ± 11.02 and 398.73 ± 26.67 mg AGE g^{-1} sample were found for the materials from plants without prickles and with prickles, respectively. According to the statistical analysis, it was determined that there are significant differences between the materials from plants with and without prickles, and that the fruits grown in the municipality of Santuario have a higher content of said compounds. These results are comparable to those of Zozio et al. (2011) who reported a content of 340 mg AGE g^{-1} sample for this fruit. The fruit from plants without prickles can be categorized as a significant source of phenolic compounds for food purposes, which present various types of biological activity and generate benefits for human health, among which the anti-inflammatory, antioxidant (LI et al., 2015), anti-neurodegenerative (ABU-BAKAR et al., 2016), anticancer (GEORGE et al., 2017), and anti-Alzheimer (LI et al., 2015) activity stand out, among others. In this sense, studies confirm that the variety, geographical region, weather conditions, and stage of ripeness affect the synthesis of phenolic compounds (LABANCA et al., 2017).

Finally, antioxidant activity between 95.06 ± 9.2 and 105.5 ± 2.02 mmol AAE g^{-1} sample was found for the fruits from plants with and without prickles, respectively. The statistical analysis established that there are no significant differences in the antioxidant activity, determined in the different materials and municipalities evaluated. However, plants without prickles can be categorized as a significant source of phenolic compounds, and they have important biological activity for human heath, other than antioxidant activity (that didn't present significant difference). Andean blackberries from plants without prickles could have an added value at an industrial level, be it in the food or cosmetic industries, due to their content of antioxidants mainly phenolic compounds which help fight oxidative stress by preventing aging (KHAN et al., 2019).

Conclusion

The diagnosis of blackberry crops by the materials planted and place of cultivation in the Department of Risaralda showed that the plants without prickles are more widely distributed in the department due to their ease of handling. According to the results of the soil analysis, most Castilla blackberry crops in the Santa Rosa, Santuario, and Pereira municipalities are within the recommended parameters for blackberry production at the national level. This study made it possible to establish the antioxidant potential mainly of the Andean blackberry fruits from plants without prickles, adapted and cultivated in the Department of Risaralda, showing a high total phenolic content and antioxidant activity. The evaluated parameters also attribute characteristics to these fruits that guarantee their competitiveness at the national and industrial levels.

Acknowledgements

The authors thank the Technological University of Pereira and the Corporation for a Specialized Network for Research and Technological Development Centers of the Agricultural Sector of Colombia (ceniRED) for financing this project.

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