

Influence of filter holder materials on the physicochemical and antioxidant characteristics of coffee beverages

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ABSTRACT

Coffee is one of the most consumed beverages in the world, and this study aimed to evaluate the influence of different manufacturing materials of Koar[®] filter holders (acrylic, stainless steel, ceramic, and porcelain) on the physicochemical characteristics and antioxidant activity of coffee beverages. The results showed that despite having similar design features (such as outlet diameter, grooves, and angle), the material of each Koar filter significantly affected the extraction dynamics of coffee components, resulting in beverages with distinct physicochemical compositions and antioxidant activities. Through multivariate statistical analysis, similarities were identified between the filter materials and the parameters evaluated. In general, coffee extracts obtained from acrylic and ceramic filters exhibited higher values of total phenolics, ABTS antioxidant capacity, reducing sugars, total soluble solids, and extraction percentage. In addition, coffee drinks from stainless steel and porcelain filters presented higher values of total titratable acidity, electrical conductivity, DPPH antioxidant capacity, and caffeine content. Understanding the effects of different filter materials on coffee extraction can contribute to optimizing brewing methods and enhancing consumer satisfaction. These findings highlight the importance of careful selection of filter holder material to ensure different sensory profiles of coffee beverages, providing valuable information for the industry and coffee enthusiasts.

Key words: Beverage quality; coffee brewing; extraction dynamics; Koar[®].

1 INTRODUCTION

Coffee is one of the most appreciated beverages worldwide, known for its complex and distinctive characteristics in terms of both chemical and sensory components (Haile; Kang, 2019). The preparation of coffee varies considerably, influenced by social, cultural, individual preferences, and even economic factors. This variety of extraction methods makes coffee a highly versatile beverage, capable of satisfying the most discerning palates.

The extraction of the beverage from roasted and ground coffee is a solid-liquid type process, in which various variables can influence the extraction kinetics, involving the absorption of water by the ground coffee and the transfer of soluble solids to hot or cold water (Angeloni et al., 2019; Córdoba et al., 2020). The choice of extraction method, along with factors such as time, temperature, and coffee-to-water ratio, plays a fundamental role in determining the sensory characteristics of the cup of coffee (Córdoba et al., 2020), as well as affecting its chemical composition, physicochemical properties (Zapata; Arango; Rojano, 2019a), and content of bioactive compounds (Olechno et al., 2020).

With the aim of providing new sensory experiences to coffee enthusiasts, the industry has developed innovative equipment for the extraction process. A notable example is the Koar[®] filter holder, developed in 2017 by Koar Café do Brasil (Recife, Pernambuco, Brazil), which uses the percolation

principle in the solid-liquid extraction process. With a conical design, oblique grooves, and a 16 mm opening for beverage flow during extraction (Koar, 2023), the Koar[®] filter holder seeks to enhance specific sensory attributes in the beverage.

It is known that the main sensory attributes present in coffee (body, sweetness and acidity) can be correlated with chemical and physicochemical parameters, the body of the drink is fundamental in sensory perception, being correlated with the content of total soluble solids (Gloess et al., 2013) and with the content of lipids and polysaccharides that contribute to the texture (body and aftertaste) (Córdoba et al., 2020). As for the sweetness present in coffee, this is generally related to the sugar levels in the coffee (Lingle; Menon, 2017). In turn, perceptible acidity is an important characteristic of specialty coffee, coming from citric, malic and tartaric acids, among other organic acids present in the drink (Batali et al., 2021), which are considered precursors of aroma and flavor, essential attributes for describing coffee quality.

Several studies (Angeloni et al., 2019; Gloess et al., 2013; Olechno et al., 2020; Zapata et al., 2019a; Zapata et al., 2019b) have already been conducted to examine changes in the physicochemical, chemical, and antioxidant properties of coffee beverages when using different filter holders and coffee extraction equipment. However, there is a scarcity of works related to the influences of filter holder materials. Thus, this study aims to evaluate the influence of different manufacturing materials of Koar[®] filter holders (acrylic, stainless steel,

ceramic, and porcelain) on the physicochemical characteristics and antioxidant activity of coffee beverages.

2 MATERIAL AND METHODS

2.1 Sample Preparation

The coffee was classified as specialty (80 points according to the Specialty Coffee Association protocol) and was solely of the Arabica species (*Coffea arabica*), Catuaí Amarelo variety, grown at an altitude of 900 meters in the city of Barra do Choça, Bahia (40° 34' 44" W). The coffee samples used in this experiment were donated by the Selen Café company (Recife, Pernambuco, Brazil).

The coffee beverages were prepared through filtration using filter holders made of different materials, including acrylic, stainless steel, ceramic, and porcelain (Figure 1). The paper filters (Koar No. 02) used are made from crepe paper with 100% cellulose fiber, without micro-holes and in a conical shape, specifically for the Koar® filter holders, and like the filter holders, these were also supplied by the company Koar Café do Brasil (Recife, Pernambuco, Brazil).

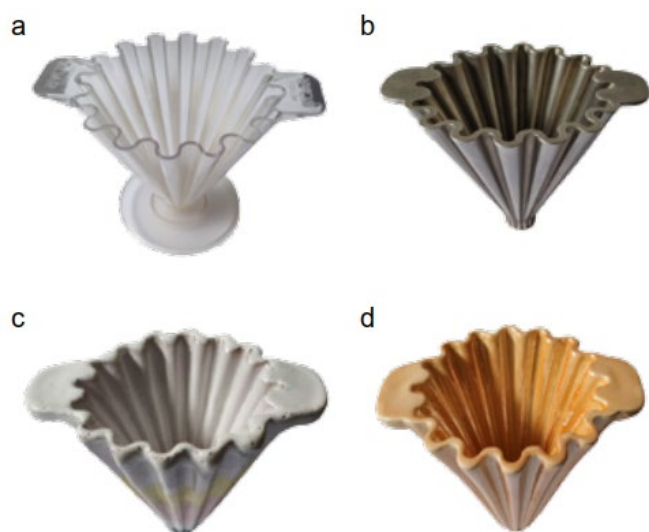


Figure 1: Koar® Percolation Filter Holders: (a) Acrylic; (b) Stainless Steel; (c) Ceramic; (d) Porcelain.

For the preparation of coffee beverages, the methodology described by Angeloni et al. (2019) was applied with some adaptations by Santos et al. (2024). The coffee beans were ground using a manual grinder with conical blades (Timemore Coffee/Chestnut C2, Shanghai, China) to a medium-fine particle size (0.5 mm, 32 mesh). A ratio of 63.63 g of coffee to 1000 mL of potable water at a temperature of 92.05 ± 0.05 °C was used, maintaining the total extraction time at 3 minutes. These extraction conditions were kept constant for the preparation of beverages using all versions of the Koar® filter holders.

During the extraction process, the temperature was continuously monitored using a digital thermometer (MYLABOR/TE07, São Paulo, Brazil) attached inside the filter holder, with measurements taken every 10 seconds up to 180 seconds.

2.2 Physicochemical Analysis

After the beverage extraction process, the coffee had a final temperature of between 80.0 and 83.0 °C, and the physicochemical analyses were carried out immediately after the samples reached a temperature of 24.5 and 26.5 °C, following the methodologies described by the Instituto Adolf Lutz (2008): Total Acidity (mL of NaOH); pH: direct reading on a digital pH meter (Marconi/PA-200, Piracicaba, Brazil); Electrical Conductivity ($\mu\text{S}/\text{cm}$): direct reading on a conductivity meter (Avla Científica/AC-200, Uberaba, Brazil); Total Soluble Solids (°Brix): measured with a digital refractometer (Megabrix/Redi-P101, São Paulo, Brazil); Aqueous Extract (%): the beverage was evaporated in porcelain crucibles in a water bath until the extract was obtained, and finally, the samples were heated in an oven at 105 °C until the weight stabilized.

The extraction percentage was calculated based on the methodology described by Santanatoglia et al. (2024). The total reducing sugars content was determined using the DNS method (3,5-dinitrosalicylic acid) described by Miller (1959). Absorbance readings were taken on a UV-VIS spectrophotometer (Bel/Wuv-M51, São Paulo, Brazil) at 540 nm, with values expressed as a percentage (%), based on a calibration curve conducted with glucose concentrations ranging from 0.1 to 1.0 g/L.

The quantification of caffeine was performed through the selective carbonization of organic matter present in the samples after the addition of sulfuric acid, followed by the extraction of caffeine using chloroform as a solvent. Absorbance readings were taken at 276 nm on a UV-VIS spectrophotometer (Bel/Wuv-M51, São Paulo, Brazil), with the caffeine content expressed as a percentage (%), following the methodology of the Instituto Adolf Lutz (2008). This was based on a calibration curve conducted with caffeine concentrations ranging from 0.6 to 2.0 g/L.

2.3 Determination Of Antioxidant Activity

2.3.1 Total Phenolics

For the determination of total phenolic content, the methodology described by Singleton and Rossi (1965) with adaptations was employed. A mixture containing 1 mL of the Folin-Ciocalteu reagent and 0.2 mL of the sample was prepared. After 1 minute, 0.8 mL of Sodium Carbonate solution (75.0 g/L) was added, and the sample was homogenized. After 2 hours, in a light-protected environment, absorbance was

measured using a UV-VIS spectrophotometer (Biochrom/Libra-522, Cambridge, United Kingdom) at 765 nm. The total phenolic content was expressed in terms of gallic acid equivalent (GAE) mg/100 mL of the sample, based on a calibration curve established with gallic acid solutions at concentrations ranging from 0.1 to 25 mg/100 mL.

2.4 ABTS+

The antioxidant activity involving the scavenging of the ABTS⁺ radical cation was determined according to the methodology proposed by Brand-Williams, Cuvelier and Berset (1995) e Mizuta et al. (2020). The ABTS⁺ solution was adjusted to an absorbance between 0.700 and 0.800 at 734 nm using a UV-VIS spectrophotometer (Biochrom/Libra-522, Cambridge, United Kingdom), through dilution. Fifty microliters (50 µL) of the coffee beverages were mixed with 1 mL of the diluted ABTS solution. The reaction mixture was incubated for 6 minutes in a light-protected environment, and the absorbance was measured at 734 nm. The ABTS radical scavenging activity was expressed in TEAC (Trolox equivalent antioxidant activity) (µmol TEAC/100 mL of sample), based on a calibration curve created with concentrations of Trolox solution ranging from 50.0 to 1000 µM.

2.5 DPPH

The antioxidant activity through the scavenging of the DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical was conducted following the methodology proposed by Dutra et al. (2019) and Mizuta et al. (2020). 0.1 mL of the coffee beverage (diluted at a ratio of 1:50) was added to 3.9 mL of 60 µM DPPH solution. After 30 minutes in darkness, absorbance was read at 515 nm using a UV-VIS spectrophotometer (Biochrom - Libra 522, Cambridge, United Kingdom). The results were expressed in TEAC (Trolox equivalent antioxidant activity) (µmol TEAC/100 mL of sample), based on a calibration curve created with concentrations of Trolox solution ranging from 50.0 to 1000 µM ($R^2 = 0.9913$).

2.6 Statistical Data Analysis

Physicochemical and antioxidant activity analyses were performed in triplicate. The data were subjected to Analysis of Variance (ANOVA), considering statistically significant differences when $p < 0.05$, and means were compared using Tukey's Test at a 5% probability level. Physicochemical and antioxidant activity data were also subjected to multivariate statistical analyses using Principal Component Analysis (PCA) and Hierarchical Agglomerative Clustering (HAC). HAC utilized the average Euclidean dissimilarity measure and Ward's hierarchical method (1963). The number of groups in the dendrogram was determined by the Mojena method (1977). Statistical analyses were conducted using R software (version 4.3.1) and Rstudio (version 2023.06.2+561).

3 RESULTS

The total acidity (TA) values found in the coffee beverages ranged from 0.70 ± 0.14 to 1.41 ± 0.01 mL of NaOH (Table 1). Filter holders made of materials with low thermal conductivity, such as Acrylic ($0.17 \text{ W/m}^2 \text{ }^\circ\text{C}$), Ceramic ($0.40 \text{ W/m}^2 \text{ }^\circ\text{C}$), and Porcelain ($0.80 \text{ W/m}^2 \text{ }^\circ\text{C}$), took longer to elevate temperatures at the beginning of extraction, except for the Stainless Steel filter holder ($80.3 \text{ W/m}^2 \text{ }^\circ\text{C}$), made of a material with high thermal conductivity (Figure 2). However, after 10 seconds, the Acrylic filter holder showed the highest temperature increase in the system. Despite being a material with low thermal conductivity, the Acrylic filter holder used in our study had a much thinner wall (2.12 mm) compared to the Ceramic filter holder with a thicker wall (8.79 mm) (Figure 2). Possibly, differences in material composition, manufacturing processes, and varying wall thicknesses of the filter holders (porcelain with 6.59 mm and stainless steel with 5.11 mm) also influenced the extraction kinetics.

Table 1: Physicochemical parameters of coffee beverages prepared using Koar® filter holders.

Parameters	Koar® filter holder materials			
	Acrylic	Stainless Steel	Ceramic	Porcelain
TA (mL of NaOH)	0.70 ± 0.14^d	1.15 ± 0.01^b	1.02 ± 0.11^c	1.41 ± 0.01^a
pH	4.98 ± 0.04^a	4.99 ± 0.02^a	4.98 ± 0.02^a	4.97 ± 0.02^a
EC (µS/cm)	2.74 ± 0.01^b	2.86 ± 0.26^a	2.55 ± 0.01^c	2.86 ± 0.04^a
TDS (°Brix)	1.66 ± 0.03^a	1.56 ± 0.00^b	1.66 ± 0.03^a	1.60 ± 0.00^{ab}
EY (%)	21.81 ± 0.71^a	20.45 ± 0.21^b	21.76 ± 0.50^a	20.99 ± 0.07^{ab}
AE(%)	14.31 ± 0.21^a	13.76 ± 0.39^c	13.96 ± 0.13^{ab}	13.83 ± 0.28^b
RS (%)	0.90 ± 0.00^a	0.55 ± 0.00^c	0.56 ± 0.03^b	0.51 ± 0.07^d
CAF (%)	0.70 ± 0.18^c	0.95 ± 0.02^a	0.53 ± 0.06^d	0.83 ± 0.02^b

Means in the same row followed by different letters differ significantly from each other ($p < 0.05$). (TA) – Total Titratable Acidity; (EC) – Electrical Conductivity; (EA) – Aqueous Extract; (TDS) – Total Soluble Solids; (EY) – Extraction Yield; (RS) – Reducing Sugars; CAF – Caffeine.

The average temperature ($^{\circ}\text{C}$) considering all measurements was: Acrylic, 77.8; Ceramic, 77.1; Porcelain, 79.1; Stainless Steel, 79.5. Stainless Steel – Porcelain, Stainless Steel – Acrylic (at the beginning of extraction, 0 s), and Ceramic – Acrylic (10 s) showed significant differences determined by the Tukey test ($p < 0.05$) (Figure 2).

Regarding the pH of the beverages, no significant differences were observed (Table 1), with values ranging from 4.87 ± 0.02 (Porcelain Koar[®]) to 4.99 ± 0.02 (Stainless Steel Koar[®]). The electrical conductivity of the beverages varied between $2.55 \pm 0.01 \mu\text{S}/\text{cm}$ (Ceramic Koar[®]) and 2.86 ± 0.26 and $2.86 \pm 0.04 \mu\text{S}/\text{cm}$ (Stainless Steel and Porcelain Koar[®], respectively) (Table 1).

The total soluble solids of the beverages varied between 1.66 ± 0.03 $^{\circ}\text{Brix}$ (Ceramic and Acrylic Koar[®]) and 1.56 ± 0.00 $^{\circ}\text{Brix}$ (Stainless Steel filter holder) (Table 1). The Acrylic and Stainless Steel filter holders presented the highest ($21.81 \pm 0.71\%$) and lowest ($20.45 \pm 0.21\%$) values, respectively, for the extraction yield parameter (Table 1).

The aqueous extract content was higher in the beverage extracted with the Acrylic Koar[®] ($14.31 \pm 0.21\%$) and lower in the Stainless Steel Koar[®] ($13.76 \pm 0.39\%$) (Table 1). The aqueous extract content is relevant for coffee industries, especially for the production of soluble coffees, as it indicates the amount of soluble extract present in the Beverage.

Regarding the content of reducing sugars, the beverage extracted in the Acrylic filter holder showed a higher percentage for this parameter, 0.9%, which corresponds to almost 40% more than in the other tested materials (Table 1).

Additionally, a decrease in acidity was observed in the beverage extracted with the acrylic filter holder and in the variation of caffeine content ($0.53 \pm 0.06\%$ to $0.95 \pm 0.02\%$) (Table 1), with the Ceramic Koar[®] responsible for the lowest

and the Stainless Steel Koar[®] for the highest content. When comparing the behavior of these filter holders, they represent the variations of lower and higher extraction temperatures, respectively (Figure 2).

The ceramic Koar[®] had the highest content of total phenolics (30.60 ± 0.45 EAG mg/mL) (Figure 3a), while the acrylic and porcelain Koar had the lowest values (27.03 ± 0.55 EAG mg/100 mL sample and 26.74 ± 0.35 EAG mg/100 mL sample, respectively).

Regarding the antioxidant potential, increases were observed in beverages from Ceramic and Acrylic filter holders (lower average temperatures, Figure 2), while the lower values of antioxidant activity were found in beverages produced with Porcelain and Stainless Steel filter holders (higher average temperatures, Figure 2) (Figure 3b).

The highest antioxidant capacity against the ABTS radical was observed in coffee beverages obtained from the Ceramic filter holder ($24800.00 \pm 5.00 \mu\text{mol TEAC}/100 \text{ mL}$) (Figure 3b), while the Porcelain filter holder provided the beverage with the lowest antioxidant activity ($21300.00 \pm 6.67 \mu\text{mol TEAC}/100 \text{ mL}$). Regarding the antioxidant capacity measured by the DPPH method, the beverages prepared in Stainless Steel and Porcelain filter holders showed the highest ($8294.00 \pm 5.65 \mu\text{mol TEAC}/100 \text{ mL}$) and the lowest ($7414.00 \pm 5.65 \mu\text{mol TEAC}/100 \text{ mL}$) free radical scavenging capacity, respectively (Figure 3b).

With the aim of identifying the most relevant patterns in coffee extractions, Principal Component Analysis (PCA) was used (Figure 4), and the acrylic Koar can be correlated with the parameters of reducing sugars (RS), total soluble solids (TSD), and extraction yield (EY), while the ceramic filter holder, due to its proximity to the acrylic one (Figure 4B), can also be correlated with TDS and EY (Figure 4a). Only the variables total acidity (TA) and aqueous extract (AE)

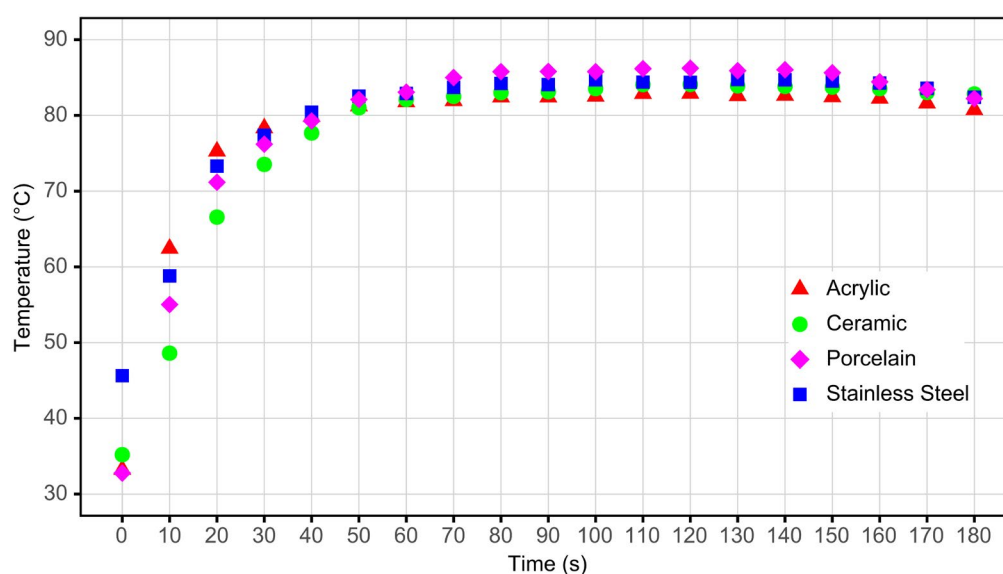


Figure 2: Temperature variations during coffee beverage extraction using different Koar filter Holder materials.

(Figure 4a) were determinant in characterizing the porcelain Koar. The beverage prepared in the stainless steel Koar (Figure

4b) showed a higher correlation with DPPH and pH, electrical conductivity (EC), and caffeine (CAF) (Figure 4a).

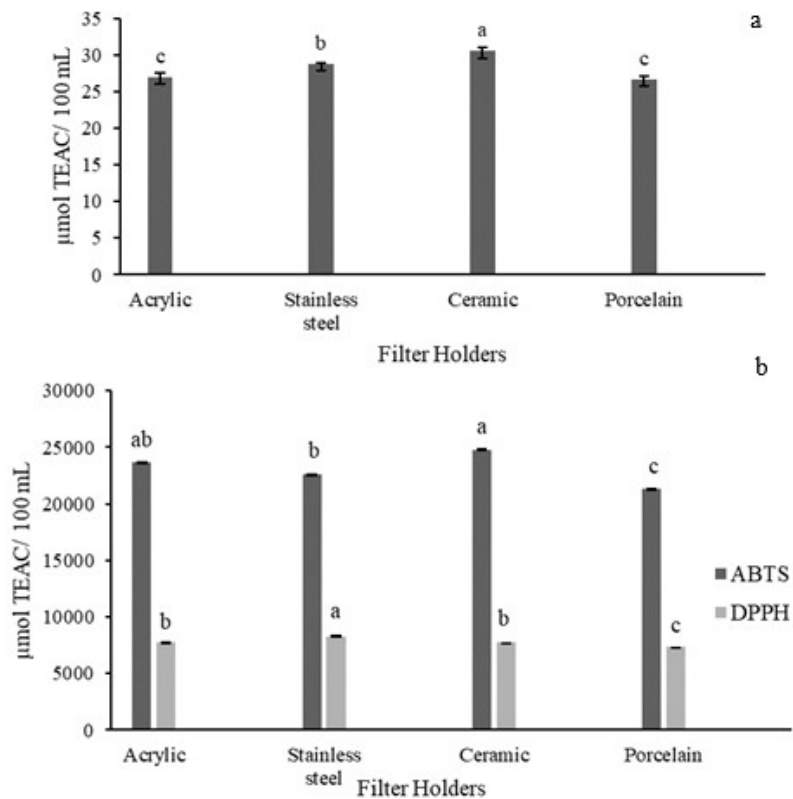


Figure 3: Total phenolics (a) and Antioxidant activity (ABTS and DPPH) (b) of coffee beverages extracted from Koar filter holders. Means followed by different letters differ significantly from each other ($p < 0.05$), by Tukey's test. (EAG) – Gallic acid equivalent (EAG). (TEAC) – Trolox equivalent antioxidant activity.

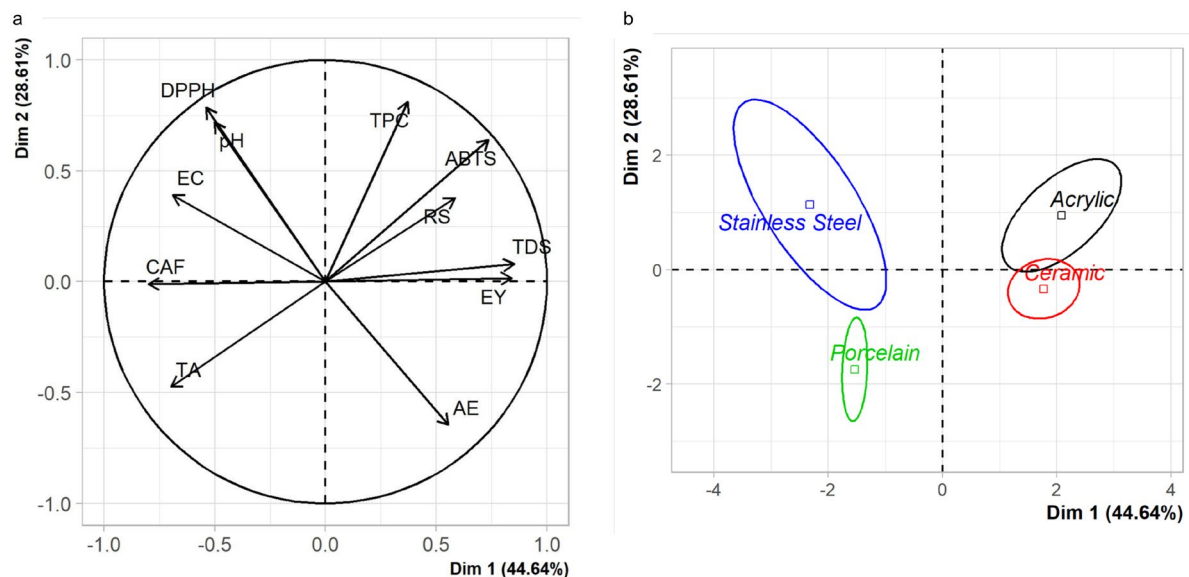


Figure 4: Principal Component Analysis of the evaluated physicochemical parameters of beverages extracted in filter holders made of different materials resulting in a total explanation of 73.25% of the data. (a). Representations of confidence ellipses of the samples on the factorial plane (Dim1 and Dim2) generated by PCA (b). (TA) – Total Acidity; (EC) – Electrical Conductivity; (AE) – Aqueous Extract; (TDS) – Total Soluble Solids; (EY) – Extraction Yield; (RS) – Reducing Sugars; (CAF) – Caffeine; (TPC) – Total Phenolics.

Additionally, a characteristic behavior was observed among the evaluated variables to characterize the coffee beverages. As the TA parameter decreases, there is an increase in ABTS radical scavenging capacity, TPC, RS, and TDS. Furthermore, as the pH of the beverage increases, the antioxidant capacity measured by DPPH also tends to increase. It was observed that the samples exhibit a similar behavior to the results of the Hierarchical Cluster Analysis (Figure 5), highlighting the proximity of the samples extracted in acrylic and ceramic Koar® filter holders, stainless steel, and porcelain through the formed ellipses (Figure 4).

4 DISCUSSION

Numerous acids can be found in coffee, primarily divided into two groups: chlorogenic acids and organic acids naturally formed during the development of coffee fruits. The initial content of organic acids can be considered an indicator of quality, as they participate in the mechanisms of degradation and formation of flavor compounds during the roasting process (Yeager et al., 2021). The acrylic filter holder showed the lowest value, while the porcelain filter holder exhibited the most significant TA values. Higher acid content is often found in extractions conducted at high temperatures (Gloess et al., 2013), a result observed in the coffee beverages extracted with porcelain and stainless steel filter holders (Table 1), which maintained higher temperatures during extraction (Figure 2).

The material of the filter holder influences the rate of heat loss from the system during beverage extraction. Therefore, thermal conductivity is an important property as it is related to the rate of heat flow through the material as a function of the temperature gradient (Incropera; Dewitt, 1992). According to the manufacturer (Koar, 2023), the acrylic filter holder material has a lower thermal conductivity ($0.17 \text{ W/m}^2 \text{ }^{\circ}\text{C}$), unlike the ceramic and porcelain materials which have $0.4, 0.80 \text{ W/m}^2 \text{ }^{\circ}\text{C}$ respectively, and the stainless steel material which has the highest value of $80.3 \text{ W/m}^2 \text{ }^{\circ}\text{C}$. When associated with the characteristics of the material, this may have contributed to the lower total titratable acidity value (Table 1) due to faster temperature loss during the extraction process.

Temperature impacts the solubility, volatility, and extraction kinetics of various coffee components (Batali; Ristenpart; Guinard, 2020; Córdoba et al., 2020). Approximately 50% of the components found in coffee are extracted in the first quarter of the water volume used in preparation, while other compounds with sensory importance are extracted more slowly (Batali; Ristenpart; Guinard, 2020). It was observed that the greatest variation in coffee extraction using different filter holder materials occurred in the first 20 seconds of extraction (Figure 2). However, after 60 seconds of extraction, temperatures remained relatively constant with maximum averages between 110 and 140 seconds: (Acrylic, $82.9 \text{ }^{\circ}\text{C}$; Ceramic, $84.1 \text{ }^{\circ}\text{C}$; Stainless Steel, $84.7 \text{ }^{\circ}\text{C}$; Porcelain, $86.2 \text{ }^{\circ}\text{C}$) (Figure 2).

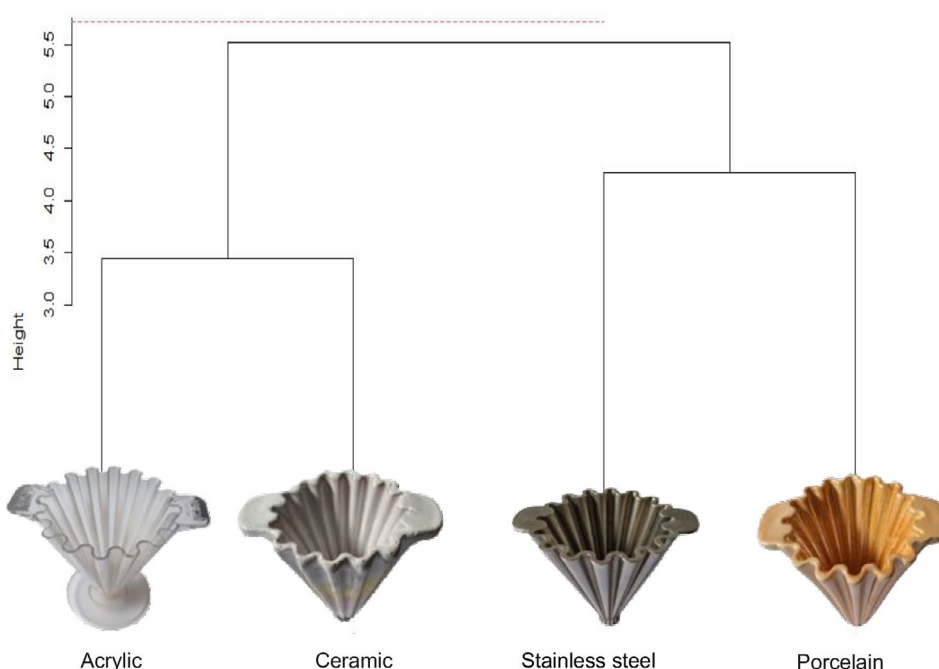


Figure 5: Hierarchical clustering obtained through the Ward method with cophenetic correlation coefficient equal to 0.86, using the average Euclidean distance between the physicochemical attributes of the evaluated beverage samples

Regarding the pH parameter values, no significant differences were observed among the evaluated beverages, and these findings are consistent with previous studies (Angeloni et al., 2019). Electrical conductivity is indicative of the total ions present in the solution. The increase in solute release to the external environment may be related to the degree of sample deterioration, including sugars, amino acids, fatty acids, proteins, enzymes, and inorganic ions (K^+ , Ca^{2+} , Mg^{2+} , Na^+ , and Mn^{2+}) (Marcos-Filho, 2015). However, in the present study, we observed a possible correlation with the extraction temperature (Figure 2) and electrical conductivity. During the 70 to 150 s interval, beverages from the stainless steel and porcelain filter holders showed higher temperatures, and this behavior may have been responsible for a significant increase in electrical conductivity.

Total soluble solids are components present in coffee powder that influence the intensity and are also responsible for the body of the beverage, an important sensory attribute for the quality control of specialty coffees (Córdoba et al., 2020). These results may be related to the gradual increase in temperature observed up to 60 s of extraction (Figure 2), consequently increasing the solubility of soluble components.

Extraction yield, or extraction percentage, is an important parameter that can be evaluated through the total soluble solids content, measuring the relationship between the mass of extracted soluble components and the mass of coffee used in beverage extraction (Córdoba et al., 2020). The Coffee Brewing Control Chart developed by Lockhart in 1957 classifies the beverage into nine zones based on the extraction yield values, with the “Ideal” zone (with values between 18% and 22%) considered of the highest quality (Frost et al., 2020; Specialty Coffee Association - SCA, 2020). All beverages prepared using Koar filter holders fall within the ideal range (Table 1).

The result obtained for reducing sugars can be explained by the lower temperatures presented by the acrylic filter holder for most of the extraction time (Figure 2). This hypothesis is consistent with findings in studies on extractions at low temperatures such as cold brew, resulting in beverages with higher sweetness and antioxidant capacity, as well as lower acidity and caffeine compared to coffees extracted at high temperatures (Rao; Fuller, 2017).

Phenolic compounds, which are responsible for coffee's antioxidant activity due to the hydroxyl groups that eliminate free radicals (Aryal et al., 2019), were also analyzed. This can be explained by the fact that the beverage prepared in the porcelain Koar® had a lower temperature at the start of the extraction process (Figure 2), negatively influencing the extraction of phenolic compounds. However, it was also observed that after 50 s of extraction, the Porcelain filter holder showed the highest temperatures, which may have caused degradation of the

phenolic components, which are generally thermosensitive (Martín et al., 2022).

Some authors suggest that the antioxidant capacity of coffee beverages can be influenced by the brewing method used (Zapata et al., 2019a; Zapata et al., 2019b). The results of this experiment with Koar® filter holders show that the material also directly influenced the extraction process, altering the antioxidant capacity of the beverages. In a study conducted by Zapata et al. (2019a), which evaluated the effect of different gravity filtration brewing methods (such as Vietnamese coffee maker, Clever, Kinto, Yama, RS 16, V60, and Kalita), they observed that beverages extracted in RS-16 and Clever showed higher ABTS antioxidant capacity compared to other beverages, approximately 33000.00 and 34000.00 $\mu\text{mol TEAC}/100\text{ mL}$, respectively. However, it is essential to note that both devices include an infusion step in the extraction process with an average time of 4 minutes and 30 seconds, which may explain the higher observed values.

A Hierarchical Cluster Analysis was performed with the aim of determining possible similarities and differences among Koar® filter holders made of acrylic, stainless steel, ceramic, and porcelain. Thus, when examining the beverages prepared in Koar filter holders of acrylic, stainless steel, ceramic, and porcelain, all share physicochemical characteristics and antioxidant capacity, being included in the same group. However, the formation of two subgroups is noticeable: Subgroup I (acrylic and ceramic) and Subgroup II (stainless steel and porcelain) (Figure 5). This separation indicates that acrylic and ceramic filter holders share more similarities than with stainless steel and porcelain ones, and these observations align with the PCA (Figure 4).

5 CONCLUSIONS

This study found that the material of the Koar® filter holder has a significant influence on the extraction of coffee components, resulting in beverages with different physicochemical compositions and antioxidant activity against ABTS and DPPH radicals. This can directly impact the sensory profile and health benefits provided by these drinks.

Beverages prepared in acrylic and ceramic filter holders showed higher levels of total phenolics, reducing sugars, total soluble solids, extraction percentage, and greater capacity to eliminate the ABTS radical. However, drinks from stainless steel and porcelain filter holders showed higher values of total acidity, electrical conductivity, caffeine, and greater capacity to eliminate the DPPH radical. These findings highlight the importance of careful selection of filter holder material to ensure different sensory profiles of coffee beverages, providing valuable information for the industry and coffee enthusiasts.

6 AUTHORS' CONTRIBUTIONS

Conceptual Idea: Santos, W.W.V.; Silva, S.P., Methodology design: Santos, W.W.V.; Silva, S.P., Data collection: Santos, W.W.V., Data analysis and interpretation: Santos, W.W.V.; Lucena, R.M., and Writing and editing: Santos, W.W.V.; Silva, S.P.; Lucena, R.M.; Oliveira, R.L.; Silva, M.E.S.

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