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The effect of pressure filtration coffee preparation methods (*Coffea arabica* L. var. *Castillo*) on antioxidant content and activity, and beverage acceptance

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Abstract

The majority of pressure filtration methods for coffee preparation constitute acceptable alternatives for the obtention of coffee with bitter notes and body. In this study, antioxidant metabolite retention, antioxidant activity, and cup profiles were determined for coffee beverages prepared using five methods of pressure filtration. The methods which registered the highest antioxidant retention rates were Espresso, Moka, and Staresso. The highest hydroxycinnamic acid content was obtained with the Staresso, Espresso, and Moka methods, in descending order. Antioxidant capacity was proportional to antioxidant compound retention, with the ORAC method, in the beverages prepared, but not with the ABTS methodology. The Presso method had the lowest antioxidant retention rate. The beverage prepared with the Aeropress method obtained the lowest amount of antioxidant metabolites. In the five preparations evaluated, the most prominent hydroxycinnamic acid was chlorogenic acid. It is recommended that coffee prepared with the Espresso or Moka methods be consumed.

Keywords: tasting; antioxidants; pressure; quality; sensorial.

Efecto de los métodos de preparación del café de filtración por presión (*Coffea arabica* L. var. *Castillo*) sobre el contenido y actividad antioxidante, y la aceptación de la bebida

Resumen

Los métodos de preparación de café de filtración por presión, en su mayoría constituyen una buena alternativa para obtener café con notas amargas y cuerpo. En este estudio, se determinó la retención de metabolitos antioxidantes, su actividad antioxidante y el perfil de taza, de bebidas de café preparadas con 5 métodos de filtración por presión. Los métodos que registraron mayor retención de antioxidantes fueron Espresso, Mocca y Staresso. El mayor contenido de ácidos hidroxycinnámicos se obtuvo con Staresso, Espresso y Mocca en orden decreciente. La capacidad antioxidante fue proporcional a la retención de compuestos antioxidantes mediante el método ORAC en las bebidas preparadas, excepto con la metodología ABTS. El método Presso obtuvo la más baja retención de antioxidantes. La bebida preparada por Aeropress obtuvo la más baja expresión de los metabolitos antioxidantes que la componen. El ácido hidroxycinnámico más predominante en las 5 preparaciones evaluadas fue el ácido clorogénico. Se recomienda el consumo de café con los métodos Espresso y Mocca.


Palabras clave: catación; antioxidantes; presión; calidad; sensorial.

1. Introduction

Coffee is the third most commercialized product globally, following petroleum and water [1,2]. Coffee lovers affirm

that a good cup of coffee depends on climatic factors and the operation variables applied in processes such as benefit, fermentation, and roasting parameters, as well as the origin, variety, and composition of the coffee processed [3,4].

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A variety of studies have reported the functional aspects of certain coffee varieties, by way of their chemical analyses, and recommended their continuous consumption, so as to reap the health benefits and sensorial qualities thereof [5, 6]. Certain investigations have reported the role of coffee, grains, fruits, and vegetables as functional foods, which preserve health through the minimization of oxidative stress, a precursor to many illnesses such as Parkinson's disease, diabetes, and cancer [5-8]. Additionally, the roasting process, via the Maillard reaction, generates products with antioxidant properties, which trap free radicals, owing to their phenolic components [9,10].

Together, flavonoids, phenolic acids, and tannins provide the greatest functionality to the coffee beverage. Tannins lend astringency, while polyphenols, flavonoids, and hydroxycinnamic acids such as chlorogenic and ferulic acid lend acidity and bitterness to the cup profile. The arabica variety lends sweet and caramel notes, while robusta coffee lends spicy, pungent, earthy notes. Coffee's antioxidant metabolites also help to highlight the more iconic flavors of this traditional beverage [11]. It is important to note that ferulic acid participates in decarboxylation reactions during roasting, and thus generates phenolic compounds. This compound then increases the antioxidant fraction in the coffee, and simultaneously provides bitter and acidic notes to the beverage [2].

The emergence of both new coffee preparations and the positioning of the barista culture constitute an emerging coffee market, which is characterized by the skill, creativity, and theoretical-practical knowledge of chemical fundamentals, as well as the motivation of connoisseurs and coffee lovers. Said preparations offer diverse sensorial profiles and antioxidant composition, in accordance with the preparation conditions employed [12]. This tendency makes way for the consumption of special coffees and the purchase of traditional and recent preparation methods, as a basis for added value increases in other products derived from coffee [13].

Pressure filtration methods are characterized by the application of pressure on a mass of compacted coffee, prior to beginning extraction by lixiviation. When the coffee is compacted, a fixed bed is created, through which water passes at approximately 90 °C, with the use of pressure, and its extraction capacity is consequently increased. Pressure application may vary, whether through the use of a piston (Starezzo and Aeropress), a lever (Presso), small holes through which the water/coffee mixture is forced to recirculate (Moka), or simply with water at pressure (Espresso). Generally, in these kinds of methods, contact time is low (seconds or minutes). However, despite the application of pressure, in order to obtain a coffee beverage, a mass transference phenomenon must occur. Therein, coffee solids pass to the water via lixiviation. Contact time varies for the methods under study, although it is always minimal, as does the coffee-water proportion, and the pressure-generating element. These variables may positively or negatively influence antioxidant metabolite composition, as well as its expression via antioxidant activity determination [14].

The relationship between the preparation method, cup profile, and antioxidant compound composition has neither been established nor used as an opportunity to offer varieties of coffee with specific sensorial and functional characteristics to the market. Certain previous studies [15,16] did not consider preparation method principle, but instead considered only those which are most popular in coffee shops or homes. In the present study, the preparation method was correlated with that of a variety of chemical antioxidant sorts, including antioxidant capacity. This occurred in parallel with the development of an adequate excelso U.G.Q. coffee cup profile, through the preparation of coffee-based beverages prepared with five different pressure filtration methods. The antioxidant metabolites studied here were as follows: total phenols, flavonoids, condensed tannins, and hydroxycinnamic phenolic acids (chlorogenic acid, caffeic acid, p-coumaric acid, and ferulic acid). Antioxidant activity was evaluated by way of the ABTS and ORAC methods.

2. Materials and methods

2.1. Raw materials

The wet parchment coffee (*Coffea arabica* L. var. *Castillo*) used was obtained from the municipality of Anserma, Caldas, Colombia, from San Rafael Farm, located at 1,750 m above sea level. It was grown at approximately 20 °C, with an average relative humidity of 72 %. One thousand two hundred grams of each sample were processed, in triplicate, for each of the determinations made.

2.2. Physicochemical analyses

The parchment coffee bean was threshed (Quantik, CR-2000, Armenia, Colombia) and sifted [17]. The excelso U.G.Q. coffee which remained on top of the 14/64 inch sieve was used for the analysis. Beans with group one and two defects were removed. The humidity content of the green coffee was determined with a forced convection stove (Dies, TH115FM, Antioquia, Colombia). The coffee was roasted at 180 °C and 100 % power in laboratory-scale equipment (Quantik, TC-150 A/R, Armenia, Colombia) until beans with a medium roast were obtained. The samples were then ground (Grindmaster 810, Mexico), in accordance with the specific needs of the preparation types employed in the present study.

The size of the ground coffee particles was verified with the Taylor series method [18]. Beverage pH was determined using a digital pH meter (Lab-850; Schott Instruments®, Germany). Soluble solids were determined with a digital refractometer (PAL-1, Atago®, Japan), and were expressed in degrees Brix (°Brix) [19]. The weight of the ground coffee and that of the beverage were determined using a precision scale (Fenix-Plus, Bogotá, Colombia) for each preparation method [20]. The Extraction Performance (EP) for each beverage was then calculated in eq. (1). Beverages were hermetically sealed in polypropylene plastic jars, and stored at 4 °C for their later analyses [21].

$$RE = \frac{m_2}{m_1} \times \text{°Brix} \quad (1)$$

Where m_1 is the weight of the toasted, ground coffee in g, m_2 is the weight of the total beverage obtained in g, and the °Brix is the beverage's soluble solids percentage.

2.3. Coffee beverage preparation using pressure filtration methods

Five preparation methods for coffee beverage preparation were evaluated, using the principle of pressure filtration. These used pressure between the roasted, ground coffee, and the water at a given temperature, in accordance with the technique of each method evaluated. Below, the procedure followed for each method is described:

2.3.1. Aeropress

Roasted, medium-ground coffee (526 microns) was used. Contact time with the hot water, at 90 °C, totaled four minutes. Fourteen grams of coffee were mixed with 150 mL of water. This method utilizes a piston or plunger system to cause filtration. This method was invented in 2005 by American Alan Adler. It consists of two plastic cylinders, which function together as a syringe that introduces air pressure to the water and ground coffee mixture, pushing said mixture through a paper filter or metal cylinder. The objective thereof is to minimize coffee infusion time, and thus reduce bitterness.

2.3.2. Presso

Roasted, finely-ground coffee (400 microns) was used. This method is known as the manual Espresso coffee machine. This method consists of a lever with two arms on a plunger, which applies pressure to the water at 90 °C. This is deposited into the container, situated above the manual plunger. Fourteen grams of roasted, ground coffee was mixed with 60 mL of hot water. This method was designed by Patrick Hunt, does not use electric energy to function, and was designed with 100 % recycled aluminum.

2.3.3. Staresso

Fourteen grams of medium-ground coffee (526 microns) were mixed with 150 mL of hot water. The coffee is placed in the appropriate section, pressed with the scoop which indicates the coffee measurement. The container is secured, with the roasted, ground coffee, to an elongated cylinder with a piston. The piston is removed, and hot water is added in the available space. The piston is secured once again, and pressure is applied manually to the piston until total beverage extraction is achieved. The beverage moves to the glass container, which acts as a mug from which to drink the hot coffee.

2.3.4. Espresso

This method causes hot water to pass at high pressure (5-18

bars, depending on the machine) through the previously compacted, roasted, and ground coffee. Extraction time takes just seconds. Fourteen grams of finely-ground coffee (400 microns) were mixed with 75 mL of hot water at 90 °C.

2.3.5. Moka or home espresso

Fourteen grams of medium-ground coffee (526 microns) were mixed with 150 mL of water for one minute, via a medium pressure filtration system opposite gravity. The coffee is placed in an airtight space in the middle of the two containers. The water rises and causes the coffee to sink, by way of a number of orifices in the bottom, and the drink stays in the upper container.

Fig. 1 shows the pressure filtration methods evaluated in the present study.

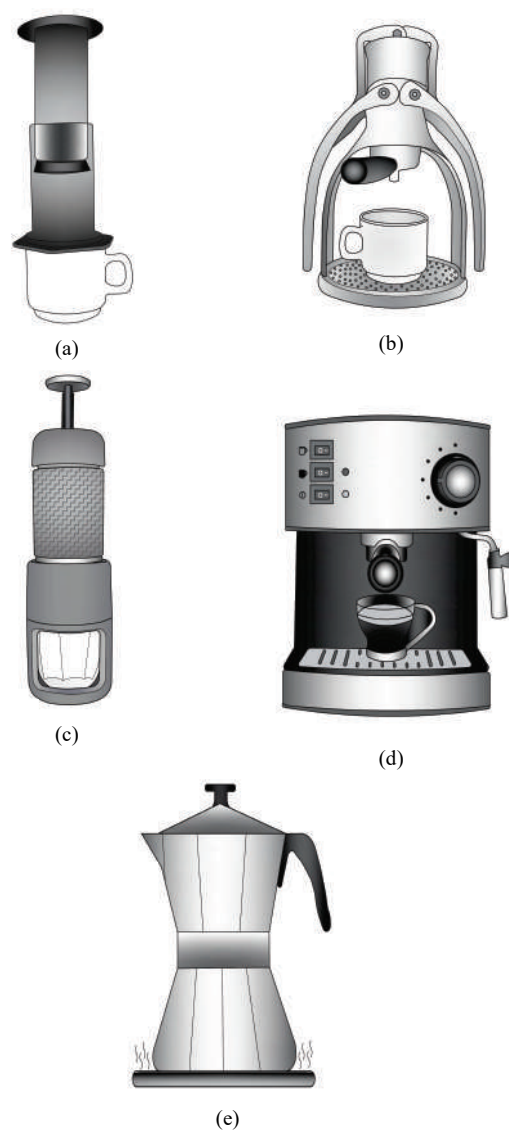


Figure 1. Pressure filtration coffee preparation methods a) Aeropress, b) Presso, c) Staresso, d) Espresso, and e) Moka.

Source: The Authors.

2.4. Coffee beverage cup profile analysis

Beverages obtained with the gravity filtration methods evaluated were tested with the Q.D.A. flavor profile (Qualitative Descriptive Analysis). One rating was given per taster (three expert tasters). The categories evaluated in each sample were: fragrance, aroma, acidity, bitterness, body, aftertaste, and overall impression.

Other categories were considered in the sensorial evaluation of the beverages, in order to describe defects therein, such as acidity, vinegar flavor, fermentation, astringency, age, rancidity, phenolic, earthy, or chemical flavors, among others. The results of the Q.D.A. cup tests were depicted on radial charts [22].

2.5. Sample preparation

The beverages prepared with the five methods under study were diluted to fixed concentrations with distilled water, in order to perform antioxidant compound and capacity measurements [23].

2.6. Total phenol determination

Phenol determination was performed using Follin-Ciocalteu's colorimetric method [24]. It constituted a pattern curve, using gallic acid as a standard. The results were expressed in mg of gallic acid/100 g sample. The readings were performed at 760 nm in triplicate. A UV-VIS spectrophotometer (Jenway, 6405, Essex, England) was used. The Follin-Ciocalteu reagent and gallic acid were obtained from the Merck trading house (Germany).

2.7. Total flavonoid content

Beginning with an aliquot of 0.5 mL of beverage sample solution, 0.5 mL of ethanolic solution was added, with AlCl_3 at 2 %. After an hour of incubation at room temperature, the absorbency was determined to be 420 nm. Catechin solutions (Sigma-Aldrich®, USA) were used, as was between 5-25 $\mu\text{g/mL}$ of ethanol (Merck, Germany), for calibration curve construction.

Total flavonoid content was calculated as mg equivalent to catechin/100 g sample. This procedure was carried out for each one of the samples in triplicate. The values presented correspond to the mean and standard deviation (\pm). A UV-VIS (Jenway, 6405, Essex, England) spectrophotometer was used [24].

2.8. Condensed tannins content

Two hundred and thirty μL of the extract sample from each coffee beverage was taken, and 670 μL of a recently-prepared vanilla solution (1 g/100 mL) was added to 70 % sulfuric acid. The mixture sat for 15 minutes at 20 °C, and the spectrophotometric reading was taken at 500 nm and compared with the curve pattern used as standard (+)-catechin. The results were expressed as mg of catechin equivalent/100 g sample [24].

2.9. Hydroxycinnamic phenolic acid content

The coffee extracts were filtered (0.45 mm pore size) with dilutions in supra-pura water. The chromatographic conditions were: mobile acetonitrile phase/acidified water (phosphoric acid pH = 2.5), (400:600 v/v). The phenolic components were eluted under the following conditions: flow of 1 mL/min, 25 °C, and isocratic conditions. The UV-visible spectrum was traversed from 200-600 nm for all spikes. The identification and quantification of chlorogenic acid, caffeic acid, p-coumaric acid, and ferulic acid was performed via the standard external method in the beverages under study. All tests were performed in triplicate [21].

2.10. ABTS antioxidant activity determination

Measurements were taken at a 734 nm wavelength. One hundred μL were used as an extract of the coffee beverage samples prepared with the different methods at different times, with 900 μL of the ABTS radical solution. Given 60 minutes to react at room temperature, in the dark, the change in reagent absorbency with an ABTS radical solution, with the sample solvent. The absorbency value was compared to the reference curve constructed with Trolox as a standard. For both compounds, the inhibitory concentration (PI) was determined to be 50 % (IC₅₀), as shown in eq. 2, and the results were expressed as TEAC_m values (μmol Trolox/100 g sample) [24].

$$\text{PI} = \left[1 - \left(\frac{A_{\text{sample}} - A_{\text{target sample}}}{A_{\text{standard}} - A_{\text{target standard}}} \right) \right] \times 100 \quad (2)$$

2.11. Oxygen Radical Absorption Capacity (ORAC) evaluation

In the ORAC determinations, 6-hidroxi-2,5,7,8-tetrametilchrome-2-carboxylic acid or Trolox (Merck, Germany) was used as standard with controlled temperature conditions, at 37 °C and 7.4 pH. The readings were performed at an excitation wavelength (1) of 493 nm and an excitation opening of five, one excitation emission of 515 nm, emission opening of 13, an attenuator of 1 %, and without attenuating plate. Fluorescein solutions of 1×10^{-2} M in Phosphate Buffer Solution (PBS) (75 mM), 2,2'-Azinobis (2-amidinopropane) dichlorhydrate (AAPH) 0.6 M in PBS (75 mM) were employed. The beverage samples were prepared with 21 μL of fluorescein, 2.899 μL of PBS, 30 μL of the extract tested, and 50 μL of AAPH. Trolox was used as a standard. The antioxidant protection effect was calculated using the differences between the areas of fluorescein between the target and sample below the decay curve, and the Trolox curve, and was expressed in μmol Trolox/100 g sample and TEAC_m, as shown in eq. 3 [24]. Said tests were performed in triplicate. The decrease in fluorescein intensity was made in a spectrofluorimeter (Perkin-Elmer LS-55, Beaconstfield, UK). The fluorescein, PBS, sodium phosphate acid and the AAPH were acquired from the Aldrich Chem. Co trading house (Milwaukee, WI).

$$ORAC = \frac{AUC_{muestra} - AUC_{control}}{AUC_{trolox} - AUC_{control}} \cdot f \cdot [trolox] \quad (3)$$

Where, AUC_{sample} is the area below the sample curve, $AUC_{control}$ is the area below the curve for the standard, AUC_{trolox} is the area below the curve for Trolox, and f is the extract dilution factor.

2.12. Statistical analyses

All determinations were made in triplicate and values expressed as averages the standard deviations (\pm). The statistical differences were determined via variance analysis (ANOVA) and the Least Significant Difference test (LSD), with a value of $p < 0.05$ at a significance level of 95 % for the comparison of means of each of the analyzed variables, antioxidant content, hydroxycinnamic phenolic acids, and antioxidant activity in the coffee beverages prepared via pressure filtration methods. The STATGRAPHICS Centurion XV statistical package was used.

3. Results and discussion

3.1. Physicochemical determinations

The green coffee, prior to the roasting process, registered 12% initial humidity, with which uniform humidity content was guaranteed, as was the ability to compare between the results obtained therefrom. The same roasting conditions were employed for all of the samples evaluated. The analysis of certain physicochemical parameters in the prepared coffee beverages is shown in Table 1.

Beverage performance was highest with use of the Staresso method, followed by that of the Moka and Espresso methods. Staresso may have performed well owing to the perpendicular pressure exerted on the cylindrical container with minimal surface area. At least four consecutive pushes were made with the Staresso piston. Thus, said pressure efficiently and directly facilitated the extraction of the soluble and insoluble solids in the beverage obtained. The method which presented lowest coffee beverage performance was Aeropress, as higher contact time did not facilitate pressure extraction. The pressure exercised to cause lixiviation was not as efficient here as in other methods. The Presso method presented intermediate beverage performance. Those with best performance presented greater darkening, as a product of their solid concentrations. All of the methods evaluated in this study were prepared with hot water. The high water temperatures guarantee an increase in solubility during the lixiviation process. ANOVA indicated a significant difference between the preparation method applied and performance obtained ($p < 0.05$).

The highest soluble solid values ($^{\circ}$ Brix) were found in the preparations made with the Espresso, Presso, and Moka, followed by the Staresso, and lastly, Aeropress methods. These results are not related to the performance obtained for the beverages corresponding to each of the pressure filtration methods evaluated. The methods with greatest soluble solid concentrations, and with a low water-coffee ratios were Espresso and Staresso. Similarly, with these two methods,

Table 1.
Physicochemical parameters of the coffee beverages prepared with different pressure filtration methods.

Method	Beverage performance	$^{\circ}$ Brix	pH	Contact time
Aeropress	10,86($\pm 0,02$)a	1,30($\pm 0,03$)a	4,91($\pm 0,02$)a	4 min
Presso	15,47($\pm 0,01$)b	4,60($\pm 0,02$)b	4,93($\pm 0,01$)a	30 s
Staresso	18,55($\pm 0,03$)c	1,87($\pm 0,01$)c	5,08($\pm 0,03$)b	1 min
Espresso	18,31($\pm 0,01$)d	6,00($\pm 0,02$)d	4,92($\pm 0,02$)a	22 s
Moka	18,43($\pm 0,02$)e	2,03($\pm 0,03$)c	4,91($\pm 0,02$)a	1 min

The average values ($n=3$) with different letters in the same column indicate statistical differences at a significance level of 5% ($p < 0.05$).

Source: The Authors.

dark beverages were obtained. These results indicate that the preparation method influenced sugar, organic acid, salt, and other water-soluble compounds' dilution.

The statistical analysis showed the significant effect that the preparation method had on soluble solid concentration in the beverages ($p > 0.05$).

The pH of the beverage prepared with Staresso was greater than that of the other beverages. The Aeropress, Presso, Espresso, and Moka methods presented similar pH values. With the Staresso method, it is possible that the pressure applied did not permit the complete solubilization of the coffee's organic acids, and for this reason the beverage obtained presented a more alkaline median than the others. Perhaps, with the Moka method, intense turbulence was generated by the hot water, which helped to mix the coffee and water. In the other methods, there was no mixture agitation. The pH value is related to the concentration of organic acids present in the coffee. Variance analysis did not indicate a significant difference ($p > 0.05$) between the drink pH and the preparation method via Aeropress, Presso, Espresso, or Moka, compared to the Staresso method.

The importance of using the same roasting conditions for the samples analyzed is that it guarantees uniform thermic degradation for the later antioxidant metabolite, activity analysis [21], as well as the cupping tests for those beverages prepared with pressure filtration methods. In beverage preparation with pressure, coffee granulometry is of vital importance, as if it is coarse, less pressure is applied, but if it is fine, the pressure applied must be greater, so as to extract soluble and insoluble solids from the grain. The latter was observed in the application of the Aeropress method [25]. In the case of the Staresso method, normal pressure is between 15 and 20 bars [26], while with traditional Espresso, 9-10 bars minimum must be applied [27]. In the remaining methods evaluated, there is no register of the pressure applied.

Caffeine, trigonelline, chlorogenic acids, citric acid, acetic acid, and formic acid present in the beans affect both the acidity and pH of the beverage prepared, and accentuate the flavor of the coffee, in accordance with the type of roasting and preparation technique employed [28,29].

3.2. Total phenol determination

Total phenol concentration was greater with the Espresso, Moka, and Staresso methods, in that order, with values of 5,306.2, 2,929.3, and 2,170.3 mg of gallic acid/100 g sample,

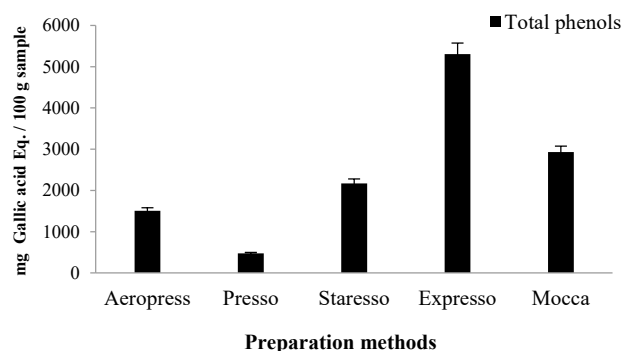


Figure 2. Total phenol concentration with the pressure filtration coffee preparation methods.
Source: The Authors.

respectively (Fig. 2). The lowest phenol content was obtained with the Aeropress and Presso methods, in descending order. The preparation method had a significant effect ($p < 0.05$) on total phenol retention. The preparation methods with lowest performance, Aeropress and Presso, had the lowest concentrations of total phenols, possibly owing to the effect of dilution in these methods.

U.G.Q. excelso coffee contains elevated concentrations of the phenolic acids responsible for its higher antioxidant activity, when compared to other Colombian coffee quality classifications [21]. Roasting frees caffeine for the thermic degradation of the phenols, making way for an increase in sensorial attributes such as the body and bitter notes which characterize coffee [30,31]. Thus, the phenolic components participate in the synthesis of secondary products of the Maillard reaction, owing to temperature action [10], such as melanoidins, which have an antioxidant effect and add color and flavor to the beverage [32].

Phenolic components are sensitive to pH changes, and participate in transesterification reactions, and influence caffeine, chlorogenic acid, and caffeic acid concentrations in the beverages prepared [33]. Said pH variations may be induced as the coffee dissolves in large amounts of water. Consumption of phenols in the diet regulates oxidative stress and protects the body from illnesses such as diabetes and cardiovascular diseases. Additionally, their antimicrobial, anti-inflammatory, and antiallergenic properties have been proven [34].

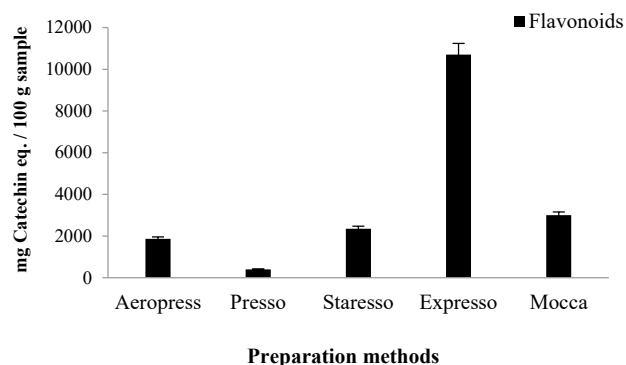


Figure 3. Flavonoid content with pressure filtration coffee preparation methods.
Source: The Authors.

3.3. Total flavonoid content

Flavonoid concentration was increased with the Espresso, Moka, and Staresso methods, with values of 10,705.2 mg, 3,003.1 mg, and 2,352.6 mg, respectively, expressed as mg of catechin equivalent/100 g sample (Fig. 3). It should be noted that retained flavonoid content in Espresso coffee was 3.6 times greater than that obtained with Moka coffee. Flavonoid content was lower for the Aeropress and Presso methods, in decreasing order. The preparation method had a significant effect ($p < 0.05$) on flavonoid retention in the beverages obtained.

Flavonoids have anti-inflammatory, anticancerogenic, and antiatherosclerosis properties. They also help to prevent illnesses such as Parkinson's and Alzheimer's diseases [35, 36]. They further contribute to microbial equilibrium on an intestinal level, as well as reduce the prevalence of coronary disease [37]. In coffee cup profiles, flavonoids are responsible for the bitter flavor.

3.4. Condensed tannins determination

Tannin retention, in the beverages prepared with different pressure filtration methods (Fig. 4), was greatest with the Espresso method, followed by the Staresso and Presso methods: 197.4, 129.5, and 118.1 mg, respectively, expressed as mg of catechin eq./100 g sample. The Moka method had a slightly lower content than that of the Presso method. The Aeropress method registered the lowest tannin content. The statistical analysis indicated a significant difference ($p < 0.05$) between condensed tannin concentration and the beverage's method of preparation.

The presence of tannins in cupping tests is closely related to astringent notes in the beverage, and are substances with high functional value [38]. In terms of the results obtained and the flavor profile test performed, the astringent notes in the beverages evaluated are in an optimal interval, given that the tannin concentration did not alter the sensorial rating, and presented one similar to that of the U.G.Q. standard. Tannins possess anti-inflammatory and antihemorrhagic properties, and help to prevent degenerative illnesses and premature aging [24].

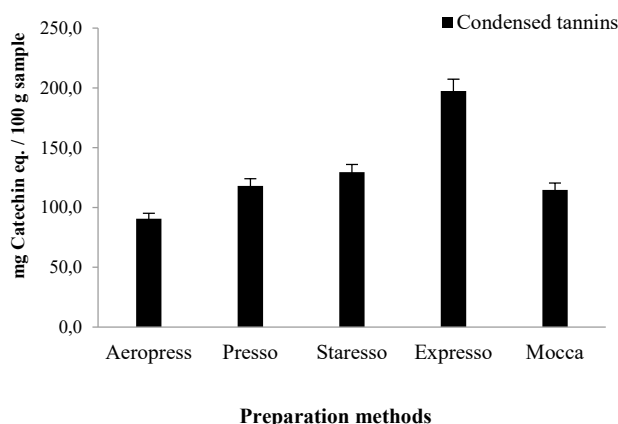


Figure 4. Condensed tannin concentration in pressure filtration coffee preparation methods.
Source: The Authors.

These substances provide an undesirable tactile sensation in coffee, characterized by constriction, frowning, and dryness in the oral cavity's mucous membrane, and influence the bitterness sensation. This is generated by the degree of polymerization of the condensed tannin molecules. These interact synergistically with saliva proteins, and impart an astringent sensation to the palate [39, 40, 41].

3.5. Hydroxycinnamic phenolic acid content

Fig. 5 shows the content of hydroxycinnamic acid in the beverages prepared with five different pressure filtration methods. The chlorogenic acid content was highest using the Staresso method, followed by that of the Espresso and Moka methods. Caffeic acid was only detected with the Staresso method. In the Espresso, Moka, Aeropress, and Presso methods, this component was not identified. P-coumaric acid content was greater with the Espresso and Moka methods, followed by the Staresso and Aeropress methods, which presented similar concentrations thereof. The Presso method registered the lowest concentration of p-coumaric acid. Ferulic acid had higher concentrations with the Espresso, Moka, and Staresso methods, and lower content with the Aeropress and Presso methods, in descending order. Only the Staresso method contained all four of the hydroxycinnamic acids evaluated. ANOVA indicated the significant effect ($p < 0.05$) of the preparation method on beverage hydroxycinnamic acid concentration.

Hydroxycinnamic acids influence the sensory properties and antioxidant activity in coffee-based drinks. Additionally, the phenolic compounds are generated during the roasting process with the separation and transformation of chlorogenic acids [42]. These provide acidity, astringency, and bitter notes to the drink [29,30], as well as the caffeine and flavonoids present. Similarly, in concordance with the present study, it was reported that, in *Coffea arabica* samples, the majority hydroxycinnamic acid was chlorogenic acid, while caffeic and coumaric acid presented the lowest concentrations [43]. The relative change in chlorogenic acid content in arabica coffee and its isomers depends on the region of origin, amount of roasting, and preparation method [11].

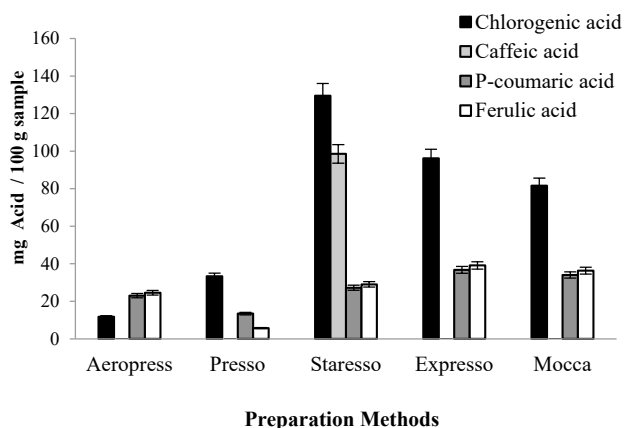


Figure 5. Condensed tannin concentration in pressure filtration coffee preparation methods.
Source: The Authors.

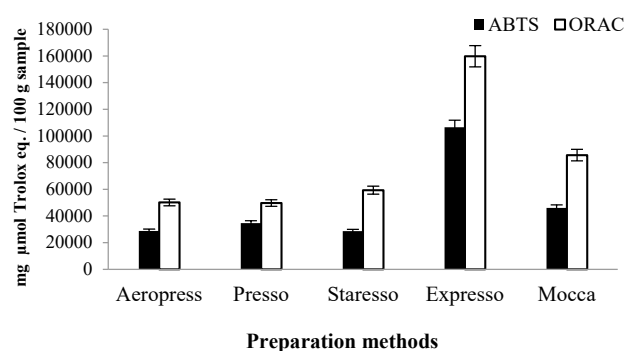


Figure 6. Antioxidant capacity for the ABTS and ORAC methods in beverages prepared with pressure filtration methods.
Source: The Authors.

3.6. Antioxidant activity determination

The antioxidant capacity values obtained with the ABTS and ORAC methods were statistically different ($p < 0.05$) (Fig. 6). The ABTS activity values, in descending order, were with the Espresso, Moka, Presso, Aeropress, and Staresso methods. With the ORAC method, antioxidant capacities were obtained, in descending order, for: Espresso, Moka, Staresso, Aeropress, and Presso methods. The antioxidant capacity determined by the ORAC method presented a direct relationship with the concentration of different types of antioxidant metabolites evaluated in the beverages prepared, in contrast with the ABTS method. These results indicated a positive correlation in the expression of the antioxidant compounds in the coffee beverages. The Presso and Aeropress applications presented the lowest antioxidant capacity registered with the ORAC methodology. In the two methodologies evaluated to determine antioxidant activity in the beverages, the Presso method presented greater activity than the Aeropress method, even when Aeropress presented a higher concentration of antioxidant metabolites than Presso, except for condensed tannin content. In that sense, antioxidant activity has an effect on a beverage's antioxidant metabolite content.

The coffee roasting process elevates antioxidant activity in coffee, due to the Maillard reaction, as well as phenolic compounds belonging to the hydroxycinnamic acid group (chlorogenic, caffeic, coumaric, and ferulic) present in the coffee [44]. One study has indicated the existence of a direct correlation between non-enzymatic browning and the antioxidant capacity of Colombian roasted coffee [45].

The chemical components which strengthen the majority of antioxidant activity in coffee are the phenolic compounds, which belong to the hydroxycinnamic acid group (chlorogenic, caffeic, coumaric, and ferulic), melanoidins, caffeine, and other volatile coffee components [33,44]. In accordance with the findings reported by [15], the Espresso method had higher ABTS activity than the Moka method. Bitterness was more marked in Espresso than in Moka coffee, possibly owing to the lower caffeine content reported in the latter [15]. Antioxidant content and activity depends on the grind of the coffee, coffee/water ratio, temperature, and extraction time of the method employed [46].

3.7. Coffee beverage cup profile analysis

The majority of the ratings given to the beverages prepared with five different pressure filtration methods presented profiles different from that of an excelso U.G.Q. pattern (Fig. 7). This indicates that the preparation method applied influenced the excelso coffee (U.G.Q.) cup profile. The statistical analysis showed significant differences ($p < 0.05$) between the coffee's preparation method and the sensorial cup profile obtained. The coffee beverage with greatest similitude to the excelso U.G.Q. pattern was that prepared with the Staresso method.

The Aeropress method presented market bitter notes, as compared to the standard pattern. The other categories remained the same as those of the excelso U.G.Q. pattern. The beverage prepared with the Presso method presented lower acidity, more bitter notes, and slightly superior body than the standard, although the remaining categories did not stray. Only the beverage obtained with the Staresso method presented a slightly higher overall impression than that of the standard pattern. The Espresso coffee presented low acidity and intensely bitter notes, and all other categories were as in the standard sample. Finally, the beverage prepared with the Moka method presented greater acidity and increased bitter notes than the excelso U.G.Q standard. Of these categories, bitterness was more marked than the acidic tone of the beverage. All remaining categories maintained the same rating as the excelso coffee standard.

The methods which earned the highest ratings in the bitterness category were: Espresso, Moka, and Presso. The Espresso and Moka methods presented higher retention of total phenols and flavonoids, the substances responsible for lending bitter notes to coffee beverages.

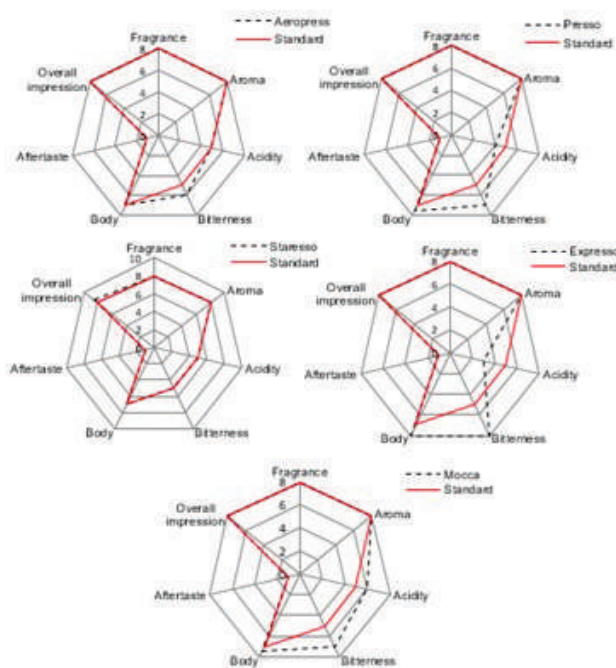


Figure 7. Sensorial profile of beverages prepared with pressure filtration, compared to a U.G.Q. pattern. Average values ($n=3$). Source: The Authors.

Chlorogenic acid content was also high in Staresso, Espresso, and Moka preparations, which is notable, as it also strengthens the bitter flavor in the drink. Similarly, it was observed that the Staresso method obtained the highest performance in extraction, and had the best overall impression rating. The preparation methods which varied most notably from the excelso U.G.Q. standard were Espresso, Moka, and Presso, which presented variations in the body, bitterness, and acidity components. It was found that tannin concentrations (see Fig. 4) were low and not significant for the cup profile, given that no taster indicated undesirable astringent notes in the coffee beverages evaluated.

4. Conclusions

The Espresso, followed by Moka and Staresso pressure filtration methods presented high compositions of antioxidants, among which total phenols, flavonoids, and condensed tannins are highlighted. Additionally, their antioxidant activity was significant with the ORAC method. Hydroxycinnamic acid content was high with use of the Staresso, Espresso, and Moka methods, in decreasing order. Similarly, the cup profile of all methods, excepting the Staresso method, presented intense notes of bitterness. The method with the highest overall impression rating was Staresso. Finally, it is recommended that coffee-based beverages be prepared using the Espresso, Moka, or Staresso methods, in order to guarantee consumption of the highest antioxidant compound content and reap their benefits. If the consumer prefers bitter, full-bodied beverages, coffee prepared with the Espresso or Moka methods is recommended. If not, that prepared with the Staresso method, which presented low bitterness ratings, together with a high overall impression and sensorial attributes similar to those of a U.G.Q. coffee, is recommended.

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