Electronic Supplementary Information for

Impact of crema on the aroma release and the in-mouth sensory perception of espresso coffee

Denis Barron,*[a] Nicolas Pineau,[a] Walter Matthey-Doret,[a] Santo Ali,[a] Julien Sudre,[a] Juan Carlos Germain,[a] Eric Kolodziejczyk,[a] Philippe Pollien,[a] David Labbe,[a] Christian Jarisch,[b] Valentine Dugas,[b] Christoph Hartmann,[a] Britta Folmer[b]

[a]Nestle Research Center, P.O. Box 44, CH-1000 Lausanne 26, Switzerland; E-mail: Denis.Barron@rd.nestle.com
[b]Nestlé Nespresso S.A., Avenue de Rhodanie 40, 1007 Lausanne, Switzerland

Crema physical characterization

Abstract - A set of six espresso coffees with different foam characteristics and similar above cup and in-mouth flavour sensory profiles was produced by combination of two varying parameters, the extraction pressure and the filtration of the coffee beverage. The coffees were subsequently evaluated in a comparative manner by a set of analytical (headspace, nose-space) and sensory (Temporal Dominance of Sensations) techniques. The presence of espresso crema in its standard quantity was demonstrated to be associated to the optimum release of pleasant high volatiles, both in the above cup headspace and in-mouth. On the other hand, the TDS study demonstrated that increasing amount of crema was associated to increasing roasted dominance along coffee consumption. Furthermore, a parallel was established between the roasted sensory dominance and the dominant release of 2-methylfuran in the nose-space. This was however an indirect link as 2-methylfuran was indeed a chemical marker of roasting but did not contribute to the roasted aroma. Lowering the standard amount of crema by filtration clearly decreased the release of pleasant high volatiles and the in-mouth roasted sensory dominance. On the other hand increasing the usual crema volume by increasing the extraction pressure did not bring any added value concerning the above cup and in-mouth release of pleasant high volatiles.

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1 Experimental

1.1 General

For this purpose, two sets of static and dynamic measurements were used. The first set of static measurements involved the determination of crema volume, bubble size distribution, and mechanical stability. All the static experiments were performed 90 seconds after coffee preparation (time after the last drop of coffee has fallen into the cup). The second set of dynamic methods included the measures of the crema liquid drainage, volume decay, and evolution of surface brightness. In this case experiments were conducted from 15 seconds to 5 minutes after coffee preparation.

1.2 Crema volume

This was measured directly inside the cup. An electronic digital calliper (Garant 15 mm - 0.01 mm, Hoffman-Groupe, Munich, Germany) was mounted onto an acrylic base with a gap in the middle that allows the calliper to sit over the cup while letting the measuring tool to pass through. During measurements, the zero level was established at the upper edge of the cup and the heights of the air/crema and crema/ liquid interfaces were recorded by placing first the tip of the calliper on top of the crema in the centre of the circumference of the cup, and then exactly at the liquid/crema interface outside the cup. A tool consisting of two rulers fixed together at the same level was used while reading the height values to avoid errors due to parallax. For translating height measurements into volume values, a cup calibration procedure was performed. The calibration consists in precisely adding step wise (5 mL at a time) pure water into the cup, and at each step record the interface position with the calliper. The resulting volume versus distance curve were then fitted with a third order polynomial equation that is used to estimate the amount of crema volume contained in the cup from the difference between the corresponding fill volumes of coffee liquid plus crema and coffee liquid alone. For each of the coffee samples, ten repetitions were performed and measurements were done 90 seconds after coffee preparation.

1.3 Bubble size distribution

This was determined with a dispersion technique consisting in diluting the sample in a viscous medium using glycerol and stabilizing the air bubbles interfaces with acetic acid and acetone. A small amount of crema (0.25-0.50 g) was transferred into a dispersing device filled with 20 g of dispersing medium, and installed onto a balance. After carefully mixing the crema with the medium, a volume of 2 x 500 µL of the resulting dispersion was transferred into a dispersion chamber, and images were taken with a BX51 research microscope (Olympus, PA, USA) connected to an Infinity 2 digital camera (Lumenera, Ontario, Canada). Image acquisition and image analysis were carried out using an in- house software designed to carry out fully automated batch analysis. Crema samples were analyzed in triplicate.

1.4 Liquid drainage and volume decay

Liquid drainage of coffee crema was followed dynamically inside the cup by using computer-assisted macroscopic imaging and image analysis. The method consisted in placing the freshly prepared coffee cup inside a dark chamber directly in front of an Infinity 2 digital microscope camera (Lumenera, Ontario, Canada) connected to a zoom lens 18-108/2.5 (Computar, California, USA) and illuminated using a light ring TL-E Circular 22W/33-640 (Phillips, The Netherlands). The camera, focused at the middle of the cup at the crema/liquid interface, was used to take a time image sequence. Images of the draining coffee crema were taken every 15 seconds during 5 minutes (first image was taken 15 seconds after coffee was prepared, time required to

transfer the cup and initiate image acquisition). Both, image storage and following analysis were done using in-house developed software (Colibri). Quantitative analysis of the liquid drainage was performed by selecting the analysis region over the image and calculating then the liquid area in every picture of the time sequence. Data was normalized by equating the area at t = 0 s to 100 %. All samples were analyzed in triplicate. Volume decay analysis was performed using similar methodology to the one employed to determine the liquid drainage, except that in this case the selected analysis region was centred on the crema rather than on the liquid phase.

1.5 Brightness surface analysis

Dynamic in-cup foam surface characterization was done by preparing the coffee sample and immediately placing the cup inside a dark chamber. The crema surface was illuminated from the top using a luminous ring (Schott S40-55, Schott AG, Germany) and digital images were taken with a camera Infinity 2 digital microscope camera (Lumenera, Ontario, Canada) connected to a macro zoon 18-108mm F72.5 lens (Navitar, Rochester NY, USA) every 15 seconds during 5 minutes (first image was taken 15 seconds after coffee was prepared, time required to transfer the cup and initiate image acquisition). The resulting color images were converted to grey level and then analyzed quantitatively by determining the mean intensity pixel value using in-house developed software (Colibri). For each sample, the surface brightness was calculated as the mean value of all the isolated pixels of the image forming part of the coffee surface after grey-scale transformation. (from 0 = black to 255 = white). The changes in surface brightness were measured over time. From this data, the slope of the surface brightness decay was calculated.

1.6 Mechanical stability

Approximately 3.4 g (± 5%) of corn flour (corn semolina yellow, 400µm) were deposited inside the cup on top of the crema with a manual kitchen sieve placed directly on top of the cup and operated only once. For each sample, 10 repetitions were performed and measurements were done by letting the corn flour fall on top of the crema exactly 90 seconds after coffee preparation.

2 Results and discussion

The results of the physical characterization of crema are displayed on Fig. 1. There was usually not much physical difference between the filtered coffees inside each pressure series. Crema volumes (Fig. 1A) were measured by the electronic calliper method. The two unfiltered coffee samples (NP and HP) displayed higher crema volumes, with HP significantly higher than NP. Conversely no significant difference was found between the filtered samples NPtd, HPtd, NPtl and HP tl. Concerning the bubble size (Fig. 1B), small but significant differences were evidenced. Unfiltered coffees both displayed drainage (Fig. 1C; HP >> NP) while filtered coffees did not. The volume decays (Fig. 1D) of the two high pressure samples (HP and filtered HP) tent to be higher than those of normal pressure samples (NP and filtered NP). The volume decays of unfiltered coffees NP and HP also tent to be higher than those of the corresponding filtered ones (Fig. 1D). On the other hand the filtration increased the brightness decay (Fig. 1E), i.e. filtered coffees darkened faster as the crema aged. Finally concerning the crema mechanical stability (Fig. 1F), no significant difference was found between the filtered samples. HP and NP unfiltered coffees displayed by far the most mechanically stable crema.

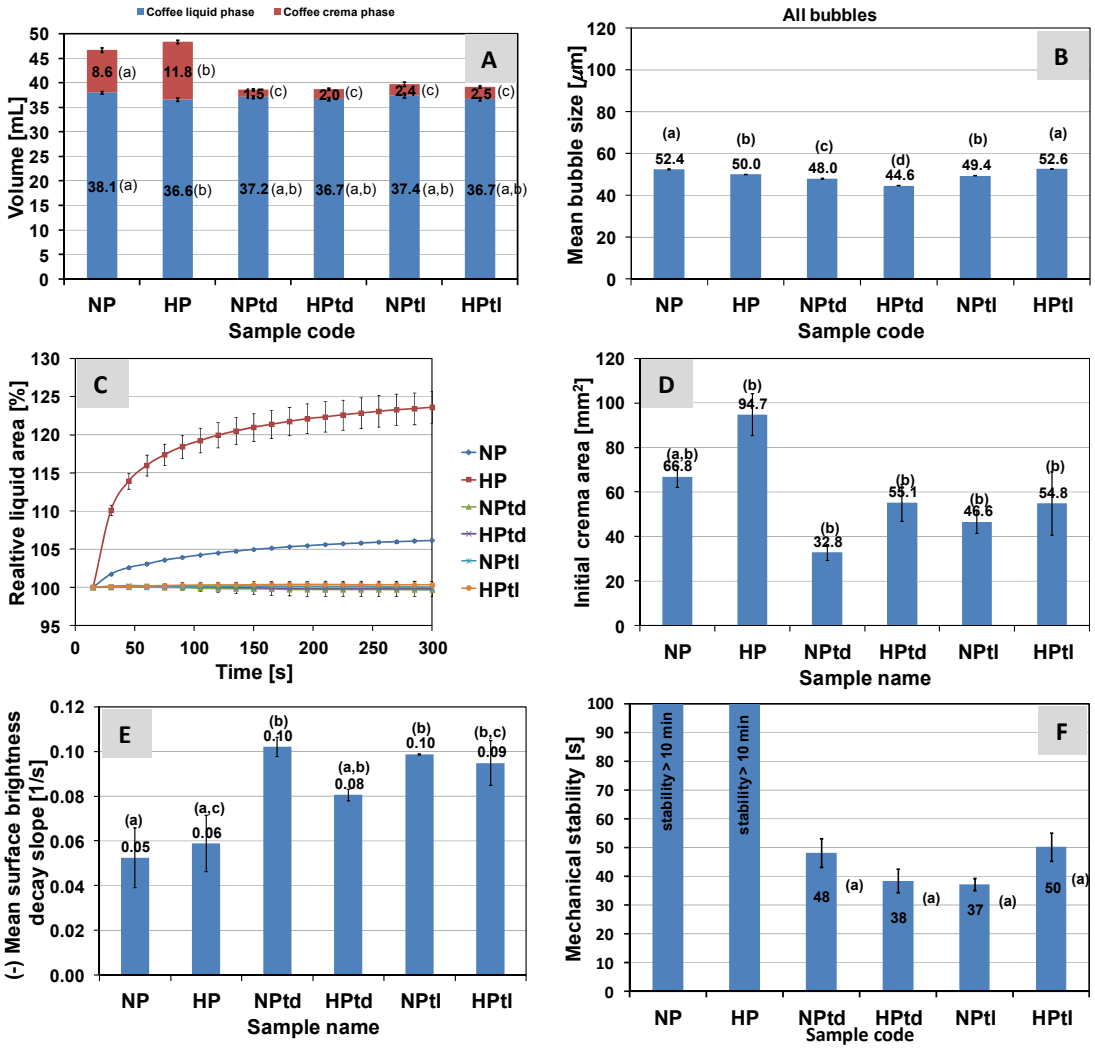

Fig. 1 The physical characterization of the crema of espresso coffees. A: Coffee crema (red) and coffe liquid phase (blue) volumes. B: All bubble size distribution. C: Liquid drainage. D: Crema volume decay. E: Crema brightness. F: Crema mechanical stability. The coffee codes and preparation parameters were as displayed in Table 1 of the paper.