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Extraction of espresso coffee by using gradient of temperature. Effect on physicochemical and sensorial characteristics of espresso

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ABSTRACT

Espresso extraction is generally carried out at a fixed temperature within the range 85–95 °C. In this work the extraction of the espressos was made in a new generation coffee machine that enables temperature profiling of the brewing water. The effect of using gradient of temperature to brew espressos on physicochemical and sensorial characteristics of the beverage has been investigated. Three different extraction temperature profiles were tested: updrawn gradient (88–93 °C), downdrawn gradient (93–88 °C) and fixed temperature (90 °C). The coffee species investigated were Robusta, Arabica natural and Washed Arabica. Results proved that the use of gradient temperature for brewing espressos allows increasing or decreasing the extraction of some chemical compounds from coffee grounds. Moreover an appropriate gradient of temperature can highlight or hide some sensorial attributes. In conclusion, the possibility of programming gradient of temperature in the coffee machines recently introduced in the market opens new expectations in the field of espresso brewing.

1. Introduction

The quality of brew coffee depends on multiple factors such as coffee species (Campa, Doulbeau, Dussert, Hamon, & Noirot, 2005; Maeztu et al., 2001) coffee blends (Fujioka & Shibamoto, 2008); bean roasting conditions (Blumberg, Frank, & Hofmann, 2010; Cavaco Bicho, Leitao, Cochicho Ramalho, de Alvarenga, & Cebola Lidon, 2011; Ludwig, Bravo, de Peña, & Cid, 2013; Nunes, Coimbra, Duarte, & Delgadillo, 1997), grinding of the roasted coffee beans (Andueza, de Peña, & Cid, 2003a) and in a great extension the brewing method i.e. drip, espresso (Gloess et al., 2013). One of the most popular presentations of coffee brews in South-Europe is the Italian espresso. Italian espresso coffee has been defined as a beverage prepared on request by extraction of ground roasted coffee beans (6.5 ± 1.5 g), with hot water (90 ± 5 °C) under pressure (9 ± 2 bar) for a defined short time (30 ± 5 s) (Illy & Viani, 1995). In the espresso brewing process, key operation variables of an espresso coffee are: grinding, ground coffee portion, tamping, water quality (Navarini & Rivetti, 2010), and also some parameters controlled by the coffeemaker such as extraction temperature, water pressure and percolation time that clearly influence the final quality of the coffee brew. During the last decade, there has been growing interest in studying the influence of some of these parameters on the quality of espresso coffee. The comparison of espressos obtained by different common coffee makers such as capsules or automatic and semi-automatic coffeemakers was studied by Gloess et al. (2013) in terms of chemical analytical methods and sensory analysis. Andueza et al. (2002) studied the influence of water pressure on the quality of arabica espresso coffee. The same authors investigated the influence of extraction temperature in the quality of espressos obtained from different coffee varieties (Andueza et al., 2003b). Results of this study evidenced differences in terms of body, flavor characteristics and overall acceptability of espresso coffees due to extraction temperature, and also differences as a function of the coffee varieties.

Thus, the selection of the optimal extraction temperature in terms of overall acceptability should consider aspects related to physico-chemical characteristics, and odour and flavor components. In some cases, optimal extraction temperature is selected when positive and negative aspects are balanced or when positive ones are predominant in the cup. In this sense, the extraction of compounds that increase components related to positive aspects while avoiding the extraction of components related to decrease the coffee quality is a challenge in the coffee industry research. In this context, the initial hypothesis of our research was that by

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controlling the espresso dispensing temperature the extraction of the different components of coffee and resulting flavor would be satisfactorily modulated in the espresso cup so as to obtain an espresso of good quality. Recently, Rancilio Group (www.ranciliogroup.com), a reputed espresso machines manufacturer has implemented in one model of their coffee machines a revolutionary technology for the temperature profiling of the brewing water for espresso coffee.

In this study, the influence of using extraction temperature ramps on physico-chemical properties and sensorial attributes of espressos obtained from three different coffee varieties has been investigated.

2. Materials and methods

2.1. Coffee samples

Samples of ground roasted coffee, Robusta natural (pure *Coffea canephora*) (R), Arabica natural (pure *Coffea Arabica*) (A) and washed Arabica (WA) were provided by a local company. The differences between natural and washed coffee are related to the methods used to extract the seed from the coffee cherry. Natural coffee is obtained by drying the cherries in the sun and washed coffee by immersing the cherries in water tanks where fermentation takes place (Odello & Odello, 2002). The beans of the selected types of coffee were roasted by a coffee roasting company at a roast point 7 over 10 (dark medium). The beans were ground just before the espresso preparation by means of a coffee grinder (MACAP MXDL, Italy) that allows regulation of ground coffee size. In order to obtain espressos in an appropriated volume (25 ± 2.5 mL) and in a fixed percolation time (25 ± 5 s) (Odello & Odello, 2002) it was necessary to find the appropriate grade of grinding for each coffee type and ramp of extraction temperature. The search of the appropriate grinding point was made by trial and error that is, by grinding the beans using different positions of the grinder blades and measuring the volume and the extraction time of the obtained espressos by following the procedure specified in Section 2.4. As it was reported that particle size distribution of ground coffee beans can affect aroma and flavor of espressos (Andueza et al., 2003a), particle size distribution of all the selected grinding grades was determined For that purpose 100 g of each ground coffee sample was grinded and sieved by using a digital sieve shaker (CISA BA200N, Spain). Particle size fractions were separated by using 8 sieves (1000, 630, 500, 400, 250, 150, 100 and 50 μm). Coffee fraction of each sieve was weighed and expressed as percentage. Particle distribution was determined in triplicate and the average is presented.

2.2. The coffee machine

Espressos were prepared by using a XCELSIUS Classe 9 Rancilio coffeemaker (Rancilio Group, Italy). The XCelsius system enables the temperature of the brew water to be set dynamically, with an increase or decrease of up to 5 °C during the 25–30 s it takes for each individual delivery. The coffee machine used in the present study possesses three extractors. The independent nature of the extractor group heads allows programming upward and descent gradients of temperature within the range (85–95 °C) for each extractor independently. The temperatures of the three extractors were programmed according to three specific thermal profiles: increasing temperature profile from 88 to 93 °C (ramp-up), decreasing temperature profile from 93 to 88 °C (ramp-down) and fixed temperature at 90 °C. The relative water pressure was fixed at 9 atm.

2.3. Water for coffee extraction

For coffee extraction commercial bottled water was used. The water quality analysis shown on the bottle label reports the following composition: bicarbonate (113 mg L^{-1}), calcium (27.7 mg L^{-1}), chloride (5.7 mg L^{-1}), fluoride (0.9 mg L^{-1}), magnesium (4.5 mg L^{-1}), potassium (4.9 mg L^{-1}), dry residue (139 mg L^{-1}), sodium (11.9 mg L^{-1}) and sulphate (11.2 mg L^{-1}). Taking into account calcium and magnesium concentration, the mineral water used in this study can be classified as soft water.

2.4. Espressos extraction

Two espressos were prepared in each extractor from 15 ± 0.5 g of coffee powder (Istituto Nazionale Espresso Italiano (www.espressoitaliano.org) compacted by using a dynamometer coffee press (MACAP NS 1106/0791). The volume of the two espressos obtained in each extractor was of 25 ± 2.5 mL and the percolation time was 25 ± 5 s to avoid over-extraction of substances with poor flavours (Illy & Viani, 1995).

An experimental design of two factors, type of coffee (R, A and WA) and extraction temperature profile (88–93 °C, 90 °C and 93–88 °C) was considered. A total of 18 samples of espressos obtained in the same conditions (type of coffee and temperature profile) were analyzed.

2.5. Physicochemical characterisation of espressos

2.5.1. Foam index and persistence of foam

Foam volume and coffee volume of the espressos were measured immediately after the extraction by using a graduated borosilicate glass cylinder. Foam index was calculated as the ratio of foam and liquid volumes measured after the extraction. Foam persistence was measured as the time that foam persists while the espresso is cooling down at room temperature. Persistence time was measured when dark round spot appeared under the foam layer (Andueza et al., 2003a).

2.5.2. Total volume, density, pH and viscosity

Espressos were cooled to room temperature (20 ± 2 °C) before measuring total coffee brew volume in a 100 mL graduated cylinder; pH in a pH meter (Crison micro pH 2000), density in a 20 mL glass pycnometer and viscosity with an Ostwald viscometer (Proton 100) (Andueza et al., 2003a). Turbidity was measured in a turbidity meter (Hanna LP2000). For turbidity measurements, 0.4 mL of espresso was diluted to 100 mL in a volumetric flask.

2.5.3. Total solids and filtered solids

Total solids were determined by drying 10 mL of espresso coffee in an oven at 100 °C for 24 h. Filtered solids were determined by weighting the dried solids retained in a glass microfiber filter 1.2 μm (Filter-Lab®) after filtering 10 mL of espresso. Drying was performed in an oven at 100 °C until constant weight.

2.5.4. Lipid content

Total lipids content was determined by liquid-liquid extraction with hexane (n-Hexane 99%, reagent grade Scharlau) following the methodology proposed by Parenti et al., 2014. 50 mL of espresso was extracted by adding 20 mL of hexane three times in a separating funnel. The organic fraction was washed with 60 mL of distilled water three times. Solid sodium sulphate anhydrous powder (Scharlau) was added to remove water from the hexane extract and then the solid was filtered by a paper filter. The total lipid content was calculated by weight after solvent evaporation.