IMPACT OF THE ROAST LEVEL ON CHEMICAL COMPOSITION OF COFFEE FROM COLOMBIA

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During the roasting process, a cascade of chemical reactions occur, from which non-volatile compounds degrade and form new compounds with potential aroma attributes. Considering that the roasting process significantly influences the biologically active compound concentration and some unwanted compound formation, such as acrylamide, it is crucial to understand the roasting process from both positive and negative aspects. The aim of this study was to evaluate the chemical composition changes in different roast level coffee samples from Colombia. The moisture, pH, acrylamide, total phenolic, and flavonoid content, and the volatile compound profile were analysed for coffee samples roasted at three different roast levels (light, medium, dark). The results showed a decrease of total phenolic and flavonoid concentration with increased roast level. Acrylamide concentration reached the highest peak in the medium roasted and the lowest in dark roasted coffee. With increasing roast level, the volatile organic acid concentration decreased, while furan and phenol compound concentration increased in the dark roasted coffee. Dark roasted coffee had the lowest acrylamide and organic acid concentration, and the highest pH in brew, which would be more suitable for coffee consumers with a sensitive stomach.

Keywords: roasting process, phenolic compounds, acrylamide, volatile profile, organic acids.

INTRODUCTION

The wide range of biologically active compounds in coffee has been linked to beneficial effects on human health. Moderate daily coffee consumption is associated with a reduced risk of cardiovascular diseases, metabolic disorders, various neurological disorders (including Alzheimer's and Parkinson's diseases), and cancer types (Poole *et al.*, 2017; Lee *et al.*, 2019). Phenolic compounds are one of the main biologically active compound groups found in plant-based products, including coffee. Phenolic acids such as chlorogenic, caffeic, gallic acid have a higher concentration in coffee beans. Epicatechin, quercetin, kaempferol, and rutin are common flavonoids in coffee cherry skin. Both classes (phenolic acids and flavonoids) have proven anticarcinogenic, anti-inflammatory, and antibacterial (Dalar *et al.*, 2018; Hu *et al.*, 2019; Król *et al.*, 2020). In Eastern European countries coffee could be considered as the main source of polyphenols. In Northern and Eastern European countries, fruits and vegetables are consumed significantly less than in Mediterranean countries. Interestingly, in the Northern and Eastern European countries, total polyphenol

intake was found to be higher than in Mediterranean countries (Zamora-Ros *et al.*, 2018). A prospective cohort study data confirmed a positive correlation between coffee consumption and decreased risk of all-cause mortality in Eastern European countries (Grosso *et al.*, 2016).

During the roasting process, non-volatile compounds degrade and form new compounds with potential aroma and flavour attributes. The pleasant acidity is a key factor for sensory quality of coffee (Figueiredo *et al.*, 2015), but increased organic acid concentration for some people can stimulate gastroesophageal reflux. The reflux can cause symptoms like heartburn, dysphagia, or pain in the chest. It is suggested to avoid coffee drinking or choose coffee with lower organic acid and caffeine content (Zaman *et al.*, 2019; Wei *et al.*, 2019). The roasting process can create some unwanted compounds and decrease the phenolic compound concentration. For example, Maillard reaction between amino acids and sugars can create pyrazines and pyrroles with positive aroma/flavour characteristics. Also, acrylamide can be formed as by-product of Maillard reaction. Acrylamide consumed in high amounts starts to work as a neu-

rotoxin, and its concentration decreases with roast level of coffee (Bagdonaite *et al.*, 2008; Koszucka *et al.*, 2019). It is important to understand the positive and negative effects of roasting on bioactive compound composition and sensory quality of coffee. The aim of this study was to evaluate differences in chemical composition depending on roast level of coffee samples from Colombia.

MATERIALS AND METHODS

Coffee samples. Green *Coffea arabica* L. (Cattura/ Bourbon variety) beans from Caldas–Chinchina, Colombia were used in this study. The samples originated from Finca La Cristalina farm, with an elevation of 1650 meters above sea level. The post-harvesting method used was natural. By Specialty Coffee Association (SCA) standards and protocols, this coffee qualifies as a specialty with 89.0 points.

Roasting process. Green coffee was roasted in a local roastery in Latvia at three different roast levels using a Diedrich IR – 2.5 roaster (Diedrich Roasters, Ponderay, ID, USA) (Table 1). Each roasting batch size was 2.2 kg. Roasting parameters are described in Table 1.

The roasted coffee beans were degassed in a dry, cool place for one week and then sealed in vacuum bags. All roasted samples were analysed within two to three weeks after roasting.

Coffee sample preparation for analyses of physical and chemical parameters. Roasted coffee beans were sealed in new 200 g vacuumed bags for the analysis of proteinogenic amino acids, fatty acids profile, and acrylamide.

Roasted coffee beans were ground in a KG79 Coffee grinder (DeLonghi, Italy) to fine grind size. Ground coffee samples were prepared immediately before analysis of moisture content and volatile compound profile. Samples were prepared and analysed in triplicate.

The roasted coffee beans were ground in a KG79 Coffee grinder (DeLonghi, Italy) to coarse grind level 20 minutes before the brewing process. The French Press brewing technique was used according to the Specialty Coffee Association guidelines (Specialty Coffee Association, 2016). The brewed coffee samples were prepared immediately before analysis of pH, total phenol content (TPC), total flavonoid content (TF) and individual phenols. Samples were prepared and analysed in triplicate.

Physical parameter analysis. The moisture content was determined by the following standards: ISO 6673:2003 (green coffee beans); ISO 11294:1994 (roasted coffee beans).

pH analysis. The pH was determined after cooling the coffee brew to room temperature and measured with a “Jenway™ 351101” pH meter (Jenway™, UK).

Proteinogenic amino acid, fatty acid profile, acrylamide content analyses. Roasted coffee beans were shipped to the Hamilton laboratory (Poland) for further analysis. Standard methods were used to assess the proteinogenic amino acids profile (PB-53/HPLC ed. II of 30.12.2008), fatty acids profile (PN-EN ISO 12966-1:2015-01, PN-EN ISO 12966-2:2017-05; except p.5.3 and 5.5, PN-EN ISO 12966-4:2015-07) and acrylamide concentration (PB-39/GC ed. IV of 12.01.2018).

Volatile compound profile analysis. The volatile compound profile was determined by Gloess *et al.* (2013) and Steen *et al.* (2017) methods with modifications. Compounds were extracted by solid phase microextraction (SPME) using carboxen/ polydimethylsiloxane (CAR/PDMS) fibre (Supelco, USA). The diluted coffee brew samples (5 ml) were transferred to a 20 ml glass vial. Extraction parameters were: extraction temperature $+50 \pm 2$ °C; incubation time 4 minutes; and extraction time 7 minutes. Injection parameters were: desorption time 15 minutes and temperature $+250$ °C. For gas chromatography, a “Perkin Elmer Clarus 500” chromatograph with a mass spectrometer and “Elite–Wax ETR column” (60 mx 0.25mm internal diameter; DF 0.25) were used. A flow rate of 1 ml min^{–1} was held using helium as the carrier gas. The compounds were identified using the mass spectral database “Nist98”.

Individual phenol analysis. Individual phenols in brewed coffee samples were analysed using high-performance liquid chromatography (HPLC) as described by Augšpole *et al.* (2018). The HPLC analysis was performed using a “LC–20 Prominence” chromatograph (Shimadzu USA Manufacturing Inc., USA) with a “Perkin Elmer C18” column (4.6 mm, – 250 mm, 5 µm). The diode array detector gradient system (PDA-SPD-M10A) and column were maintained at $+30$ °C. The mobile phase consisted of methanol (A, 20%), water (B, 78.4%) and acetic acid (C, 1.6%). Starting flow rate was 1 ml min^{–1}. The retention times of samples were compared with standards to determine the individual phenolic compounds in coffee samples.

Table 1. Coffee sample roasting parameters and moisture content

Parameters		Green coffee	Light roast	Medium roast	Dark roast
Roast temperature, °C		-	195	200	210
Roast time, min.		-	10	11	12
Colour parameters	L*	-	37.01 ± 0.02	33.94 ± 0.03	27.67 ± 0.02
	a*	-	4.90 ± 0.04	8.57 ± 0.05	5.4 ± 0.05
	b*	-	5.05 ± 0.01	6.16 ± 0.01	4.04 ± 0.01
Moisture content, %		10.7 ± 0	3.0 ± 0	2.2 ± 0	2.0 ± 0

Colour was measured in CIE L*a*b* colour system using colorimeter (ColorTec-PCM, USA).

Total phenol content (TPC). TPC was determined according to the spectrophotometric method using Folin–Ciocalteu reagent (Singleton *et al.*, 1999) with gallic acid as a standard. Folin–Ciocalteu reagent (Sigma–Aldrich Chemie, Steinheim, Germany) (diluted in a ratio 1:10 with distilled water) was added (2.5 ml) to diluted coffee extract (0.5 mL). After 5 minutes, 7.5% Na₂CO₃ solution (2.0 ml) was added. After 30 minutes, the absorbance of samples was measured at $\lambda = 765$ nm using a Jenway 6300 spectrophotometer (Barloworld Scientific Ltd., UK) as described by Laukaleja and Kruma (2019). The total phenolic concentration was expressed as gallic acid equivalents per 100 ml of brewed coffee (mg GAE 100 ml⁻¹).

Total flavonoid concentration (TFC). TFC was determined using spectrophotometry as reported by Niseteo *et al.* (2012) with some modifications. Briefly, diluted coffee extract (0.5 ml) was added to distilled (2.0 ml) water, and then 5% NaNO₂ solution (0.15 ml) was added. After 5 minutes, 10% AlCl₃·6H₂O solution (0.15 ml) was added. After 5 minutes, 1M NaOH solution (1.0 ml) was added, and the flask was mixed. After 15 min of incubation at room temperature, the absorbance of samples was measured at $\lambda = 415$ nm with a Jenway 6300 spectrophotometer (Barloworld Scientific Ltd., UK) (Laukaleja and Kruma, 2019). Total flavonoid concentration was expressed as catechin equivalents (CE) per 100 ml of brewed coffee (mg CE·100 ml⁻¹).

Statistical analysis. The data were reported as means with standard deviations (SD). One-way ANOVA was carried out to determine significant differences in chemical parameters among coffee samples. Significant differences were determined at $p \leq 0.05$. The data were analysed with Microsoft Office Excel 2013. A Principal Components Analysis (PCA) correlation biplot PCA was produced using XLSTAT software (vs. 2020.2.3.65347, XLSTAT, New York, NY, USA).

RESULTS

Moisture content and pH. Moisture content ranged from 10.7% in green coffee and rapidly decreased to 3.0% in light roasted coffee, to 2.2% in medium roasted, and to 2.0% in dark roasted coffee (Table 1). The pH was the highest in green coffee (pH = 5.58) and decreased to pH 5.0 in light roasted coffee, then again increased from pH 5.17 in the medium roasted to pH 5.31 in the dark roasted coffee (Table 1).

Amino acid and fatty acid profile. Among 17 amino acids, 13 showed the highest concentration in medium roasted coffee (Table 2). Only serine and cysteine concentration decreased with increased roast level. At all roast levels glutamic acid had the highest concentration. No association between roast level and amino acid concentration were found by Fisher's exact test. However, strong correlation was observed between several amino acids. Arginine had strong correlation with cysteine ($r = 0.999$; $p < 0.05$), and glutamic acid with glycine ($r = 1.000$; $p < 0.05$). Leucine had strong correlation with alanine, tyrosine, valine, methionine, isoleucine, and phenylalanine ($r = 0.998$; $p <$

Table 2. Amino acid content in different roast level coffee, g·100 g⁻¹

Amino acids	Green coffee	Light roast	Medium roast	Dark roast
Aspartic acid	0.85a	0.68c	0.75b	0.69c
Glutamic acid	1.99b	1.84c	2.15a	2.11a
Serine	0.52a	0.31b	0.3b	0.2c
Glycine	0.65ab	0.58b	0.68a	0.67a
Histidine	0.22a	0.17	0.19	0.18
Arginine	0.6a	0.1b	0.08c	0.057d
Threonine	0.61a	0.53a	0.59a	0.55a
Alanine	0.46a	0.43a	0.51a	0.51a
Proline	0.57b	0.51bc	0.59ab	0.61a
Tyrosine	0.32a	0.28a	0.33a	0.33a
Valine	0.52ab	0.47c	0.53a	0.53a
Methionine	0.14a	0.14a	0.15a	0.15a
Cysteine	0.15d	0.062a	0.045b	0.028c
Isoleucine	0.34a	0.31a	0.35a	0.35a
Leucine	0.85b	0.78c	0.91a	0.92a
Phenylalanine	0.52ab	0.47b	0.55a	0.55a
Lysine	0.58a	0.078c	0.086b	0.077c

Different letters (a, b, c) within a row indicate the statistically significant difference between coffee samples ($p < 0.05$).

Fig. 1. Fatty acid concentration in different roast level coffee.

0.05). Strong correlation was also detected between alanine, tyrosine, valine, methionine, isoleucine, and phenylalanine ($r = 1.000$; $p < 0.05$).

Total saturated fatty acid (SAFA), total monounsaturated fatty acid (MUFA), and total polyunsaturated fatty acid (PUFA) concentrations were the highest in medium roast and the lowest in the light roasted coffee (Fig. 1).

Volatile compound profile. Forty-one compounds from eight chemical classes were detected in all roast levels. Furan compounds in all roast levels had the highest peak area mean percentage, compared to other chemical classes (Table 3). Light roasted coffee had the highest aldehyde, organic acid, and alcohol concentration, while medium roasted coffee had the highest pyrazine and furan concentration, and dark roasted coffee — the highest terpene, phenolic acid, and ketone concentration.

Acrylamide concentration. In light roasted coffee, the acrylamide concentration was 290 $\mu\text{g} \cdot 100 \text{ g}^{-1}$ (Fig. 2). However, acrylamide concentration was highest in medium

Table 3. Sum of volatile compound peak areas per chemical class in coffee beans of different roast levels

Chemical classes	Sum of peak areas, %		
	light roast	medium roast	dark roast
Aldehydes	12.97 a	6.46 c	9.89 b
Organic acids	21.12 a	7.63 c	10.3 b
Alcohols	1.68	-	-
Terpenes	1.22 b	0.79 c	27.80 a
Phenolic acids	0.65 b	0.57 c	1.63 a
Ketones	10.23 b	5.49 c	10.94 a
Furans	29.59 b	51.75 a	28.22 b
Pyrazines	22.53 b	27.32 a	11.21 c

Different letters (a, b, c) within a row indicate the statistically significant difference between coffee samples ($p < 0.05$).

Fig. 2. Acrylamide concentration in different roast level coffee.

roasted coffee ($310 \mu\text{g} \cdot 100 \text{ g}^{-1}$) and then rapidly decreased in dark roasted coffee ($260 \mu\text{g} \cdot 100 \text{ g}^{-1}$).

Total phenolic, flavonoid, and individual phenol compound concentration. The highest total phenolic and flavonoid concentration was found in light roasted coffee ($292.85 \text{ mg GAE} \cdot 100 \text{ ml}^{-1}$ and $18.26 \text{ mg CE} \cdot 100 \text{ ml}^{-1}$, respectively) and the lowest in dark roasted coffee ($246.17 \text{ mg GAE} \cdot \text{ml}^{-1}$; $15.79 \text{ mg CE} \cdot \text{ml}^{-1}$) (Table 4). From 14 phenolic compounds that were detected, nine were phenolic acids (2-hydroxycinnamic acid, 3,5-dihydroxybenzoic acid, 4-hydroxybenzoic acid, caffeic acid, chlorogenic acid,

Table 4. Total phenolic and flavonoid concentration in different roast level coffee brews*

Compound	Light roast	Medium roast	Dark roast
TPC, mg GAE 100 ml^{-1}	292.85 ± 0.05	265.30 ± 0.03	246.17 ± 0.03
TFC, mg CE 100 ml^{-1}	18.26 ± 0.05	16.71 ± 0.04	14.79 ± 0.03

*Data expressed as means $\pm$ standard deviations (SDs)

ferulic acid, gallic acid, p-coumaric acid, and sinapic acid) and five were flavonoids (catechin hydrate, epicatechin, luteolin, rutin, and vanillin) (Table 5). The highest concentration, irrespective of the roast level, occurred for 3,5-dihydroxybenzoic acid and chlorogenic acid, although their concentration decreased most rapidly with roasting. For example, the chlorogenic acid concentration decreased from $117.54 \text{ mg} \cdot \text{ml}^{-1}$ in light roasted coffee to $53.0 \text{ mg} \cdot \text{ml}^{-1}$ in dark roasted coffee. Only sinapic and 4-hydroxybenzoic acid increased with the increased roast level.

PCA plot. Principal Component Analysis (PCA) was used to visualise the roasting effect on the chemical compound profile (Fig. 3). The first Principal Component represents effect of the roast level on chemical compound composition. The second component separated the samples based on the amino acid concentration in medium roasted. Light roasted coffee showed a positive association with most phenolic compounds and a negative association with fatty acid concentration. Medium roasted coffee had strong association with aspartic, lysine, and acrylamide concentration.

DISCUSSION

Moisture content and pH. Moisture content in the sampled green coffee beans was similar to that reported in other studies, under 11%, which is suggested to maintain the quality standards for specialty coffee (Borém *et al.*, 2016; Tolessa *et al.*, 2016). Some studies have linked moisture content with pH in coffee (Lee *et al.*, 2017). The pH level

Table 5. Means of individual phenol compound concentration in different roast level coffee brews

Coffee sample	Means of concentration $\pm$ standard deviations, $\text{mg} \cdot 100 \text{ ml}^{-1}$		
	light roast	medium roast	dark roast
Gallic acid	$0.02 \pm 0.03\text{b}$	$0.07 \pm 0\text{a}$	$0.07 \pm 0\text{a}$
3,5-Dihydroxybenzoic acid	$217.24 \pm 0.96\text{a}$	$182.68 \pm 0.63\text{b}$	$114.81 \pm 0.45\text{c}$
Catechin hydrate	$2.54 \pm 0.19\text{a}$	$2.62 \pm 0.10\text{a}$	$1.91 \pm 0.14\text{b}$
4-Hydroxybenzoic acid	$1.95 \pm 0.04\text{c}$	$2.92 \pm 0.02\text{b}$	$3.66 \pm 0.08\text{a}$
Chlorogenic acid	$117.54 \pm 3.41\text{a}$	$96.00 \pm 1.12\text{b}$	$53.50 \pm 1.62\text{c}$
Caffeic acid	$1.34 \pm 0.88\text{c}$	$2.14 \pm 0.09\text{a}$	$1.82 \pm 0\text{b}$
Epicatechin	0.19 ± 0	-	-
Vanillin	$0.18 \pm 0.03\text{a}$	$0.15 \pm 0\text{b}$	$0.08 \pm 0\text{b}$
p-Coumaric acid	$0.04 \pm 0.01\text{a}$	$0.01 \pm 0\text{b}$	$0.01 \pm 0\text{b}$
Sinapic acid	$0.85 \pm 1.21\text{b}$	$2.07 \pm 0.02\text{ab}$	$2.46 \pm 0.01\text{a}$
Ferulic acid	$0.05 \pm 0\text{b}$	$0.06 \pm 0\text{a}$	$0.06 \pm 0\text{a}$
2-Hydroxycinnamic acid	$0.06 \pm 0.02\text{a}$	$0.03 \pm 0\text{b}$	$0.02 \pm 0\text{b}$
Rutin	$9.70 \pm 0.32\text{a}$	$7.40 \pm 0.22\text{b}$	$3.37 \pm 0.31\text{c}$
Luteolin	$0.72 \pm 0.50\text{a}$	$0.36 \pm 0\text{b}$	$0.34 \pm 0.01\text{b}$

Different letters (a, b, c) within a row indicate the statistically significant difference between coffee samples ($p < 0.05$).

Fig. 3. Principal Component Analysis of chemical composition in different roast level coffee (variables in **bold** - amino acids; variables in *italic* – fatty acids; variables with underline – individual phenolic compounds; variables with dotted underline – important volatile compounds).

increased with increased roast level in a study by Rao *et al.* (2020). Previous studies also support that pH level is determined by aliphatic acid formation from carbohydrate degradation during roasting. For example, formic acid and acetic acid are associated with a lower pH level in light roasted coffee (Ginz *et al.*, 2000; Borém *et al.*, 2016; Rao, Fuller and Grim, 2020).

Amino acid and fatty acid profile. Level of roasting did not show direct association with the amino acid profile. In line with previous studies, glutamic and aspartic acids are the dominant amino acids in roasted coffee (Bressanello *et al.*, 2017). However, the present study did not confirm previously reported rapid degradation of amino acids with increased roasting level (Guenther *et al.*, 2007; Wei *et al.*, 2017). Only arginine and serine showed large decrease in concentration during roasting, as reported previously (Moreira *et al.*, 2012). The changes of fatty acid profile are in line with previous studies. The higher fatty acid content in medium roasted coffee can be explained by lipid degradation (Lee *et al.*, 2017). The lipid degradation suggests the fatty acid concentration would be higher in dark roasted coffee, but this was not detected in our study. A possible explanation is that phenolic compound inhibited lipid oxidation (Hu *et al.*, 2019).

Total and individual phenol, flavonoid content. The degradation of phenolic acid and flavonoid compounds with increasing roast level explains the decrease of total phenol and flavonoid concentration. Chlorogenic and 3,5-dihydroxybenzoic acids have been reported as the most abundant phenolic compounds in coffee. These two compounds are suggested to be responsible for melanoidin formation (Moreira *et al.*, 2012; Coelho *et al.*, 2014). However, only chlorogenic acid has been associated with potential antioxidative activity in coffee, even if the 3,5-dihydroxybenzoic acid concentration is higher (Alcalde *et al.*, 2019).

Chlorogenic acid thermal degradation can result in formation of other compounds with potential antioxidative activity, one of which is caffeic acid (Kamiyama *et al.*, 2015) and this study results confirmed that caffeic acid concentration increased with roast level. Another possible reason for rapid degradation of chlorogenic acid at a light roast level is its transformation into chlorogenic acid lactones (Farah *et al.*, 2005). Budryn *et al.* (2015) observed that chlorogenic acid starts to degrade to chlorogenic acid lactones rapidly when the roasting temperature is above 203 °C.

Volatile compound profile. The high proportion of furan compounds compared to other chemical classes can be explained by their formation from carbohydrate and amino acid degradation at first, but with longer roast period furans from polysaturated acid oxidation (Petisca *et al.*, 2012; Gruczyńska *et al.*, 2018; Cordoba *et al.*, 2019). The increase of the volatile phenolic compound concentration is associated with phenolic compound degradation. For example, caffeic acid degradation in dark roasted coffee results in formation of volatile phenols such as 2-methoxy-4-vinylphenol. In the PCA plot, dark roasted coffee had positive association with 2-methoxy-4-vinylphenol and 2-methoxyphenol (Kamiyama *et al.*, 2015). These phenolic volatile compounds are associated with a smoky, spicy, and even burnt aroma (Brattoli *et al.*, 2013; Poltronieri and Rossi, 2016). Similar to phenolic acids, volatile organic acid concentration decreased with increased roast level, because of thermal instability. Organic acids such as acetic and formic acids are formed in roasting from carbohydrates. Ginz *et al.* (2000) reported that organic acids start to degrade at a medium roast level (above 240 °C), but in that study roasting occurred for only three minutes. The negative correlation between phenolic and volatile organic acid concentration confirmed the pH increases with the roast level. Therefore, dark roasted coffee could be more tolerable for coffee consumers with gastro esophageal reflux symptoms. However,

these consumers should be aware of the caffeine concentration also (Wei *et al.*, 2019; Zaman *et al.*, 2019). The PCA plot shows association of light roasted coffee with volatile compounds like benzyl alcohol and 4-hydroxy-2,5-dimethyl-3(2H)-furanone, which are associated with fruity, floral and caramel taste in other studies as well as with positive impact on coffee aroma quality (Toledo *et al.*, 2016; Pereira *et al.*, 2019).

Acrylamide content. Acrylamide formation often is associated with the Maillard reaction (reaction between reducing carbohydrates and asparagine). However, there was no association found between aspartic acid (asparagine) and acrylamide content in coffee in the present study. Some studies indicated that acrylamide could be formed through amino-dehydroxylation, or through pyrolytic reactions (which involves serine and cysteine) by converting pyruvic acid to lactic acid and generation of acrylamide (if ammonia is present) (Guenther *et al.*, 2007; Bagdonaite *et al.*, 2008). This might explain the results of our study, because the decrease of serine and cysteine concentration at a light roast level could be explained by their involvement in acrylamide formation. Scientific opinions vary about the peak point of acrylamide concentration decrease. Bagdonaite and Murkovic (2004) observed the highest acrylamide concentration after the first five minutes of roasting, both at 220 and 240 °C. In contrast, Bertuzzi *et al.* (2020) reported the acrylamide peak level after 10 minutes of roasting at 175–177 °C and rapid decrease after 14 minutes of roasting at 203–205 °C. In our study, the acrylamide content was lower than Regulation (EC) No. 852/2004 Benchmark levels for the presence of acrylamide in roasted coffee (400 µg·kg⁻¹) (Commission Regulation (EU) 2017/2158). The coffee brewing method can also influence the acrylamide extraction. Bagdonaite and Murkovic (2004) and Michalak *et al.* (2020) reported that extraction time and grind size have the strongest correlation with acrylamide concentration in the brew.

CONCLUSIONS

The highest total and individual phenolic and flavonoid concentration was found in light roasted coffee (291.85 mg GAE·ml⁻¹; 18.26 mg CE·ml⁻¹) and it decreased with increased roast level. From a volatile compound point of view, the light roasted coffee had higher concentration of volatiles associated with fruity, creamy, and caramelised aroma, flavour characteristics, while the dark roasted coffee had higher concentration of volatiles, such as phenolic acids, which are associated with smoky, burnt aroma, flavour characteristics. Dark roasted coffee had the lowest acrylamide concentration, organic acid content, and the highest pH in coffee brew, which would be more suitable for coffee consumers with gastro esophageal reflux symptoms.

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GRAUzdēšanas PROCESA IETEKME UZ KOLUMBIJAS KAFIJAS ĶĪMISKO SASTĀVU

Pētījuma mērķis bija novērtēt ķīmiskā sastāva izmaiņas trīs dažāda grauздējuma pakāpēs (gaiša, vidēja, tumša) kafijā no Kolombijas. Gaiša grauздējuma kafijā tika konstatēti lielāks kopējo un atsevišķo fenolu, flavonoīdu saturs, kas samazinājās līdz ar grauздēšanas pakāpes palielināšanos. Hlorogēnskābe un 3,5-dihidroksibenzoskābe uzrādīja proporcionāli lielāko koncentrāciju starp 14 atsevišķiem fenolu savienojumiem. Fenolu savienojumu noārdīšanās veidojusi gaistošos fenolus, kā 2-metoksifenols ar dūmakainu, deguma aromātu, kura koncentrācija attiecīgi bija lielāka tumša grauздējuma kafijā. Gaiša grauздējuma kafijā ir lielākais organisko skābju saturs un mazākais pH. Akrilamīda koncentrācija sasniedza augstāko vērtību vidēja grauздējuma kafijā un strauji samazinājās tumša grauздējuma kafijā. Nevienā no grauздēšanas pakāpēm netika pārsniegta pieļaujamā akrilamīda koncentrācija salīdzinājumā ar Eiropas Nekaitīguma iestādes noteikto references līmeni grauздētā kafijā ($400 \mu\text{g}\cdot\text{kg}^{-1}$). Cilvēkiem, kurus apmierina kafijas skābums, būtu ieteicama viegla grauздējuma kafija, kurā arī ir lielākā fenolu savienojumu koncentrācija. Savukārt kafijas patērētājiem ar gastroezofageālā atpūlņa simptomiem būtu ieteicams izvēlēties tumša grauздējuma kafiju, kurā ir mazāks skābju saturs.