THE EFFECT OF GRAVITY-DRIP FILTRATION METHODS ON THE CHEMICAL AND SENSORIAL PROPERTIES OF COFFEE (*Coffea arabica L. var. Castillo*)

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ABSTRACT: Coffee prepared via gravity-drip filtration is an alternative to obtain varied sensorial profiles and determine the acidity, bitterness, and body thereof. In the present study, the retention of certain bioactive components was determined, as was the antioxidant activity and cup profiles for coffee beverages prepared by way of seven different gravity-drip filtration methods. The methods which registered the greatest bioactive metabolite retention were the Vietnamese, Clever, and RS 16 methods. The greatest hydroxycinnamic acid content was obtained with the Clever, Yama, Vietnamese, and V60 methods, in descending order. Antioxidant capacity was proportional to the retention of bioactive components, by way of ABTS and ORAC techniques, in the beverages prepared. The V60 and V60 Kalita methods retained the lowest amounts these compounds and their activity. The most predominant hydroxycinnamic acid in the seven evaluated preparations was chlorogenic acid. In accordance with consumer preferences, which seek functional food, it is recommended that coffee be consumed using the Clever or Vietnamese preparation methods, which present fuller body and enhanced bitter notes. In their absence, the RS 16 method is suggested, which presents a sensorial profile identical to that of the U.G.Q. pattern, with less intensity of bitterness.

Index terms: Coffee, barismo, antioxidants, drip, bitterness, preference.

O EFEITO DE MÉTODOS DE FILTRAÇÃO POR GOTEJAMENTO POR GRAVIDADE NAS PROPRIEDADES QUÍMICAS E SENSORIAIS DO CAFÉ (*Coffea arabica L. var. Castillo*)

RESUMO: O café preparado por filtração por gotejamento por gravidade é uma alternativa para obter perfis sensoriais variados e determinar a acidez, o amargor e o corpo dos mesmos. No presente estudo, a retenção de determinados componentes bioativos foi determinada, assim como a atividade antioxidante e os perfis de xícara para bebidas de café preparadas por meio de sete diferentes métodos de filtração por gotejamento por gravidade. Os métodos que registraram a maior retenção de metabólitos bioativos foram os métodos vietnamita, inteligente e RS 16. O maior teor de ácido hidroxicinâmico foi obtido pelos métodos Clever, Yama, Vietnamese e V60, em ordem decrescente. A capacidade antioxidante foi proporcional à retenção de componentes bioativos, por meio das técnicas ABTS e ORAC, nas bebidas preparadas. Os métodos V60 e V60 Kalita mantiveram as menores quantidades desses compostos e sua atividade. O ácido hidroxicinâmico mais predominante nas sete preparações avaliadas foi o ácido clorogênico. De acordo com as preferências dos consumidores, que buscam alimentos funcionais, recomenda-se que o café seja consumido usando os métodos de preparação Clever ou Vietnamita, que apresentam corpo mais cheio e notas amargas melhoradas. Na sua ausência, sugere-se o método RS 16, que apresenta um perfil sensorial idêntico ao da U.G.Q. padrão, com menos intensidade de amargura.

Termos para indexação: Café, barismo, antioxidantes, gotejamento, amargor, preferência.

1 INTRODUCTION

Coffee is among the most often sold stimulating beverages in the world, and is recognized and appreciated by adults for its sensorial attributes (LIANG et al., 2016). Coffee is one of the best-solidified agricultural chains in countries such as Brazil, Vietnam, Colombia, Indonesia, and Uganda, among others. Coffee processing lovers and connoisseurs have proven that a good cup depends on a variety of factors, which include climatic factors, operation variables applied in the milling, fermentation, and roasting processes, as well as aspects related to origin, variety, and coffee composition (FNCC, 2018; ARANGO, 1999).

Various studies have reported the functional aspects of certain coffee varieties, based on chemical analyses, and recommend their continuous consumption to exploit the health benefits thereof (AGUIAR et al., 2016; CANO-MARQUINA et al., 2013). Additionally, the simultaneous roasting process produces Maillard reactions and countless secondary products with antioxidant and free-radical-trapping properties, which are attributed principally to their proportion of phenolic components (LIU AND KITTS, 2011; MOREIRA et al., 2017).

Components with phenolic acid and tannin-type antioxidant activity contribute sensoriality and functionality to the coffee beverage. Tannins generate astringency, while polyphenols and

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hydroxycinnamic acids, such as chlorogenic acid and ferulic acid, add acidity and bitterness to the cup profile. They thus aid in the creation of the sensorial attributes characteristic of this traditional beverage (SUNARHARUM et al., 2014). It is important to highlight that ferulic acid participates in decarboxylation reactions during roasting, which spur the formation of phenolic compounds. As such, this component increases antioxidant proportions in coffee, and provides simultaneously bitter and acidic notes to the beverage (LEE et al., 2015).

New coffee preparations, together with the consolidation of barista culture, according to a novel potential coffee market, characterized by new techniques, ingenuity, empiricism, the application of basic chemical concepts, and motivation of coffee connoisseurs and lovers. Said preparations provide new sensorial profiles and varied antioxidant composition, in accordance with the preparation conditions applied, which lends added value to coffee drinks (ILLY, 2018).

Gravity-drip filtration methods are characterized by the involvement of the lixiviation process, which is performed by way of a filter. Said filter may be made of plastic (Rs 16), paper with various pore sizes (V60 and Clever), may be ceramic (V60 Kalita), or a perforated metallic surface (Kinto, Yama). When the drip occurs, both contact and extraction, time is prolonged (minutes). Cone (Clever, Kinto, Yama, V60 Kalita, and V60), vessel (Vietnamese, RS 16), or filtration unit size produce the beverage volume obtained. Similarly the presence of rough, smooth, or oblique surfaces yield different cup profiles. All gravity filtration methods that involve leaving the extract to drip are performed with water heated to 90 °C, which is designed to increase extraction process performance. The mass transference velocity during lixiviation may depend on paper filter pore diameter, or, if paper is not used, the size and number of orifices, and the filter material used. All described variables influence antioxidant concentration and antiradical ability, either positively or negatively, by way of antioxidant activity determination (LIANG AND KITTS, 2014).

The preparation method-sensorial profile-antioxidant metabolite composition relationship has neither been established nor used as an opportunity to offer coffee beverages with unique characteristics to the market, from the sensorial, chemical, or functional points of view. Previous investigations (SANTINI et al., 2011; ÇELIK AND GÖKMEN, 2018), have not considered preparation methods. Instead, only the most popular coffee beverages in coffee houses or homes have been studied. In the present investigation, the principle of preparation is correlated with antioxidant composition, together with beverage acceptance, by expert tasters.

The objective of the present studio is to evaluate the concentration of compounds with antioxidant activity, parallel to the development of a sensorial profile of excelso coffee (U.G.Q.) during coffee-based beverage preparation via seven gravity-drip filtration methods. The antioxidant components evaluated were: total phenols, 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

Raw materials

Parchment coffee (*Coffea arabica L. var. Castillo*) from the Anserma municipality, which is located in the Caldas department of Colombia, was utilized. The crop was located on the "San Rafael" farm, at 1,750 meters above sea level, at 20°C and 72% relative humidity, on average. Exactly 1,200 g of coffee was analyzed for the performance of the above-mentioned determinations, in triplicate.

Physicochemical analysis

The coffee was threshed (Quantik, CR-2000, Armenia, Colombia) and sifted (NTC 5248, 2013). For all analyses, the U.G.Q.-type excelso coffee which remained on the 14/64" netting was utilized. The pasilla coffee was removed, as were other beans with Group I and Group II defects. The moisture content of green coffee was determined on a stove, via gravimetry (Dies, TH115FM, Antioquia, Colombia). The coffee was roasted at 180 °C and 100 % power, in a laboratory roaster (Quantik, TC-150 A/R, Armenia, Colombia), until a medium roast was obtained. Samples were later ground (Grindmaster 810, Mexico), in accordance to the seven types of preparations selected for this study.

The size of the ground coffee particulate was verified with Taylor series sieves (NTC 2441, 2011). Beverage pH was evaluated with a digital potentiometric method (Lab-850; Schott Instruments®, Germany). Soluble solids were determined via refractometry (PAL-1, Atago®, Japan), and expressed as degrees Brix (°Brix). The weight of the ground coffee and that of the obtained beverage were ascertained with a precision scale (Fenix-Plus, Bogota, Colombia) for each preparation method. Extraction Performance (EP) was calculated for each beverage (Equation 1). Said refreshments were hermetically sealed in plastic polypropylene jars and stored at -40 °C for analysis.

$$RE = \frac{m_2}{m_1} \times {}^{\circ}Brix$$

Where m_1 is the weight, in grams, of the roasted, ground coffee, m_2 is the weight, in grams, of the total beverage obtained, and °Brix is the percentage, in soluble solids, of the drink.

Coffee refreshment preparation via pressure filtration methods

Seven coffee beverage gravity-drip filtration preparation methods, which place hot water between the roasted, ground coffee, were utilized in accordance to the procedure of each method evaluated. Below, the process observed for each method is described:

-Vietnamese: Coarsely-ground roasted coffee was employed. Hot water contact time, at 90 °C, was one minute. Exactly 14 g of coffee was mixed with 150 mL of water. The Vietnamese drip coffee maker, or phin, was made of stainless steel, and had a perforated base with a total of 80 orifices. The coffee was added directly to the recipient, as was hot water. The weight of the water caused the coffee to be infused and pass directly to the cup, with the help of gravity. The coffee maker was placed directly above the cup.

-Clever: Medium-ground roasted coffee was employed. This method consists of a cone made of thermoresistant plastic. The cone has a small orifice at the bottom. A paper filter was placed on top of the cone, and the coffee was placed therein. The cone has a shut-off valve, which retains the coffee until completion of contact time with hot water, approximately four minutes. The cone was placed on top of a coffee cup, the valve was opened, and the drip process began. When the cone has lifted from the edges of the cup the liquid flow stopped automatically. Exactly 14 g of roasted, ground coffee was put in contact with 150 mL of hot water.

-Kinto: Exactly 21 g of medium-ground coffee was used with 225 mL of hot water. The coffee was placed in the stainless Steel Kinto, with ultrafine pores, which was located on the tip of the cone. The water was then added on top of the coffee. The water-coffee contact time totaled four minutes. The cone was placed over the mouth of a glass jar, designed especially for this preparation method. Once the water passed through the filter, the content of the jar was emptied into a cup.

-Yama: This method consists of a stainless steel cone, with numerous orifices placed on a glass support. Hot water was added on top of the weighed coffee, until it finished filtering into a glass recipient. The coffee-water contact time totaled one minute. Exactly 21 g of fine-ground coffee was put in contact with 225 mL of 90 °C water.

-RS 16: Exactly 18 g of medium-ground coffee was added to 250 mL of water, with a contact time of five minutes, by way of a filtration system which consists of 48 small orifices, distributed uniformly in the lower part of the glass cup, which permit the drip discharge of the beverage. The coffee was placed in the cup, on top of the coffee cup. Hot water was added on top of the coffee, and extraction began immediately. The beverage was deposited into the cup ready to be consumed. With this method, paper filters were not employed.

-V60 Kalita: Medium-ground roasted coffee was utilized. Contact time with the 90 °C water was four minutes. Exactly 44 g of coffee was mixed with 150 mL of water. The Kalita paper filter was placed inside the porcelain cone. The interior of the cone has three small orifices distributed triangularly. The ripples on the V60 Kalita cone are horizontal.

-V60: Exactly 14 g of medium-ground coffee was added to 150 mL of hot water. A V60 paper filter (Hario brand) was placed on the methacrylate cone, which provided oblique ripples that formed a 60° angle. The coffee was added on the paper, as was hot water. The water-coffee contact time was four minutes. The beverage was deposited directly into the cup, and the extraction continued until the water stopped passing through the paper filter in the cone. The cone had a single orifice at the bottom.

Figure 1 shows the gravity-drip filtration methods evaluated in the present study.

Coffee beverage cup profile analysis

The beverages obtained via the gravity-drip filtration methods were tasted, using the Q.D.A. (Quantitative Descriptive Analysis) flavor profile. One evaluation was provided per taster (three expert tasters), and these were averaged. The pattern used for sensory analysis was an U.G.Q.-type excelso coffee (Figure 6- Red Lines).

FIGURE 1 - Gravity-drip filtration coffee preparation methods a) Vietnamese, b) Clever, c) Kinto, d) Yama, e) RS 16, f) V60 Kalita, and g) V60. Source: Author elaboration.

The attributes evaluated for each drink were as follows: fragrance, aroma, acidity, bitterness, body, and overall impression. Additionally, in the sensorial evaluation, other descriptors were considered for the description of beverage defects, such as acridity, vinegar, fermentation, and astringency, among others. The results of the Q.D.A. test are presented in radial charts below (NTC 3566, 2011).

Sample preparation

The beverages prepared with the seven methods studied were diluted with distilled water to fixed concentrations, so as to perform the antioxidant metabolite and antioxidant activity determinations (ROJANO et al., 2015).

Total phenol determination

By way of the Follin-Ciocalteu method, total phenols were evaluated (ZAPATA et al., 2013). A curved pattern was created, using gallic acid as a standard. The results were expressed as mg of gallic acid/100 g sample. Readings were performed in triplicate, at a wavelength of 760 nm. A UV-VIS (Jenway, 6405, Essex, England) spectrophotometer was employed. The Follin-Ciocalteu reactant and gallic acid were acquired from the Merck trading house (Germany).

Condensed tannins

Exactly 230 μL of sample extract was taken from each coffee beverage, and 670 μL of a recently-prepared vanillin solution (1 g/100 ml) in 70% sulfuric acid was added. The mixture was incubated for 15 minutes at 20°C. Each reading was performed at 500 nm, and was compared to the curve pattern, using (+)-catechin as standard. Condensed tannin content was expressed in mg of catechin equivalent/100 g sample (ZAPATA et al., 2013).

Hydroxycinnamic phenolic acid content

The samples were filtered (0.45 mm pore size) with supra-pura water dilutions. The chromatographic conditions were: mobile phase acetonitrile/acidified water (phosphoric acid pH = 2.5), (400:600 v/v). Phenolic compounds were analyzed under the following conditions: flow of 1 mL/min, at 25 °C, and in isochratic conditions. The visible UV spectrum was transversed from 200 to 600 nm for all peaks. The identification and quantification of chlorogenic, caffeic acid, p-coumaric acid, and ferulic acid was performed by way of the standard external method in the samples studied. Readings were made in triplicate (NARANJO et al., 2011).

Determination of ABTS antioxidant activity

Exactly 100 µL of extract from the samples prepared with the different methods, and 900 µL of ABTS radical solution was used. Each reading was performed at a wavelength of 734 nm. Samples were left idle for 60 minutes, at room temperature, and in the dark. Changes in absorbency (A) were evaluated, with respect to the reference of the reactant corresponding to an ABTS radical solution with the sample solvent. The absorbency value was compared to the Trolox pattern reference curve. For both compounds, the inhibitory concentration of 50 % (IC50), shown in Equation 2, and the results expressed as TEAC m values (µmol Trolox / 100 g sample), were determined (ZAPATA et al., 2013).

$$\text{Percentage inhibition} = \left[1 - \left(\frac{A_{sample} - A_{blank\ sample}}{A_{reference} - A_{blank\ reference}}\right)\right] x\ 100$$

Oxygen Radical Absorption Capacity (ORAC) evaluation

As a standard, 6-hidroxi-2, 5, 6, 7-tetrametilchrome-2- carboxylic acid, or Trolox (Merck, Germany) was used in controlled conditions: at 37 °C and 7.4 pH. Determinations were made at an excitation wavelength (l) of 493 nm and with an excitation opening of five, emission l of 515 nm, and emission opening of 13, with an attenuator of 1% and without an attenuator plate. Fluorescein solutions of 1x10^{-2} M were used, mixed with a Phosphate Buffer Solution (PBS) (75 mM), 2.2'-Azinobis (2-amidinopropane) dichlorhydrate (AAPH), 0.6 M in PBS (75 mM). Samples were prepared with 21 µL of fluorescein, 2,899 µL of PBS, 30 µL of tested extract, and 50 µL of AAPH. The antioxidant protector effect was calculated by way of the differences in areas below the fluorescein decline curve, between the target and the sample, and was compared to the Trolox calibration curve. Results were expressed as µmol Trolox / 100 g sample or TEAC m (Equation 3) (Zapata et al., 2013). Said results were expressed as the average of three replicas. Samples were evaluated with a spectrofluorimeter (Perkin-Elmer LS-55, Beaconstield, UK). The AAPH, sodium aluminum phosphate, PBS, and fluorescein, were obtained from the Aldrich Chem. Co. trading house (Milwaukee, WI, USA).

$$\text{ORAC} = \frac{\text{AUC}_{\text{sample}} - \text{AUC}_{\text{control}}}{\text{AUC}_{\text{trolox}} - \text{AUC}_{\text{control}}} . \text{f} . [\text{trolox}]$$

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

Statistical analysis

All determinations were made in triplicate. Results were expressed as averages and standard deviations (±). A variance analysis (ANOVA) was performed, in order to establish statistical differences, and a Least Significant Difference (LSD) test for I, with a value of $p<0.05$, at a 95% significance level, was carried out, so as to compare the averages of each of the variables analyzed: antioxidant compound content, hydroxycinnamic phenolic acid, and the antioxidant capacity of the coffee beverages prepared with gravity-drip filtration methods. Parametric statistics was used in sensory analysis data (the normality test was accepted). The STATGRAPHICS Centurion XV statistical package was employed for this purpose.

3 RESULTS AND DISCUSSION

Initially, work was performed with uniform humidity among the group of samples evaluated, so as to guarantee that results would be comparable. The initial humidity content of green coffee was fixed at 12 %. In the present study, obtention of the same degree of thermic degradation was of great importance, as the same roasting conditions were applied to all samples prior to antioxidant concentration and antioxidant capacity evaluations (NARANJO et al., 2011).

Additionally, the same roasting conditions were used for all analyzed samples. The analysis of certain physicochemical parameters of the coffee drinks is shown in Table 1.

Beverage performance was highest with the Clever method, followed by the Vietnamese and RS 16 methods. The Clever method had a high performance owing to the perpendicular configuration of its cone, as well as the rapid liquid discharge, on completion of contact time.

TABLE 1 - Physicochemical parameters of coffee drinks prepared with various gravity-drip filtration methods.

Method	Beverage performance	°Brix	pH	Contact time
Vietnamese	10.96(±0.02)a	1.21(±0.03)a	4.91(±0.02)a	1 min.
Clever	15.07(±0.01)b	1.94(±0.02)b	5.13(±0.01)b	4 min.
Kinto	8.75(±0.03)c	1.07(±0.01)c	4.88(±0.03)c	4 min.
Yama	8.41(±0.01)d	1.00(±0.02)d	4.92(±0.02)a	1 min.
RS 16	9.73(±0.02)e	1.13(±0.03)e	4.81(±0.02)d	5 min.
V60 Kalita	2.74(±0.02)f	1.02(±0.02)f	5.04(±0.02)e	4 min.
V60	8.02(±0.02)g	1.00(±0.02)d	4.92(±0.02)a	4 min.

Average values (n=3) with different letters in the same column indicate statistical differences at the 5% significance level ($p>0.05$).

The discharge system efficiently mixed the water and coffee, and facilitated the extraction of soluble and insoluble solids in the drink obtained. The method which presented the lowest coffee beverage performance was the V60 Kalita, as the paper filter pore size did not achieve efficient extraction, as compared to the other methods. The ANOVA indicated a significant difference between the preparation method applied and performance obtained ($p<0.05$).

Soluble solids presented higher values in the preparations performed with the Clever method, followed by that of the Vietnamese and RS 16 methods. These results show a direct relationship between the performance of the drink obtained and each gravity-drip filtration method evaluated. The methods with the highest soluble solid concentrations and with low water-coffee relationships were the Clever and Vietnamese methods. These results indicate that the preparation method influenced the dilution of sugars, organic acids, salts, and other water-soluble compounds. Statistical analysis showed a significant effect of the preparation method on soluble solid beverage concentrations ($p>0.05$).

Drink pH, prepared with the Clever method, was higher than the other beverages. The Vietnamese, Yama, and V60 methods presented similar pH values. No method presented mixture shaking. The pH value is related to organic acid concentration in the coffee. Variance analysis did not indicate a significant difference ($p>0.05$) between the pH of the drinks and the preparation method, with the Vietnamese, Yama, and V60 methods, in contrast to the remaining methods. The substances which affect acidity and pH in coffee-based beverages are: formic acid, citric acid, acetic acid, trigonelline, chlorogenic acids, and caffeine. Additionally, together, they contribute to the development of flavor, combined with specific roasting conditions and different coffee-preparation techniques (DE LUCA et al., 2016; NGUYEN AND BYUN, 2013).

Total phenol concentration was greater with the Clever, RS 16, Vietnamese, and Kinto methods, in that order, with values of 1,991.4, 1,862.4, 1,425.9, and 1,240.6 mg of gallic acid/100 g sample, respectively (Figure 2). The lowest phenol content was obtained with the V60 and V60 Kalita methods, in descending order. The preparation method had a significant effect ($p>0.05$) on total phenol retention. The preparation methods with the lowest performances were V60 and V60 Kalita, which registered the lowest concentrations of total phenols, possibly owing to the effect of dilution in these preparation methods.

When comparing different qualities of Colombian coffee, it has been determined that excelso coffee (U.G.Q.) contains higher concentrations of phenolic acids, which are responsible for its important antioxidant activity (NARANJO et al., 2011). Roasting frees caffeine from the bean, owing to the thermic phenol degradation effect, which makes way for increases in sensorial attributes, such as bitterness and body, in the beverage obtained (CHENG et al., 2016; SWAK et al., 2017). Further, phenolic components promote the synthesis of products secondary to the Maillard reaction, due to high roasting temperatures (MOREIRA et al., 2017**.** Said products include melanoidins, which have antioxidant effects and provide color, aroma, and flavor to the beverage (LEE et al., 2017).

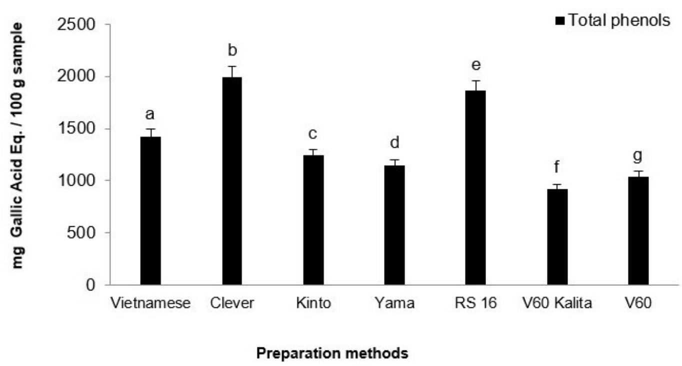

FIGURE 2 - Total phenol concentration with gravity-drip coffee filtration methods. Average values (n=3) with different letters in the same variable indicate statistical differences at the 5% significance level (p>0.05).

Phenolic compounds are sensitive to pH changes, participate in transesterification reactions, and influence the caffeine and chlorogenic and caffeic acid concentration in the obtained drinks (HEČIMOVIĆ et al., 2011). Said pH variations depend on the coffee-water ratio used in beverage preparation. Phenolic compounds regulate exudative stress and protect the body from cardiovascular illness and diabetes. Additionally, their antiallergenic, anti-inflammatory, and antimicrobial properties have been proven in multiple clinical studies (MUSSATTO, 2015).

As related to tannin retention in the beverages prepared with different gravity-drip coffee filtration methods (Figure 3), said concentration was highest with the Vietnamese method, followed by that of RS 16, Clever, and Kinto, in the amounts of 146.1, 120.5, 119.4, and 82.3 mg, respectively, expressed as mg of catechin eq./100 g of sample. The RS 16 and Clever methods presented similar tannin content. The V60 and V60 Kalita methods registered the lowest tannin content. Statistical analysis indicated a significant difference (p>0.05) in condensed tannin concentration by beverage preparation method.

Tannins are chemical components with important nutritional value. On a sensorial level, they are related to perceived astringency in coffee-based beverages (CAETANO et al., 2017). In terms of the condensed tannin content results found in the present study, said concentration is at an optimal interval, given that, in the cup test, no taster registered undesirable flavors or cup defects related to this descriptor. Additionally, various preparations presented ratings similar to those of excelso. Tannins help to prevent hemorrhages and inflammatory processes in the body. They also help to prevent premature aging and degenerative disease (ZAPATA et al., 2013). Tannins are characterized by providing an undesirable tactile sensation in coffee, which generates dryness, puckers and constricts the mucous membranes in the mouth cavity. They influence the sensation of bitterness, owing to the degree of polymerization of condensed tannin molecules. Further, they act synergistically with proteins present in saliva to present an astringent sensation, which is a combination between dryness and bitterness, when foods with these contents are consumed (PONCET-LEGRAND et al., 2010; CHIRA AND TEISSEDRE, 2014; WATRELOTA et al., 2018).

In Figure 4, the hydroxycinnamic acid content in the drinks prepared with the seven gravity-drip filtration methods may be observed. Chlorogenic acid content was highest with the Clever method, followed by the Yama, Vietnamese, and V60 methods. Chlorogenic acid was the predominant compound in the evaluated methods. Caffeic acid content was identified only with the V60 Kalita method. In the other methods evaluated, this compound was not identified. P-coumaric acid content was highest with the Clever, Yama, and V60 methods. Ferulic acid concentration was highest with the Clever, Yama, and V60 methods, and low content was found with the RS 16 and Kinto methods, in descending order. Only the V60 Kalita method contained the four hydroxycinnamic acids evaluated. The RS 16 and Kinto methods presented the lowest concentrations of all acids evaluated. The ANOVA indicated a significant effect (p>0.05) of the preparation method on hydroxycinnamic acid concentration in the drink.

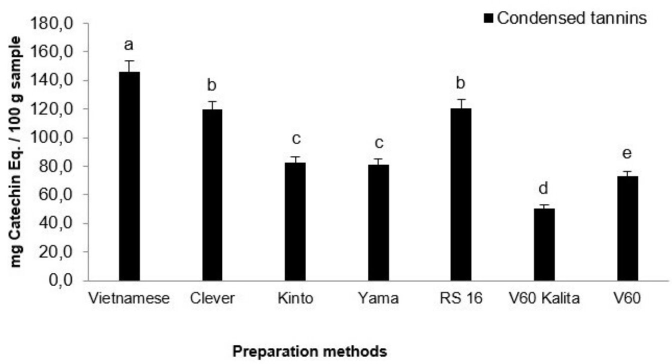

FIGURE 3 - Condensed tannin concentration in gravity-drip coffee filtration methods. Average values (n=3) with different letters in the same variable indicate statistical differences at the 5% significance level (p>0.05).

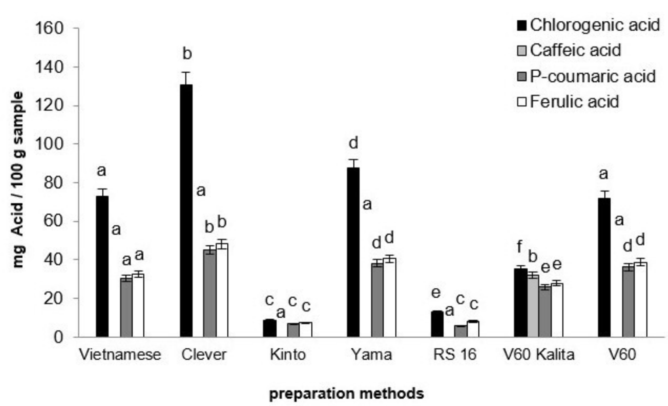

FIGURE 4 - Hydroxycinnamic phenolic acids in beverages prepared with gravity-drip filtration methods. Average values (n=3) with different letters in the same variable indicate statistical differences at the 5% significance level (p>0.05).

Hydroxycinnamic acids not only influence antioxidant activity in coffee, but also contribute to the beverage's perceived sensorial quality. Phenolic compounds are generated during the coffee roasting process, due to breakage and transformation of chlorogenic acids (ROSS et al., 2011). In the cup test, chlorogenic acids influenced drink astringency, bitterness, and acidity (CHENG et al., 2016), in the same way as flavonoids and caffeine. In accordance with the results of the present study, the hydroxycinnamic acid present in the majority of *Coffea arabica* samples was chlorogenic acid, while caffeic and coumaric acid presented the lowest concentrations (CHEONG et al., 2013).

The antioxidant capacity values obtained with the ABTS and ORAC methods were statistically different (p>0.05) (Figure 5). ABTS activity values, in descending order, were registered for the RS 16, Clever, Yama, Vietnamese, Kinto, V60 and V60 Kalita methods. With the ORAC method, antioxidant capacities were obtained, in descending order, for the RS 16, Clever, Vietnamese, Kinto, V60, Yama, and V60 Kalita methods. The antioxidant capacity determined with the ORAC method presented a direct relationship with the concentration of the different types of antioxidant metabolites evaluated in the prepared beverages, in contrast to ABTS method results. This indicates a positive correlation in the expression of antioxidant content in coffee beverages ready for consumption. Applications with V60 and V60 Kalita showed the lowest antioxidant capacity registered in the two methodologies evaluated. In both methodologies evaluated to determine antioxidant activity in the drinks, the RS 16, Clever, and Vietnamese methods presented the most activity, as well as high antioxidant concentrations, although not in a strict order. Thus, antioxidant activity is more relevant to antioxidant metabolite content in these beverages.

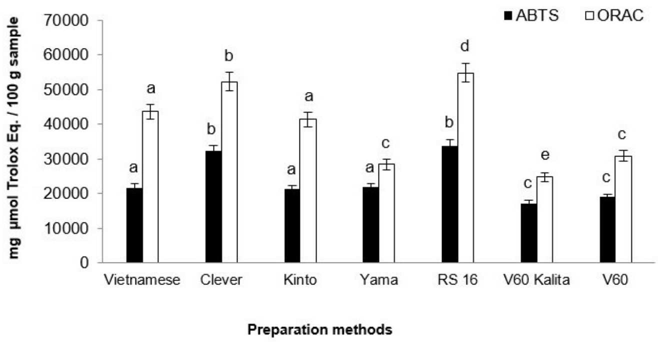

FIGURE 5 - Antioxidant capacity with the ABTS and ORAC methods in beverages prepared with gravity-drip filtration methods. Average values (n=3) with different letters in the same variable indicate statistical differences at the 5% significance level (p>0.05).

The roasting process elevates antioxidant activity in coffee, as a consequence of the chemical substances generated in the Maillard reaction, such as melanoidins (VIGNOLI et al., 2011). Certain studies conclude that there is a direct relationship between characterized non-enzymatic scalding (Maillard reactions) and the antioxidant capacity of coffee (CONTRERAS-CALDERÓN et al., 2016), where the processing conditions, such as temperature, pH, and the presence of depleted sugars and amino acids are determinants for the finalization of these chemical transformations. Various studies have indicated that chemical substances, such as hydroxycinnamic acids (chlorogenic, caffeic, coumaric, and ferulic) and melanoidins in coffee, directly influence the beverage's antioxidant activity (VIGNOLI et al., 2011; HEČIMOVIĆ et al., 2011). Antioxidant activity and the concentration of these metabolites depend on factors such as the degree of coffee milling, the coffee/water ratio, temperature, and extraction time involved with the method used in beverage preparation (NISETEO et al., 2012). ABTS antioxidant activity measured in coffees filters with *C. arabica* coffee presented values similar to those reported in the present study (LUDWIG et al., 2014; JESZKA-SKOWRON et al., 2016). Another, which compared a coffee filtered with other traditional preparations (Napolitano, Mocha, and Expresso), in terms of phenolic compounds and ABTS activity concentration, found a lower concentration, and the lowest antioxidant activity in filtered coffee, owing to parameters such as temperature and pressure, which promote greater performance in extraction in methods such as Mocha, Napolitano, and Expresso (Caporaso et al., 2014). When comparing the tocopherol content in different coffee preparations, it was found that the lower the concentration of this compound, which also exhibits antioxidant activity, the lower its concentration in filtered coffee, compared to other coffee preparations, such as the Turkish, Mocha, Expresso, and boiled methods, in descending order, as this antioxidant metabolite is retained in the filter, which prevents its passage into the beverage prepared (ALVES et al., 2010).

The ratings assigned to the beverages prepared with the seven different gravity-drip filtration methods generally presented different profiles, with respect to the U.G.Q. pattern (Figure 6). This indicates that the preparation method applied influences the cup profile of an excelso coffee (U.G.Q.). Statistical analysis indicated significant differences (p>0.05) between coffee preparation methods and the sensorial cup profile obtained. The coffee drinks with sensorial ratings identical to the U.G.Q. pattern were prepared with the Kinto, Yama, and RS 16 methods.

The Vietnamese method presented low acidity, and developed full body, compared to the other beverages prepared and the sample pattern. The remaining attributes were the same as the U.G.Q. pattern. The beverage prepared with the Clever method presented marked bitter notes, body slightly fuller than that of the pattern, and its overall impression rating was higher than that of the pattern and the other drinks evaluated. In other words, it was more widely accepted. The other attributes of the Clever method were the same as those of the reference pattern. The beverage obtained with the V60 Kalita method only presented acidic notes superior to the reference pattern and the other beverages evaluated.

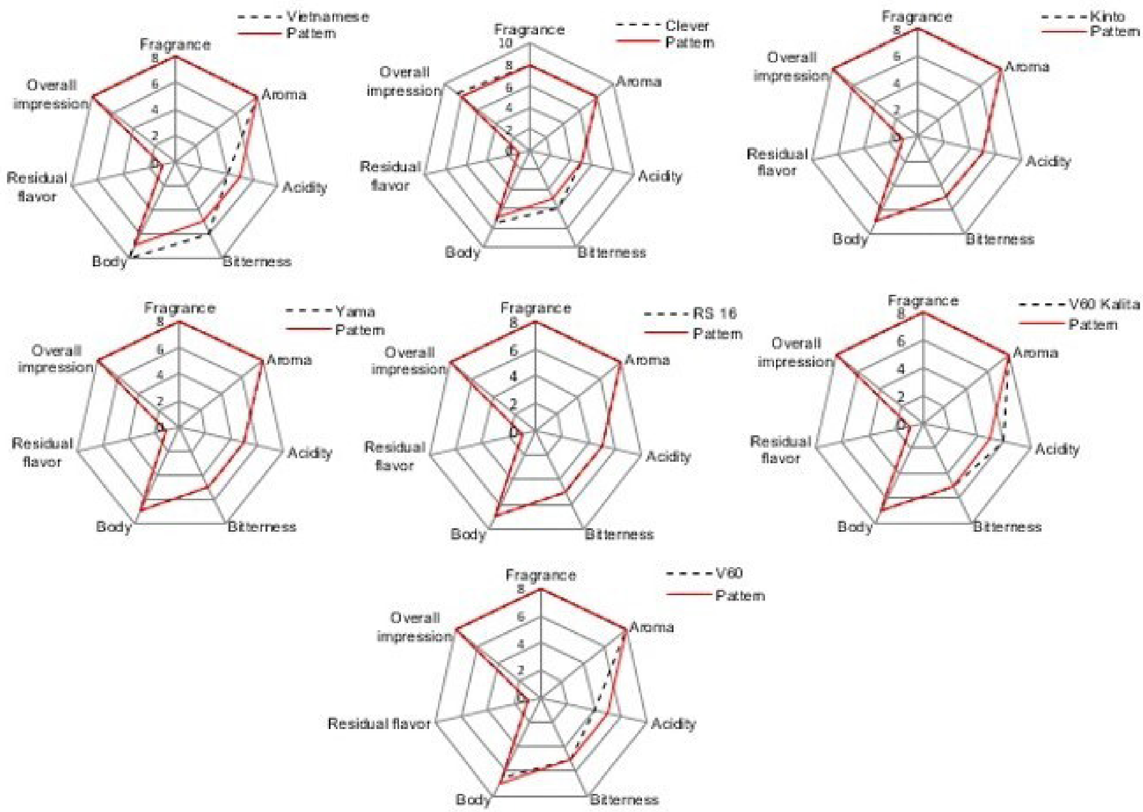

FIGURE 6 - Sensorial profile of beverages prepared with gravity-drip filtration, compared to the U.G.Q. pattern. Average values (n=3).

The coffee obtained with the V60 method presented low acidity and body compared to the U.G.Q. pattern, although the other attributes were identical to those in the reference sample. Finally, it was observed that beverages with body equal to or fuller than that of the excelso pattern presented antioxidant activity and elevated retention of these metabolites, in the group of samples evaluated.

Of the group of samples evaluated, those which obtained the highest ratings in the bitterness attribute were the Vietnamese and Clever methods. The Clever and Vietnamese methods also registered high concentrations of total phenols and flavonoids, substances which are responsible for lending bitter notes to coffee beverages. In the case of the RS 16 method, which presented high total phenol and flavonoid retention, there was no increase in the bitterness attribute, as its sensorial profile was exactly that of the excelso pattern. It presented a low chlorogenic acid concentration, as well as low concentrations of the other hydroxycinnamic acids (Figure 4). Chlorogenic acid content was also high in the Vietnamese and Clever methods. This acid also tends to strengthen the bitter flavor of the cup. Similarly, it was observed that the Clever method, which had the highest extraction performance, also obtained the highest overall impression rating. The preparation methods which showed the largest departures from the U.G.Q. pattern were the Vietnamese, Clever, and V60 methods. These presented variations in body, bitterness, and acidity attributes. In terms of the tannin concentrations indicated in Figure 2, said concentrations were low and minimally significant for the cup profile, as no taster indicated undesirable astringent notes in the coffee drinks evaluated.

4 CONCLUSIONS

The Vietnamese, Clever, and RS 16 gravity-drip filtration methods of coffee preparation presented high antioxidant compound content, which included total phenols, flavonoids, and condensed tannins. Additionally, their antioxidant activity was significant when the ABTS and ORAC methods were applied. Hydroxycinnamic acid content was highest with the Clever, Yama, Vietnamese, and V60 methods, in descending order. Similarly, the cup profile for all methods, except the Vietnamese and Clever methods, presented marked bitter notes. The method which yielded the highest rating in overall impression was Clever. Finally, coffee-based beverage preparation is recommended with the Vietnamese, Clever, and RS 16 methods, in order to guarantee consumption of the highest antioxidant content and their expression, referred to as antioxidant activity. If the consumer prefers bitter beverages, Clever and Vietnamese methods of preparation are recommended. In the opposite case, consumption of coffee prepared with the RS 16 method, which presented a sensorial profile exactly equal to the U.G.Q. pattern is recommended.

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