



Is cafestol retained on the paper filter in the preparation of filter coffee?



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ABSTRACT

Coffee brew presents sensory, stimulatory and antioxidant properties highly appreciated by consumers, despite being associated with an increase in the level of blood cholesterol due to the effects of the diterpenes, especially cafestol, present in the lipid fraction. Although it is believed that the paper filter retains the brew diterpenes, new studies have shown that sometimes coffee filtered through paper can also increase the blood cholesterol level, putting in doubt the efficiency of the paper filter in retaining the diterpenes. Thus the objective of the present study was to verify the distribution of cafestol between the paper filter, the spent coffee and the coffee brew itself, from two coffee samples containing high and low cafestol contents selected from 13 samples of different cultivars and from different locations. In addition, the effect of the roasting degree on the cafestol contents of the roasted coffee was evaluated and the relationship between particle size of the roasted coffee and the extraction of solids. The highest cafestol content was found in the lightly roasted coffee, and the coffee brew presented higher solids contents when the particle size of the coffee powder was below 500 μm . The results showed that of the initial cafestol concentration present in the roasted coffee, the paper filter retained 12.41%, the spent coffee 87.45% and the brew 0.15%. Thus, one can conclude that the greater part of the coffee cafestol is retained by the spent coffee, due to the low extraction of the lipid fraction by the hot water.

1. Introduction

Coffee is one of the most consumed beverages in the world and the demand is increasing, such that between 2012/13 and 2015/16, the consumption increased from 146.9 million 60 kg bags to 155.7 million 60 kg bags, according to the International Coffee Organization (2017). This increment in consumption is due to the sensory characteristics and antioxidant and stimulant properties, as well as to the various forms of preparation which satisfy the diverse consumer demands. Amongst the ways of preparing coffee one can mention boiled or Scandinavian coffee, Turkish coffee, coffee prepared in an Italian coffee maker or mocha, coffee prepared in a French press, espresso coffee and filter coffee, amongst others (Moenfard, Silva, Borges, Santos, & Alves, 2015a; Zhang, Linforth, & Fisk, 2012).

Recent studies have shown that non-filtered coffee brews contain higher diterpene contents than filtered coffees (Moenfard et al., 2015a). The diterpenes (cafestol and kahweol) are compounds present in the lipid fraction of the coffee, and are related to increases in blood cholesterol, especially in the case of cafestol. According to Urgert and Katan (1997), the consumption of 10 mg of cafestol per day for 4 weeks increases the total blood cholesterol level by 5.0 mg/dL, whilst the consumption of 10 mg of kahweol only increases it by 0.9 mg/dL.

The facts that the cafestol concentrations found in filter coffee vary from 0.12 mg/L (Gross, Jaccaud, & Huggett, 1997) to 42.00 mg/L (Corrêa et al., 2013), and that the cafestol concentrations reported in brews prepared without filtering, such as those obtained from an espresso machine and from a French press, were 26.47 mg/L and 53.3 mg/L, respectively (Moenfard et al., 2015a; Zhang et al., 2012), can explain the contradictory results in relation to the increase in blood cholesterol (Corrêa et al., 2013; Thelle & Strandhagen, 2005).

Diverse factors can affect the diterpene concentrations in roasted coffees, such as the species (Campanha, Dias, & Benassi, 2010), the cultivar and year harvested (Kitzberger et al., 2013) and the roasting degree (Zhang et al., 2012). Considering that a high cafestol concentration in a sample could surpass the capacity of a paper filter to retain it, consequently producing filtered beverages with a high cafestol content, the objective of the present study was to verify retention of the cafestol on the paper filter and in the spent coffee and brew, using two samples with high and low cafestol contents, especially selected for the present study.

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Table 1
Processing and location of the pre-selected coffee cultivars.

| Cultivar | Processing | Location (altitude) |
|-----------------|----------------|----------------------------|
| Catuai Vermelho | Natural | São Paulo - SP (925 m) |
| Rubi | Pulped | Minas Gerais - MG (1100 m) |
| Acaía | Natural | Minas Gerais - MG (1200 m) |
| Mundo Novo | Natural | Minas Gerais - MG (1200 m) |
| Icatú | Pulped natural | Minas Gerais - MG (1200 m) |
| Laurina | Pulped natural | Minas Gerais - MG (1200 m) |
| Catuai Vermelho | Natural | Minas Gerais - MG (1200 m) |
| Catuaí | Natural | Minas Gerais - MG (1200 m) |
| Tupi | Natural | Paraná - PR (610 m) |
| Catuai Vermelho | Natural | Paraná - PR (610 m) |
| Mundo Novo | Natural | Paraná - PR (610 m) |
| Mundo Novo | Pulped natural | Paraná - PR (521 m) |
| Mundo Novo | Natural | Paraná - PR (521 m) |

2. Materials and methods

2.1. Green coffee – Specification

In order to identify green coffee samples with elevated cafestol concentrations, 13 samples were taken from a variety of agricultural properties in the coffee region of Brazil, 1 sample coming from the State of São Paulo, 7 from the State of Minas Gerais and 5 from the State of Paraná (Table 1). After determining the cafestol contents, two samples were selected, one with a high cafestol content (Catuaí Vermelho cultivar) harvested in Paraná (Brazil), and the other with a low cafestol content (Catuaí cultivar) harvested in Minas Gerais (Brazil).

Defective beans were removed from the green coffee samples, and only beans retained between sieves for coffee 14 (0.56 cm diameter) and 15 (0.6 cm diameter), were analyzed. Both samples were harvested completely mature and sun dried directly (natural process).

2.2. Moisture determination

The moisture content of the green and roasted coffees was determined with samples of 5 and 10 g, respectively, using an oven at 105 °C (Marconi, Piracicaba, São Paulo, Brazil), and drying to constant weight. The analyses were carried out in triplicate.

2.3. Ground roasted coffee

The selected coffee beans (200 g) were roasted to 3 roasting degrees according to the AGTRON/SCAA disks (Staub, 1995): light roasted (Agtron disk 85), medium roasted (Agtron disk 65) and dark roasted (Agtron disk 45), using a coffee roaster (Probat - Werke Von Gimbom Maschine Fabrik GmbH, Emmerch-Khein, Germany). The roasting time varied between 9 and 20 min and the temperature between 200 and 215 °C. After cooling to room temperature (25 °C), the beans were ground in a coffee grinder (La Spaziale MC6, Italy), but only particles below 500 µm (35 mesh) were used to prepare the brew. The color parameters of the ground roasted coffee were determined in a Color Quest XE-Hunterlab colorimeter (Reston, USA), in the calibration mode with reflectance specular excluded (RSEX), D65 illuminant and hue angle of 10°.

2.4. Coffee brew preparation

The coffee brew was prepared using 10 g of ground coffee and 100 mL of hot (91 ± 2 °C) filtered water (ABIC, 2016). The filtering time using a paper filter without micropores was 5 min. In order to know diterpene concentrations in an unfiltered coffee brew, the French press method was used at same time for both samples. After cooling, the coffee brews were frozen, freeze dried (Liotop L101-Liobras, Brazil) and stored at 5 °C until the diterpenes were determined. Five repetitions of

each sample were prepared.

2.5. Quantification of the dry extract

The total solids or dry extract of the brews was determined according to AOAC (2000). For this analysis, 20 mL of filtered brew was placed in an oven at 70 °C (Marconi, Piracicaba, São Paulo, Brazil) and dried to constant weight. The analyses were carried out in triplicate.

2.6. Diterpenes extraction

The diterpenes were extracted according to Dias, de Faria-Machado, Mercandante, Bragagnolo, and Benassi (2014). The sample (0.2 g) was saponified with 2.0 mL potassium hydroxide (2.5 mol/L) in 96% ethanol (v/v) at 80 °C for 1 h. A 2.0 mL aliquot of ultrapure water was then added and the unsaponifiable fraction extracted with 2.0 mL of methyl tert-butyl ether (MTBE). The non-polar phases resulting from the three extractions were pooled, washed with 2.0 mL of ultrapure water, evaporated in a nitrogen flow and diluted in 4 mL of mobile phase (80% methanol) for the green coffee, roast coffee and spent coffee, and in 2 mL for the freeze dried coffee brews. After filtration through a 0.22 µm membrane (Millipore, Germany), 20 µL were injected into the high performance liquid chromatograph (HPLC). Five extracts were prepared for each sample.

2.7. Diterpenes quantification

The diterpenes were determined using an HPLC (Shimadzu, Japan) equipped with a binary pump system (LC-10AD), degasser using helium gas (DGu-2A), chromatographic column heater at 25 °C (CTO-10A), automatic injection system (SIL-10A) and a diode array detector (SPD-M10A).

The diterpenes were separated according to the methodology of Zhang et al. (2012) with modifications to the methanol concentration and flow rate of the mobile phase. The mobile phase was 80% methanol in an isocratic system with a flow rate of 0.6 mL/min. A Shimpack CLC-ODS (M) (250 mm × 4.6 mm × 5 µm) reverse phase column (Shimadzu, Kyoto, Japan) was used.

This procedure was used for the green and roasted coffee samples, the spent coffee and the freeze-dried coffee brews. The diterpene contents of the paper filters were obtained from the differences between the concentrations found in the roasted coffees, and the sum of the concentrations found in the respective brews and spent coffee.

Cafestol and kahweol were detected at 230 and 290 nm, respectively, and quantified by external standardization with an analytical curve (7 points in triplicate, $r^2 = 0.99$). The concentration range used for both standards was from 1.0 mg/L to 1000 mg/L.

Cafestol and kahweol were identified by mass spectroscopy (MS) using an HPLC (Shimadzu, Japan) equipped with quaternary pumps (LC-20 CE), on-line degasser (DGu-20A5), chromatographic column heater (CTO-20A), Rheodyne valve with a 20 µL sampling loop. The system was coupled in series to a diode array detector (Shimadzu, SPD-M20A) and a mass spectrometer (MS) with an ion-trap analyzer and atmospheric pressure chemical ionization (APCI) source from Bruker Daltonics (Esquire 4000, Bremen, Germany). The following working conditions were used for the mass spectrometer: positive mode; corona current of 4.0 µA; source temperature of 450 °C; dry nitrogen gas, N₂; temperature, 350 °C; flow rate, 4 L min⁻¹; nebulizer pressure, 60 psi, and MS/MS fragmentation energy, 1.4 V. The mass spectra were acquired over an *m/z* (mass-to-charge ratio) scan range from 100 to 700 (scan mode).

2.8. Statistical analyses

The results of the chemical analyses were analyzed using the analysis of variance, the causes of variation being the samples, the roasting

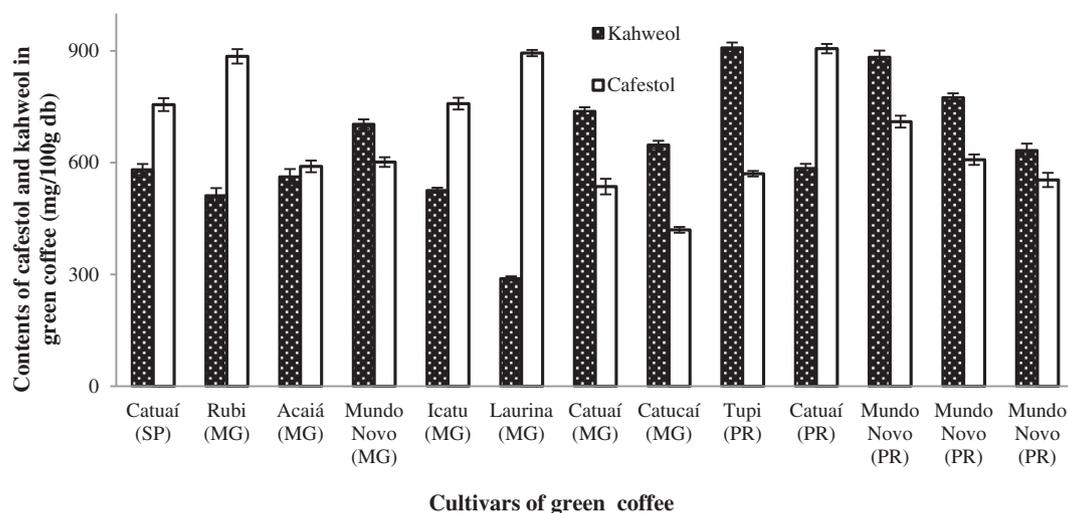


Fig. 1. Cafestol and kahweol contents in green coffee ($\text{mg } 100 \text{ g}^{-1}$).

degrees, solid content and the particle sizes, and the means were compared by Tukey's test ($p < 0.05$). All the statistical analyses were carried out using the Statistica 10 program (STATSOFT, 2011).

3. Results and discussion

Fig. 1 shows that the cafestol concentrations obtained for the samples analyzed varied from 419.66 to 906.04 mg/100 g on a dry weight basis. Samples of the varieties Catuaí Vermelho (PR), Laurina (MG) and Rubi (MG) presented the highest concentrations. Since the cultivar Catuaí represents the greater part of the coffee plantations in Brazil, the sample of the variety Catuaí Vermelho (PR) was chosen for the present study.

The cafestol concentrations found in the cultivars studied were close to the values reported by Kitzberger et al. (2013) (270–668 mg/100 g) for diverse cultivars (IPR100, IPR102, IPR 106 and Catuaí), with the exception of the cultivars Rubi (MG), Laurina (MG) and Catuaí (PR) which showed higher values. The higher cafestol concentrations found in the samples Rubi (885.31 mg/100 g) (pulped coffee) and Laurina (894.22 mg/100 g) (pulped natural coffee), both from Minas Gerais, and Catuaí (906.04 mg/100 g) (natural coffee) from Paraná, could be attributed to the type of processing, cultivar and the environmental conditions (Cheng, Furtado, Smyth, & Henry, 2016; Joët et al., 2010; Kitzberger et al., 2013; Scholz et al., 2014; Scholz et al., 2016).

Although the present study was focussed on the cafestol concentration during the preparation of the filtered coffee brew, since this has a greater effect in elevating the blood cholesterol level as compared to kahweol (Urgert & Katan, 1997), it could be of interest to know the kahweol concentrations in the samples, considering the anti-inflammatory, antitumoral and anticarcinogenic properties of this compound (Cárdenas, Quesada, & Medina, 2014; Park, Song, & Jeong, 2016; Um et al., 2010). The concentrations of kahweol varied from 289.22 to 908.64 mg/100 g of green coffee on a dry weight basis, values close to those reported by Kitzberger et al. (2013) (371–986 mg/100 g) for the Catuaí, IPR100, IPR102 and IPR106 cultivars.

Considering the contradictory results with respect to the effect of roasting degree on the diterpene concentrations in roasted coffee (Campanha et al., 2010; Dias et al., 2014; Kitzberger et al., 2013; Zhang et al., 2012) and the interest in maintaining the high diterpene concentrations in the Catuaí (PR) sample, in order to evaluate possible saturation of the paper filter, the effect of roasting degree on the cafestol and kahweol concentrations in the roasted coffee was studied. Table 2 shows the color parameters of the green and roasted beans of the Catuaí (PR) sample analyzed in the present study. The values for luminosity (L^*) were within the range found by Dias et al. (2014) in the

Table 2

Characteristics of the Catuaí (PR) sample according to roasting degree.

| Roasting degree | Luminosity* (L^*) | Cafestol** (mg/100 g) | Kahweol** (mg/100 g) |
|-----------------|---------------------------|-----------------------------|-----------------------------|
| Green coffee | 59.40 ± 1.17 ^a | 906.04 ± 14.53 ^a | 585.01 ± 13.68 ^a |
| Light roast | 30.06 ± 0.49 ^b | 888.32 ± 16.17 ^a | 577.12 ± 9.71 ^a |
| Medium roast | 25.33 ± 0.65 ^c | 879.26 ± 14.95 ^a | 561.70 ± 13.35 ^b |
| Dark roast | 20.48 ± 0.39 ^d | 846.08 ± 5.10 ^b | 552.20 ± 4.57 ^b |

* Mean values ($n = 6$) ± standard deviation. Different superscript letters indicate a difference within the column ($p < 0.05$).

** Mean values ($n = 5$) ± standard deviation. Different superscript letters indicate a difference within the column ($p < 0.05$).

evaluation of the effect of roasting on the diterpene concentrations. Differences were observed between the color of the green coffee and the three roasting degrees, represented by a decrease in luminosity (L^*).

The cafestol concentrations found in the green coffee and in the light and medium roasted coffees did not vary one from the other (Table 2), but the dark roasted coffee showed a lower cafestol concentration, a result in agreement with the data reported by Zhang et al. (2012). Kahweol was more affected by the roasting degree showing a lower concentration in the medium and dark roasted coffees than in the green and lightly roasted coffees. The decrease in concentration of the cafestol and kahweol with increase in the roasting degree found in the present study is in agreement with the observations made by Dias et al. (2014), who showed a decrease in these compounds after 8 min of roasting, when the values for L^* were below and close to 25. This decreasing behavior explains why, depending on the roasting degree, the diterpenes undergo dehydration forming dehydrocafestol and dehydrokahweol, such that the diterpene concentrations diminish (Dias et al., 2014). Hence the present study was done with the light roasting degree.

In order to choose the particle size permitting the greatest extraction of cafestol, the particle size used for traditional commercial coffees was taken into consideration (Fig. 2) and also previous studies. Thus Moenfarid, Silva, Borges, Santos, and Alves (2015b) and Buchmann, Zahm, Kölling-Speer, and Speer (2010) evaluated the variables allowing for the greatest extraction of diterpenes and lipids from espresso coffee brew, and found greater extractions with a finer particle size (greater percentage of particles below 500 μm).

With respect to the extraction of solids, Andueza, Peña, and Cid (2003) studying the effect of particle size in the extraction of espresso coffee found greater extraction from finer particles than from larger particles. In the present study, a greater solid content was found in filter

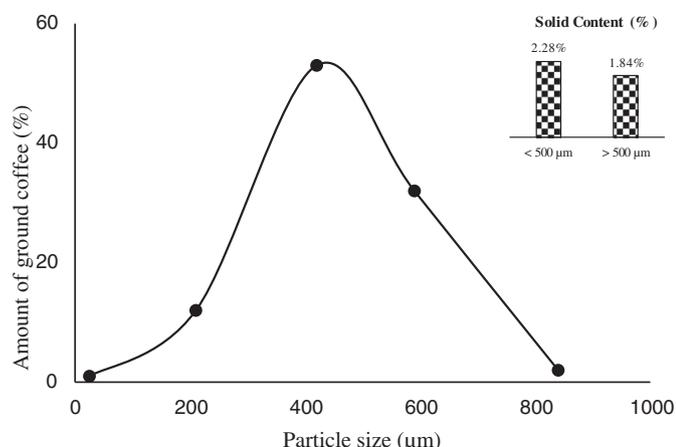


Fig. 2. Particle size of the ground roasted coffee and its relationship with the solid content in the filter coffee brews.

Table 3
Comparison of the cafestol and kahweol concentrations found in filter coffee brews in the present study and reported in the literature.

| Coffee sample | Particle size | Cafestol (mg/L) | Kahweol (mg/L) |
|--------------------------------|-------------------------------|-----------------|----------------|
| ^a Catuai | < 500 µm | 2.30 ± 0.28 | 1.01 ± 0.16 |
| ^a Catuai | < 500 µm | 1.07 ± 0.06 | 1.18 ± 0.11 |
| ^b Arabica | 500–550 µm | 0.12 | 0.14 |
| ^c Arabica & Robusta | < 500 µm | 0.5 | 0.17 |
| ^d Arabica | 43% > 420 µm & 48% 200–420 µm | 0.66 | Not reported |
| ^e Arabica | < 300 µm | 8.87 | 2.46 |
| ^f Arabica & Robusta | Not reported | 35.73, 42.00 | 3.4, 5.26 |

- ^a Data found in the present study.
- ^b Gross et al. (1997).
- ^c Moeenfarid et al. (2015a).
- ^d Urgert et al. (1995).
- ^e Sridevi et al. (2011).
- ^f Corrêa et al. (2013).

brews prepared with particle sizes below 500 µm in comparison with particle sizes above 500 µm (Fig. 2). This can be explained by the fact that a smaller particle provides a greater contact surface between the coffee and the hot water, allowing for a greater extraction of solids, including that of the diterpenes. Thus a particle size below 500 µm was used in the present study.

The diterpene concentrations found in the brews prepared with the Catuai (PR) and Catuai (MG) cultivars were calculated in mg/L to facilitate comparison with data in the literature (Table 3). The cafestol concentrations found in the brews prepared with the Catuai (PR) and

Catuai (MG) samples were higher than the values reported by Urgert et al. (1995), Gross et al. (1997) and Moeenfarid et al. (2015a). These differences can be justified by the diterpene concentration in the sample used by Moeenfarid et al. (2015a), since the robusta coffee species shows lower cafestol contents and the absence of kahweol when compared with Arabica coffee (Dias et al., 2010). On the other hand, Gross et al. (1997) and Urgert et al. (1995) used larger particle sizes than used in the present study, a variable that does not facilitate the extraction of diterpenes (Moeenfarid et al., 2015b). Although diverse variables (sample, roasting degree and particle size) were considered in order to maximize the cafestol concentration in the filtered coffee brew, the results obtained were lower than the concentrations reported by Sridevi, Giridhar, and Ravishankar (2011) and Corrêa et al. (2013) (Table 3). These differences can be attributed to the smaller particle size used in the preparation of the brew (Sridevi et al., 2011) or could be a consequence of some variable not considered in the present study. Considering the fragility of the paper filter after filtering the coffee brews, the spent coffee and the filter paper were placed together into an oven at 60 °C and dried to constant weight. The spent coffee was then carefully separated from the paper filter, but it was observed that in all cases the finest particles remained on the paper, so the quantification of the diterpenes in the spent coffee was done without these finest particles.

Table 4 shows the values found for cafestol and kahweol in the green coffees, roast coffees, spent coffee, freeze dried brew and paper filter. In order to maintain as much as possible the diterpene concentrations in the green coffee, the light roasting degree was used. Thus the cafestol concentrations found in the green and roasted coffees were similar for Catuai (PR) and Catuai (MG), and the roasting degrees were similar for both samples according to the luminosity value (L*).

It can be seen that for the cultivar Catuai (PR), the paper filter retained 13.10% of the total cafestol of the roasted coffee, but the highest percentage was retained in the spent coffee (86.75%) and the lowest percentage (0.15%) in the brew. A similar distribution between the spent coffee, brew and paper filter was observed for kahweol (Table 4).

Table 4 shows that only a small fraction of the diterpenes present in the roasted coffee passed into the filter coffee brew, which is justified by the low extraction of lipids by the hot water. The literature has also reported low lipid contents in filter coffee brew of between 8 and 80 mg/L (Farah, 2012; Petracco, 2001; Sehat, Montag, & Speer, 1993; van Dusseldorp, Katan, van Vliet, Demacker, & Stalenhoef, 1991). In addition, Moeenfarid et al. (2015a) showed that the free forms of cafestol and kahweol predominate in the filter coffee brew. Thus the lipid fraction which passed into the filter coffee brew would be the polar fraction capable of being extracted by the hot water, cafestol and kahweol being in this fraction, being minor components whose joint concentration in the ground roasted coffee can be between 0.9 and 1.5 g/100 g (Kitzberger, Scholz, & Benassi, 2014; Kitzberger et al.,

Table 4
Cafestol and kahweol concentrations in the green coffees, roasted and spent coffees, brews and paper filters.

| Coffee sample | Cafestol (mg/10 g roasted coffee) | Kahweol (mg/10 g roasted coffee) | Luminosity (L*) |
|--------------------|-----------------------------------|----------------------------------|-----------------|
| Catuai (PR) | | | |
| Green coffee | 90.06 ± 1.45 | 58.50 ± 1.36 | 59.40 ± 1.17 |
| Roasted coffee | 88.83 ± 1.61 (100%) | 57.71 ± 0.97 (100%) | 30.06 ± 0.49 |
| Spent coffee | 77.06 ± 1.29 (86.75%) | 51.26 ± 0.93 (88.83%) | ND |
| Paper filter | 11.64 ± 1.28 (13.10%) | 6.39 ± 0.93 (11.08%) | ND |
| Brew | 0.13 ± 0.02 (0.15%) | 0.05 ± 0.01 (0.09%) | ND |
| Catuai (MG) | | | |
| Green coffee | 43.96 ± 0.89 | 65.78 ± 1.24 | 58.90 ± 1.12 |
| Roasted coffee | 44.17 ± 0.81 (100%) | 66.11 ± 1.10 (100%) | 30.50 ± 0.58 |
| Spent coffee | 38.18 ± 0.22 (88.14%) | 58.68 ± 0.20 (86.32%) | ND |
| Paper filter | 5.92 ± 0.22 (11.71%) | 7.35 ± 0.20 (13.57%) | ND |
| Brew | 0.07 ± 0.03 (0.14%) | 0.08 ± 0.01 (0.10%) | ND |

Mean values (n = 5) ± standard deviation, * Mean values (n = 6) ± standard deviation, ND = not done.

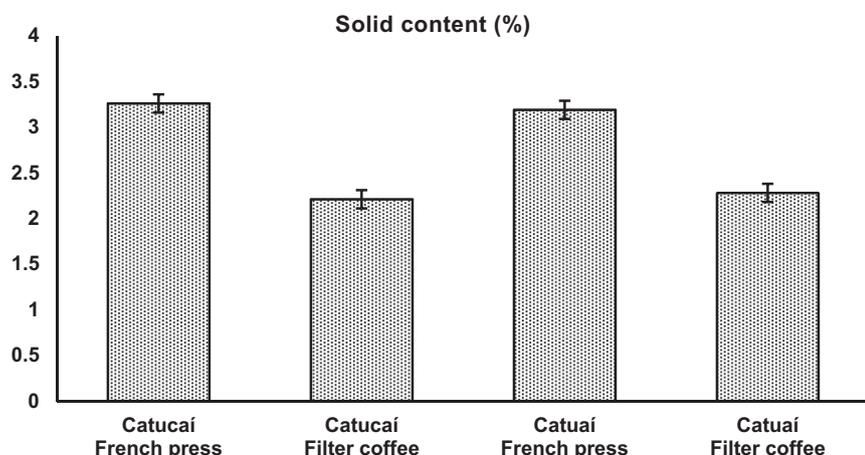


Fig. 3. Solid content in coffee brews (g/100 mL).

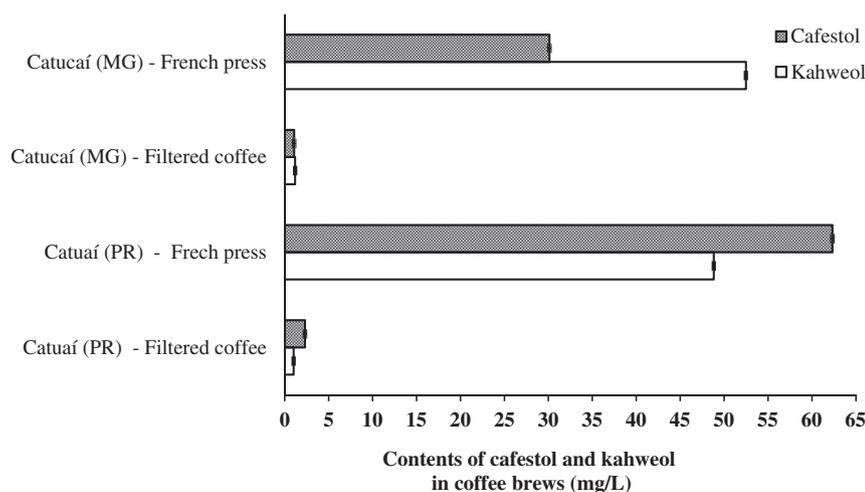


Fig. 4. Comparison of the cafestol and kahweol concentrations found in the brew of the filtered coffee and French press coffee.

2013).

In order to determine if the distribution of cafestol during the filtration process could be affected by the cafestol concentration in the sample, the Catucaí (MG) sample was selected, since this contained the lowest cafestol concentration (Fig. 1). As can be seen in Table 4, the percent retentions of cafestol by the paper filter, spent coffee and coffee brew when the latter was prepared using the Catucaí (MG) sample were similar to those obtained when the sample with the highest cafestol content, Catucaí (PR), was used. This suggests that a constant percentage of diterpenes was extracted under the extraction conditions used in the present study, which could be a consequence of the low capacity of the hot water to extract the coffee lipids, as discussed previously, or could be justified by the amount of fine particles retained on the paper filter. In order to answer this question was prepared French press coffee with Catucaí (MG) and Catucaí (PR) samples. Fig. 3 shows greater total solids content in French press coffees in comparison with filter coffee brews. This can be explained by the fact that the smaller particles passed into the French press coffee since the fine-mesh screen plunger of French press does not retain the fine coffee particles.

The solid content in the coffee brews (Fig. 3) can explain the higher cafestol concentrations in French press coffees (30.12 and 62.31 mg/L) in comparison with filter coffee brews (1.07 and 2.3 mg/L) for Catucaí (MG) and Catucaí (PR), respectively (Fig. 4). Thus the solid content in filter coffee brew measured the compounds extracted by the hot water whilst the solid content in French press coffee measured the compounds extracted by hot water plus the fines coffee particles. These particles were responsible to increase the cafestol concentration in French press coffee. As from these results one can say that the principal function of the paper filter is to retain the fine particles of the ground roasted

coffee, which increase the cafestol and kahweol contents in the brews.

Since Urgert and Katan (1997) reported the consumption of 10 mg of cafestol per day for 4 weeks increases the total blood cholesterol level by 5.0 mg/dL, whilst the consumption of 10 mg of kahweol only increases it by 0.9 mg/dL, the diterpene concentrations in filter coffee brews prepared with Catucaí (PR) and Catucaí (MG) would hardly increase the cholesterol level of the large coffee consumers, like the Dutch, who consumed about 260.4 L per capita in 2015 (CBCNEWS, 2016).

The higher diterpene concentrations in French press coffee than filter coffee (Fig. 4) explain why the long-term of consumption of French press coffee potentially raises serum low-density lipoprotein (LDL) cholesterol (De Roos et al., 2000) and why doctors encourage people to choose filter coffee.

One interesting result which can be seen in Table 4 is that approximately 0.15% of the cafestol present in the ground roasted coffee passed into the filter coffee brew. This percentage is low when compared with those found by Moenfarid et al. (2015b) of from 1.35% to 2.73% for espresso coffee, extracted under various conditions. It is useful to know the percentage of diterpenes that can be extracted from the roasted coffee during preparation of the brew, considering that, depending on the extraction method used, one can extract a variable amount of cafestol, a compound related to the amount of blood cholesterol (Urgert & Katan, 1997) and which can be found in a wide range in different roasted coffees (246–742 mg/100 g) (Kitzberger et al., 2013; Kitzberger et al., 2014). Thus as a function of the cafestol concentration in the roasted coffee one can recommend the best type of brew preparation method to obtain a low cafestol content in the brew. Coffees with high cafestol contents, such as that used in the present

study, can be recommended for the brew preparation methods that show low diterpenes extraction, such as filter coffee, whereas coffees with low cafestol contents can be used for the preparation of espresso coffee.

4. Conclusions

As from the present study one can conclude that the greater part of the cafestol present in the roasted coffee can be found in the spent coffee when filter coffee is prepared, independent of the initial concentration in the roasted coffee, and that the paper filter impedes the passage of fine particles into the brew, retaining an average of 12.4% of the cafestol present in the roast coffee. In addition, it was shown that the diterpenes are less stable in dark roasting procedures, cafestol being more stable than kahweol.

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