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Charting Water for Better Coffee

If there is one aspect of speciality coffee that we can all agree on, it is that the quality of our water is essential for brewing great coffee. But how do we consistently ensure that high quality water brings out the best our coffee has to offer while keeping our equipment in good working order?

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Aside from being essential to equipment maintenance, if the water used for extraction is unsuitable it can mask a coffee's full flavour and aroma potential. Given the seemingly never-ending cascade of facts and information about the diverse properties of water, it is difficult to build a clear picture when it comes to calibrating our water for brewing consistently delicious speciality coffee.

This is particularly important when we consider the many different compositions of water used for brewing around the world in cupping labs, roasteries, coffee shops and at home. In order to provide some further clarity on this hotly debated subject, the new *SCAE Water Chart: Measure, Aim, Treat* establishes a solid foundation for a unified and transparent discussion around water for coffee.

Introduced to the coffee community at the Re:co Symposium in Dublin earlier this year, the SCAE Water Chart sets out a handy framework for promoting an exchange of ideas about the quality of the water that we use for different brewing methods.

Developed by Marco Wellinger and Samo Smrke at the Zurich University of Applied Sciences (ZHAW) under the guidance of the Head of SCAE's Research Committee, Chahan Yeretzian, the SCAE Water Chart seeks to address three fundamental questions:

- **Measure:** What is the composition of my water in terms of total hardness and alkalinity?
- **Aim:** What composition should I target with regard to sensory and technical considerations?
- **Treat:** How do I choose a treatment to get me there?

While there are many complex parameters and phenomena in water science that affect cup quality, the SCAE Water Chart focuses on two of the most crucial drivers for coffee extraction; total hardness and alkalinity. For the large majority of tap water compositions, this represents the most practical approach to achieve a water composition that allows for optimal extraction conditions. »

Just as the Coffee Brewing Chart, introduced in the late the 1950s, has established itself as a generally recognised method to consistently and properly brew a cup of coffee, we expect that the SCAE Water Chart will become a reference on how to approach the subject of water for coffee extraction.

What do we need to measure?

As we know, pure water consists of two hydrogen atoms combined with one oxygen atom to give us the chemical formula H_2O. However, as water is such a good solvent, many other chemical compounds become dissolved in water, which is why water has a relatively high electrical conductivity. The illustration below shows one of the most common graphs used by water treatment specialists or scientists when investigating the characteristics of water.

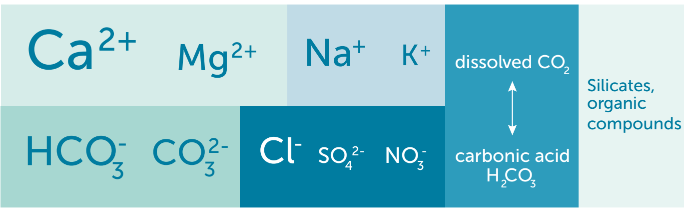

Figure 1: *Overall composition of water*

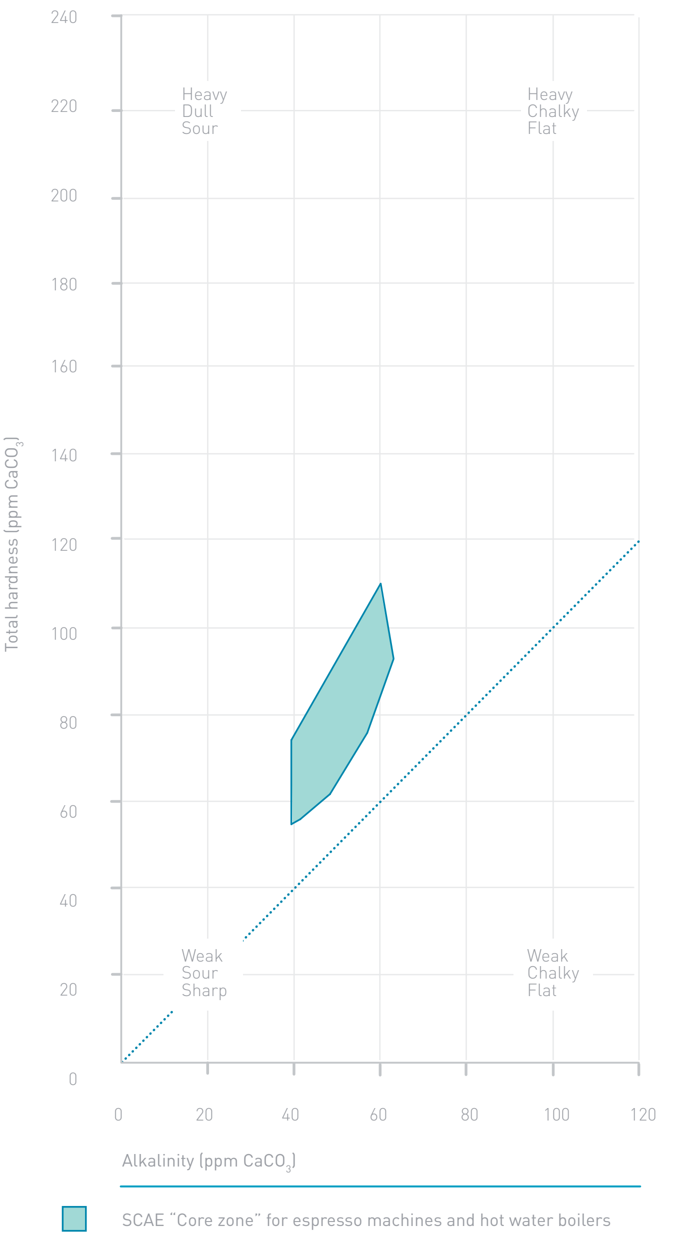

Figure 2: *SCAE Water Chart's recommended 'core zone' for total hardness and alkalinity*

To the left of figure 1, we can see that the positive on the upper level and negative ions below are always of equal size. This is because water must always meet charge neutrality — in other words, the positive charge must be equal to the negative charge. The positive ions are most commonly dominated by magnesium (Mg^{2+}) and calcium (Ca^{2+}), making up total hardness, but Sodium (Na^+) and Potassium (K^+) also commonly occur. The negative ions are usually mostly Hydrogencarbonate (HCO_3^-), which makes up the alkalinity, but Sulfates (SO_4^{2-}), Chlorine (Cl^-) and Nitrate (NO_3^-) also often occur.

The middle section illustrates the dissolved uncharged solids in water such as carbon dioxide and its aquatic twin, carbonic acid. Finally, the right element of figure 1 shows the uncharged components found in water. These are namely silicates or organic compounds that make up a fraction of the dissolved solids present.

Although the concept of total hardness treats magnesium and calcium ions as equals, it can be a very helpful yardstick when measuring the quality of a water's given composition. By using this calculation, predictions about the general effects of water on flavour can be made – and crucially, a direction for choosing an appropriate water treatment can be formulated.

Locally available data on water quality can be obtained freely from most providers. These often include a detailed report which breaks down essential information on a whole host of different parameters such as chemical composition, including alkalinity and total hardness and pH of the tap groundwater supplied to a specific area.

What water should I be aiming for?

First, water for coffee extraction should be odour-free and hygienic. The water should be completely free of chlorine, hypochlorite and chloramines, as well as taste-influencing organic compounds. These can impart a strong unpleasant flavour in the resulting brew – even at concentrations which are not perceivable in the water itself. The following two parameters set out a solid foundation for good water composition:

- Total hardness relates to the sum of essential flavour carriers such as magnesium (Mg) and calcium (Ca) in equivalent concentrations in water. The recommended range of total hardness is within 50-175 ppm $CaCO_3$
- Alkalinity is the concentration of acid-neutralising ions in water, primarily hydrogencarbonate (HCO_3^-). Alkalinity has a direct influence on the attenuation/buffering of acids extracted from coffee, so high alkalinity results in decreased acidity of the beverage. The recommended alkalinity should be at or near 40 ppm $CaCO_3$ with an acceptable range of 40-75 ppm $CaCO_3$.

Left (Figure 2) is an illustration of SCAE's 'core zone' for coffee extraction using a two-way axis of total hardness versus alkalinity.

What is the best water treatment for brewing better coffee?

It can be expected that most supplies from a single groundwater source will have a high degree of stability. On the other hand, if multiple sources feed the tap water network, daily and seasonal variations in water composition may occur. If this is the case, closer monitoring may be required to detect changes from one day to the next, or over the course of a year.

A good way to measure and detect changes in the water supply is with the use of an instrument called a conductivity meter – sometimes referred to as TDS meter. However, this should not be

FILTER COFFEE PREPARATION

- Brew ratio: 14.8 (325 mL water at 92°C/22 g coffee)
- Brew method: V60
- Extraction time: 3:30 minutes
- Extraction yield: 20%

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confused with refractometers which measure the strength (% TDS) of a beverage. Although this will give only a very rough estimate of a total solids content, it is a simple and inexpensive way to monitor and detect changes in the water composition of a tap source – or the efficiency of a water treatment system. Since changes in water composition can be detected by its conductivity, it offers the opportunity to monitor water quality in real-time.

After measuring the initial water composition and deciding on a target for a desired water quality, the next crucial step is to choose a suitable treatment where there is a need to modulate water for coffee extraction. From commonly used ion-exchangers, such as softeners or decarbonizers, or reverse osmosis methods, there is a wide range of single or multiple water treatment systems available commercially to suit the vast majority of needs. A more detailed analysis of water treatment systems is provided in the Water Chart, circulated with the autumn issue of *Café Europa* and available freely to SCAE members as a download in the resource area of the website.

The Study

Considering the huge range of different coffee origins and varieties, roasting profiles, extraction techniques and sensory preferences, Chahan Yeretzian states: 'The SCAE Water Chart aims to provide a distillation of the wealth of existing research and information available as well as offering a systematic approach to handling water quality. Yet this comes at the cost of some simplifications or approximations. While in the vast majority of real life situations these are absolutely justified and in fact make the beauty and usefulness of the SCAE Water Chart, it is important to be aware of these. This is particularly true when working with highest quality speciality coffee, aiming to push the boundaries and trying to extract the absolute best out of speciality coffee.'

In order to test the extraction behaviour of water explored in the SCAE Water Chart, the researchers wanted to address the specific question of how differing Mg/Ca-ratios affect the extraction and sensory profile of a brew. They did this by modulating the proportions of Magnesium and Calcium making up a fixed total hardness (of 70 ppm $CaCO_3$) and a fixed alkalinity at the lower end of the core zone (40 ppm $CaCO_3$) indicated in the SCAE Water Chart.

A washed Arabica Pacamara varietal from Las Quebradas Farm situated in the Chalatenango region, El Salvador, was chosen for the experiment. Regarded as a highly resilient, high yielding varietal, Pacamaras are celebrated for their balanced acidity, distinctive flavours and intense aromas whilst offering up a dense body and creamy mouth feel. A light roast degree and coarse grind size were used to optimise the filter coffee's cup profile. The experiment set out to analyse the brew using three different Mg/Ca-ratios by measuring the following four analyses in five repetitions in order to even out random variations:

- Percentage of Total Dissolved Solids (TDS) corresponds to measuring the percentage of dissolved solids after filtration of suspended coffee particles in the brew using a VST LAB Coffee II Refractometer
- Percentage of Total Solids (TS) is the amount of solids in the extract, including non-dissolved, suspended solids. »

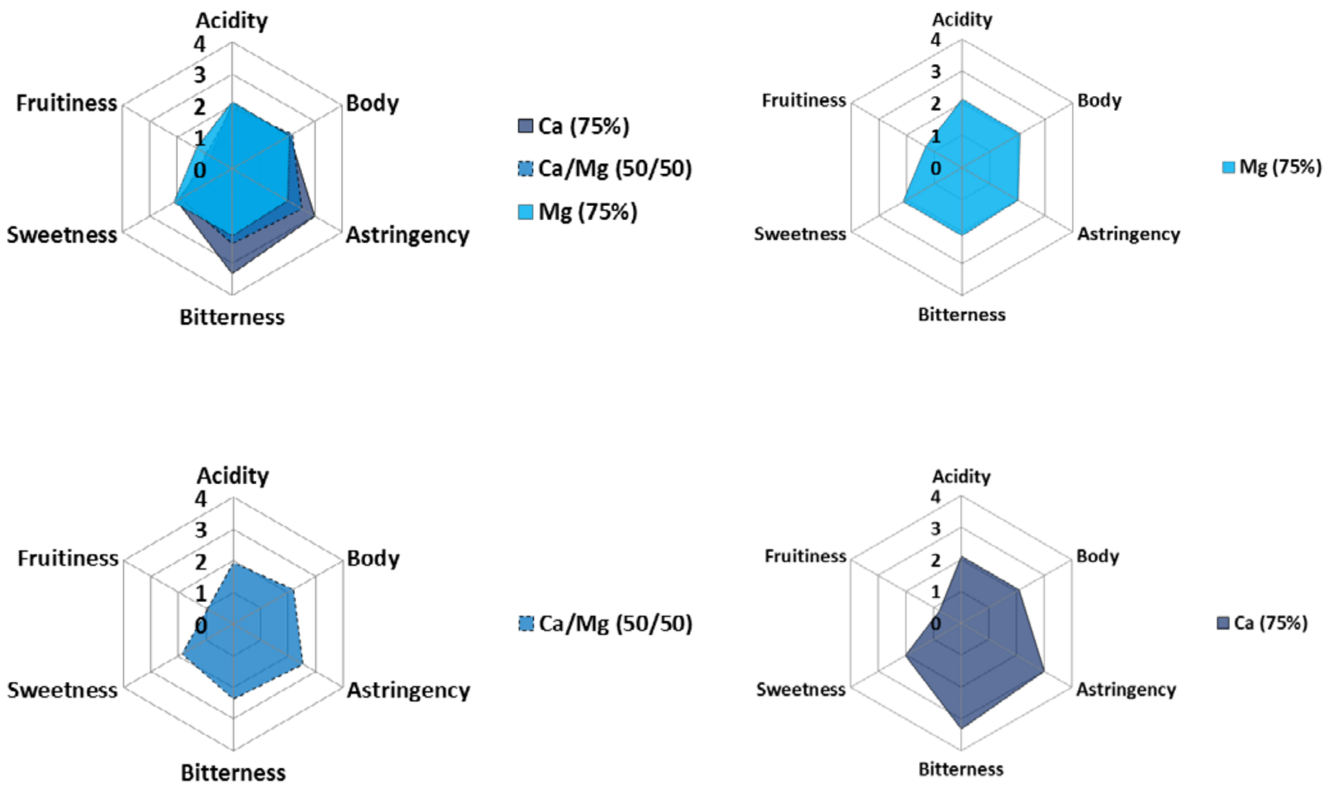

Figure 3: *Sensory profiles of filter coffee, extracted with water of Total Hardness of 70 ppm $CaCO_3$ and varying Mg/Ca-ratio (1:3; 1:1, 3:1).*

To measure, the coffee is not filtered and a known amount of extract is dried in the oven at 105°C for 24 hours. The percentage weight of the solids that remain after drying relative to the weight of the initial extract corresponds to TS

- Volatile Aroma Compounds (VAC) were measured using Gas Chromatography and Mass Spectrometry – a highly sensitive instrument which analyses the composition of volatile organic compounds in the headspace of the coffee extract
- Sensory analysis was conducted in a blind triplicate experiment by three qualified coffee cuppers to assess the sensory attributes on a scale of 0-5 (0 being the lowest intensity and 5 being the highest).

For each of the four measurements, the filter coffee was extracted with three different water types. Although the total hardness was fixed at 70 ppm $CaCO_3$, the Mg/Ca ratio varied from 3:1 to 1:1 to 1:3.

Results & Conclusion

The research team found that the TDS and TS of the coffee solution remained at 1.58% for both measurements and no impact was observed with differing Mg/Ca ratios.

However, significant differences were found in the sensory analysis that was conducted. Illustrated in figure three (page 3), we can see that decreasing the concentration of magnesium as an equivalent to calcium in the water had a noticeable effect on the sensory attributes of the cup. At a ratio of 1:3 (e.g. 25% Mg to 75% Ca), the cupping panel perceived a significant increase in the intensity of astringency and bitterness while the perceived level of fruitiness in the coffee was reduced slightly. Meanwhile, the sensory attributes of acidity and sweetness remained constant throughout the experiment. The constant cupping score for body is consistent with the observation that both TDS and TS were not affected by different Mg/Ca ratios.

Besides the purely scientific considerations, regional, cultural or individual preferences may also play a significant role in the choice of an optimal water composition for coffee extraction. In cities like San Francisco in the US where tap water is very soft for example (e.g. total hardness and alkalinity below 40 ppm $CaCO_3$), this will undoubtedly influence specific taste differences, brewing or even roasting styles. But in spite of these wide variations in water composition and subjective questions of taste, SCAE's Water Chart sets out a clear and accessible framework specifically designed for users to chart new waters that bring out the best our coffee has to offer.

Head of SCAE's Research Committee, Chahan Yeretzian, concluded: 'While the SCAE Water Chart establishes a solid framework for a unified and transparent discussion of water for coffee, this particular study on the Ca/Mg ratio allows developing a more refined albeit complex view on water for coffee extraction. It is particularly relevant when aiming to bring out the best from highest quality speciality coffee. In conclusion, the SCAE Water Chart introduces clarity to this debate and serves as a useful toolbox on how to adopt the right water treatment method that works best for you, your coffee and your customers.'

SCAE's *Water Chart: Aim, Measure, Treat* is freely available as a resource for SCAE members on scae.com. ◆

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