



**NORDIC BARISTA CUP &
SPECIALITY COFFEE ASSOCIATION OF EUROPE**

GRINDING RESEARCH REPORT

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2013
NBC

INTRODUCTION

In 2013, the Speciality Coffee Association of Europe (SCAE) published the research paper 'European Extraction Preferences in Brewed Coffee'. Our objective was to scientifically establish European coffee taste preferences. It was the result of a dedicated programme of field-based research conducted throughout Europe in 2011. It was the first publication in a new research initiative and was both welcomed and valued by our members.

Continuing the association's commitment to research based education, SCAE partnered with the Nordic Barista Cup (NBC) in 2013 to continue this research initiative. The opportunity to work together with the NBC and sensory scientist Francisca Listov-Saabye gave SCAE an excellent second step in our research journey, targeting the murky subject of flat versus conical burrs in coffee grinding.

This paper sees both the continuation of SCAE's commitment to research based education but also the beginning of a scientific journey which will bring our members an annual deliverable of research based data to help our community drive excellence in speciality coffee, which is based on fact rather than opinion.

Paul Stack

Chair SCAE Education Committee 2012-2014

June 2014



WHAT TO EXPECT.....

Myth busting based on scientific research. A walk through of the entire grinding research project which led up to the highlight of presenting the research at the Nordic Barista Cup 2013. An in-depth review of the challenge at SCAE in Nice where the coffee attendees did NOT recognise the difference between the coffees. The grand finale with the disclosure of the hard true facts from the live evaluation cupping at NBC 2013 - The attending coffee professionals in Oslo could NOT taste the difference between flat and conical grinding burrs.

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BACKGROUND

THE PROJECT MANAGER

Francisca Listov-Saabye has a master's degree in Food Science, specialising in sensory science. She has been gathering a broad knowledge in consumer and sensory science as well as new product development and food production over 13 years in the food industry.

CONTACT INFORMATION

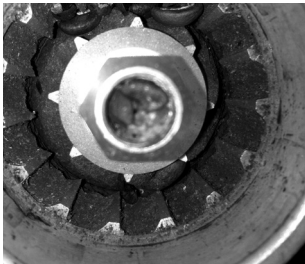
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THE NBC/SCAE GOLD CUP GRINDING RESEARCH PROJECT

Back in 2011 during the competitions at the Nordic Barista Cup a discovery was made: The temperature of the ground coffee seemed to increase throughout the session. This assumption was the basis on which Francisca did a small scale trial at the next NBC in 2012. The trial investigated the temperature increase in the ground coffee beans during the espresso completion, where 250 espressos were produced in 40 min. The discussions of the results lead to developing the present NBC/SCAE Gold Cup grinding research project.



On coffee debate forums, in blogs and "through the grapevine" there was a saying, an understanding, that there was a taste difference between a flat and a conical burr grinder. We set out to investigate this. How do the grinder characteristics such as burr size and type (flat or conical) influence the taste of coffee?

Hypothesis: There is a taste difference between a flat and a conical burr grinder!



MATERIALS & EQUIPMENT

THE COFFEE LAB

At Europa Tietgen, a café and canteen setting in Copenhagen, Francisca set up her coffee lab collecting a lot of grinders and brewers.

The grinders were chosen according to variance in burr size and burr type as well as being grinders targeted at consumer, prosumer and coffee professional markets.

An investigation of the coffee bars in Copenhagen was conducted and additional grinders were obtained in order to represent the reality of baristas etc.

In the coffee lab, trials were conducted looking into coffee retention, regrind, setting of grinders and usability in general. See table of grinders.



EQUIPMENT

- Water and coffee was weighed using a G&G digital pocket scale, model LS2000H (sensitivity 0-1000 gram 0,05 gram, 1000-2000 gram 0,1 gram).
- The temperature of the brew as well as of the samples for %TDS measurement was measured using a Testo Quicktemp 826-T3 thermometer or a Fluke 53-2 thermometer with a 9065 probe.
- The total dry solids (%TDS) was measured by a VST LAB Coffee II Refractometer.
- Coffee was brewed on either a Wilfa Svart Presisjon machine filter brewer or a programmable BUNN filter ICB brewer.
- Two different types of filters were used: Wilfa svart presisjon uses standard white paper filters size 4 from supermarket. These were washed with hot water prior to brewing. For the BUNN brewers, official BUNN paper filters were used. These were used dry due to practicality and the side of the filter being vertical.

COFFEE

The coffee used throughout the research is Ethiopian TADE, sourced and roasted by Solberg & Hansen, Norway. The roast profile is a light Nordic style roast. For each separate test during the research fresh roasted batches were used, co-ordinating to ensure evaluation was within 5-14 days after roasting.

WATER

The brew water was filtered water. The filter BWT Bestmax 2XL was used.







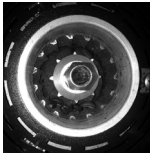
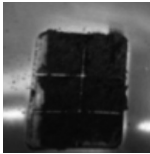
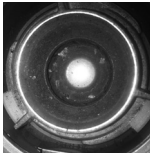
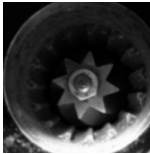
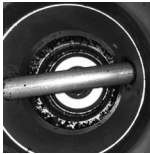
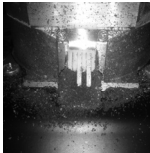
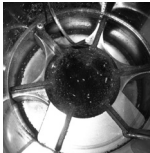
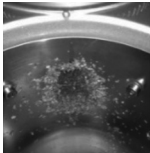
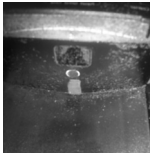
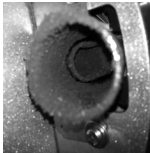
At the SCAE World Coffee convention in Nice the filtered and controlled water at the fair was used.

At the Nordic Barista Cup in Oslo the clean Norwegian water was filtered by Everpure 7FC filter.

WEIGHT OF COFFEE

For the coffee retention trials, the coffee beans going into the grinder as well as the ground coffee coming out of the grinder were weighed. For the range of grinders tested in this study the weight of coffee in hardly ever resembles the weight of coffee out. Of any of the grinders!

TABLE OF GRINDERS IN SENSORY PROFILING

| GRINDERS | NUOVA SIMONELLI | LA MARZOCCO | MAZZER | MAHLKÖNIG | FAEMA | MAHLKÖNIG |
|---------------------------|---|---|---|--|---|---|
| MODEL | Mythos | MD5 | Robur | Vario | MC99 | K30 |
| APPEARANCE |  |  |  |  |  |  |
| BURR TYPE | flat | conical | conical | flat | conical | flat |
| BURR SIZE | 75 mm | 65 mm | 71 mm | 54 mm | 68 mm | 65 mm |
| BURR MATERIAL | Titanium coated steel | Stainless steel | Stainless steel | Ceramic | Stainless steel | Stainless steel |
| MOTOR SPEED (RPM) | 1400 | 620* | 500 | 1000 | 320 | 1420 |
| HOPPER | plastic | glass | plastic | plastic | plastic | plastic |
| DOSER | - | + | - | - | + | - |
| RETENTION | 0,7 ± 0,9 gram | 0,3 ± 0,6 gram | 1,4 ± 0,9 gram | 0,5 ± 1,7 gram | 0,6 ± 0,7 gram | 0,5 ± 0,3 gram |
| |  |  |  |  |  |  |
| STATIC ELECTRICITY |  |  |  |  |  |  |
| SETTING OF GRINDER | Steeples, easy | Steeples, medium | Steeples, hard | Steps, 10*22 positions | Steeples, easy | Steps, 20 positions |

*Calculated

THE SENSORY TESTS

Two different sensory test types has been used in the research project – discriminative and descriptive testing respectively.

For the discriminative test, different triangle test was conducted. The respondent is to pick the odd sample out of three cups of coffee.

For the descriptive test, two quantitative profiling trials are conducted.

SENSORY PROFILING

The main difference between classic coffee tasting, cupping, and sensory profiling is the use of a different evaluation scale. Secondly, it's the actual set up where cupping usually takes place in a social setting where multiple judges evaluates 6 to 12 cups in one round whereas sensory science judges individually evaluates one product at a time.

TRAINING OF THE JUDGES

For each of the descriptive tests, training sessions with the judges were carried out. For three sessions of a couple of hours, the entire group was gathered around a table. The variance of the coffees in the test were tasted blind. Based on a discussion about the coffees using physical references the judges agree upon perceived attributes to describe the profile.

The panel leader, in this research project Francisca Listov-Saabye, brings physical references (fresh flowers, pieces of lemon and oranges, liquorice powder, dark chocolate etc.) based on prior tasting of the coffees.

During the training sessions, the panel came up with other suggestions for the vocabulary, from which the panel leader brought physical references for the next session (e.g. cut pipe tobacco, caramel sauce, fudge, raisins and different types of roasted nuts). The final vocabulary representing the coffees from the different grinders were determined and the use of the line scale was practised.

SMELL

| | | |
|------------------|---------|-------|
| HAZELNUTS | NOTHING | A LOT |
| LEMON | NOTHING | A LOT |
| CHOCOLATE | NOTHING | A LOT |
| FLORAL | NOTHING | A LOT |
| TOBACCO | NOTHING | A LOT |

TASTE

| | | |
|-------------------|---------|-------|
| SWEET | NOTHING | A LOT |
| ACIDIC | NOTHING | A LOT |
| BITTER | NOTHING | A LOT |
| SOUR | NOTHING | A LOT |
| TOBACCO | NOTHING | A LOT |
| LEMON | NOTHING | A LOT |
| CHOCOLATE | NOTHING | A LOT |
| LIQUORICE | NOTHING | A LOT |
| HAZELNUT | NOTHING | A LOT |
| ROASTED | NOTHING | A LOT |
| BURNT | NOTHING | A LOT |
| CARAMEL | NOTHING | A LOT |
| MOUTH FEEL | NOTHING | A LOT |

Unmarked line scale used in the present grinder research project.

With a vertical mark, the judge scored the exact strength of the given sensory attribute ranging from nothing to a lot. In the data processing, the sensory scientist measured the position of the mark corresponding to the perceived intensity.

The results were prepared using multivariate statistics using the following programmes, Panel Check, Unscrambler and Latentix.

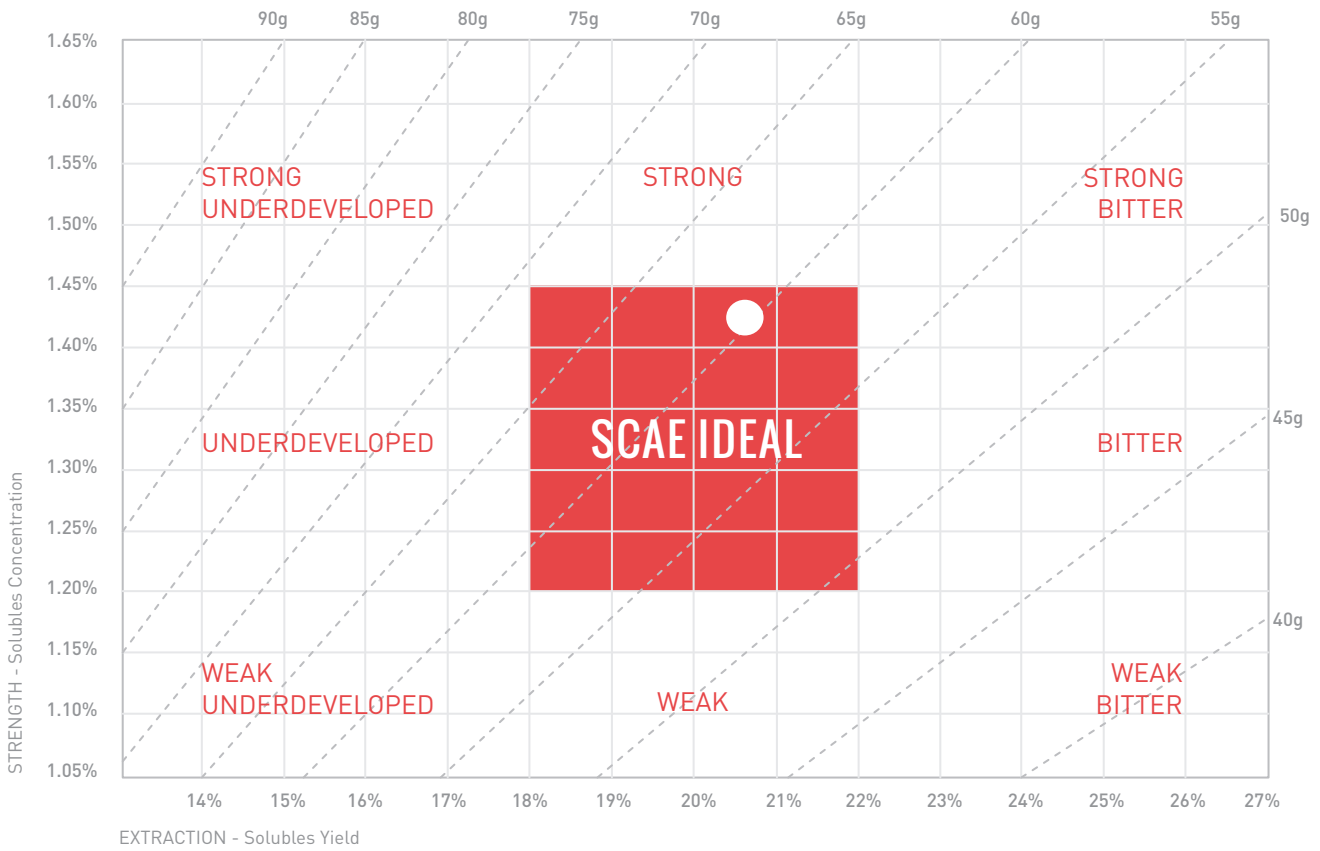


Figure 1. SCAE Coffee Brewing Control Chart

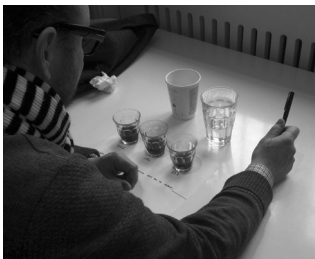
For the whole project the coffee is brewed to the same %TDS. This is to be able to compare different grinders. The initial setting of a chosen grinder is determined based on different brews and a subjective tasting with the aim of finding the optimum spot for the coffee. The target %TDS lies within the SCAE ideal square in the Coffee Brewing Control Chart.

RESULTS

TRIANGLE TESTING - IS THERE A DIFFERENCE?

CONSUMERS

| | |
|--------------------|---|
| TEST | Triangle (discriminative) #1 |
| RESPONDENTS | 50 |
| SETTING | Canteen, individual tables |
| GRINDERS | La Marzocco MD5 (conical) Nuova Simonelli Mythos (flat) |
| BREW | Wilfa Svart Presisjon |
| TDS | 1,43% (21% extraction) |
| COFFEE | Etiopian Tade, Solberg&Hansen |



Are consumers able to taste the difference between coffee from a flat burr grinder and coffee from a conical burr grinder? This was tested in a canteen setting where 50 consumers did a triangle test (randomised between the six options, see Appendix).

The consumers found **NO SIGNIFICANT DIFFERENCE BETWEEN FILTER COFFEE FROM FLAT AND CONICAL BURRS** since only 9 consumers were able to pick the odd sample out. ($P < 0,001$, Meilgaard et al.)

COFFEE PROFESSIONALS

| | | |
|--------------------|--|---|
| TEST | Triangle (discriminative) #2 |  |
| RESPONDENTS | 164 | |
| SETTING | Booth, Coffee Fair, SCAE, Nice/France | |
| GRINDERS | Mazzer Robur (conical) Mahlkönig K30 (flat) | |
| BREW | Programmable Bunn filter ICB brewer | |
| TDS | 1,43% (21% extraction) | |
| COFFEE | Etiopian Tade, Solberg&Hansen | |

The triangle test was repeated by coffee professionals at the SCAE World of Coffee fair in Nice, June 2013. Here 164 people from the coffee industry performed a triangle test. Fully randomised so that no one got identical test standing next to each other. This was explained to the respondents coming to the booth.



Figure 2. 164 respondents in Nice, France

The triangle test participants in Nice is an extensive diversity of the multiple roles in the coffee community with a predominance of people having everyday hands-on experience with the coffee and thus tasting coffee extensively.

A background questionnaire was obtained in order to get maximum information about the respondents. This revealed the coffee professionals were familiar with the type of test brew, since 70 people had filter brew as their preferred coffee drink.

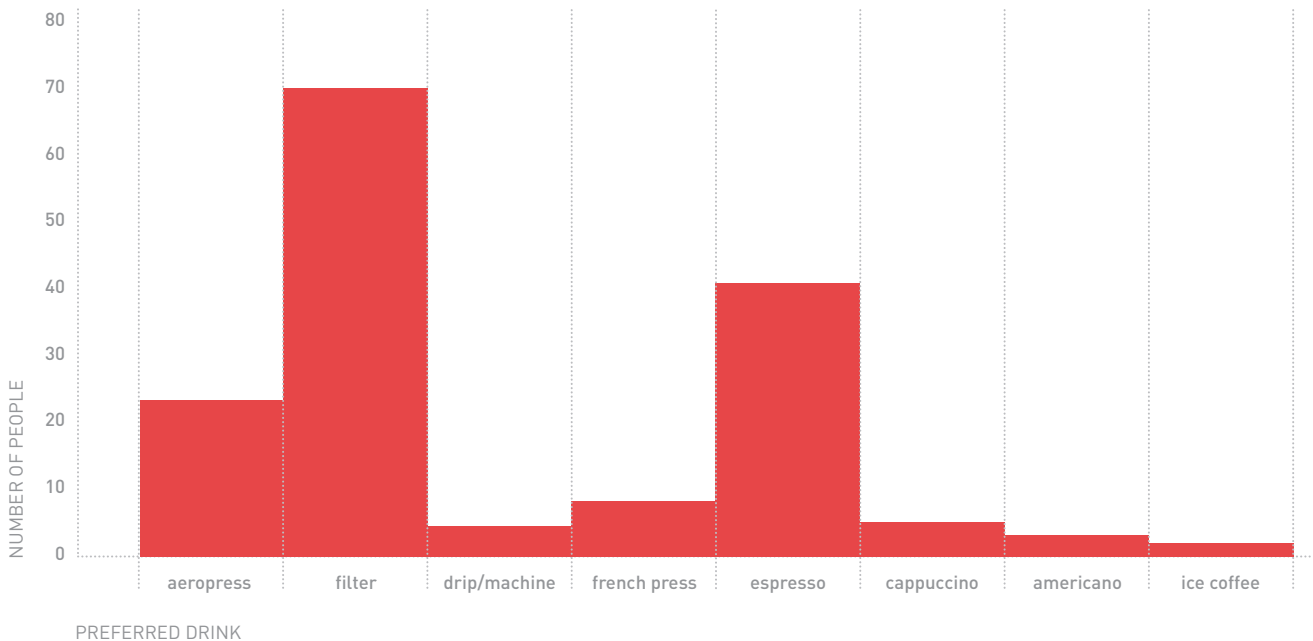


Figure 3. Most preferred coffee drink for the respondents

The coffee professionals feel strongly about their coffee. With the question above regarding preferred coffee drink you could tick a box if you use sugar and/or milk/cream in the coffee. Several people wrote NO! beside the boxes.



Figure 4. Home of respondents in triangle test, Nice 2013

The Coffee Professionals participating in the research were primarily from different parts of Europe, with a large number of the respondents familiar with the lighter roasting trend from the Nordic countries.

The respondents coming by the NBC booth in Nice to participate in the triangle test were also asked about their history in the coffee business. This reveals that there is no correlation amongst time in the coffee business and the ability to distinguish between flat and conical burrs regarding to taste.

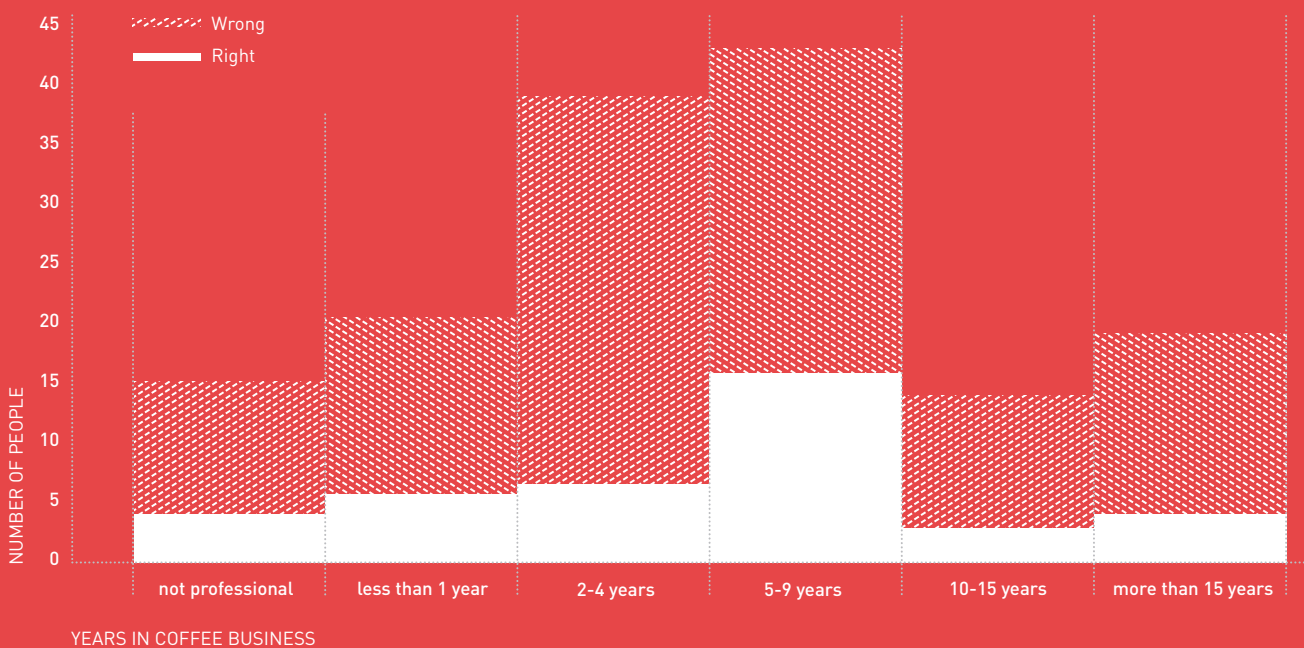


Figure 5. Length of experience in coffee business

Also no learning effect from coffee consumption was found since there is no correlation between daily coffee intake and the ability to get the right answer.

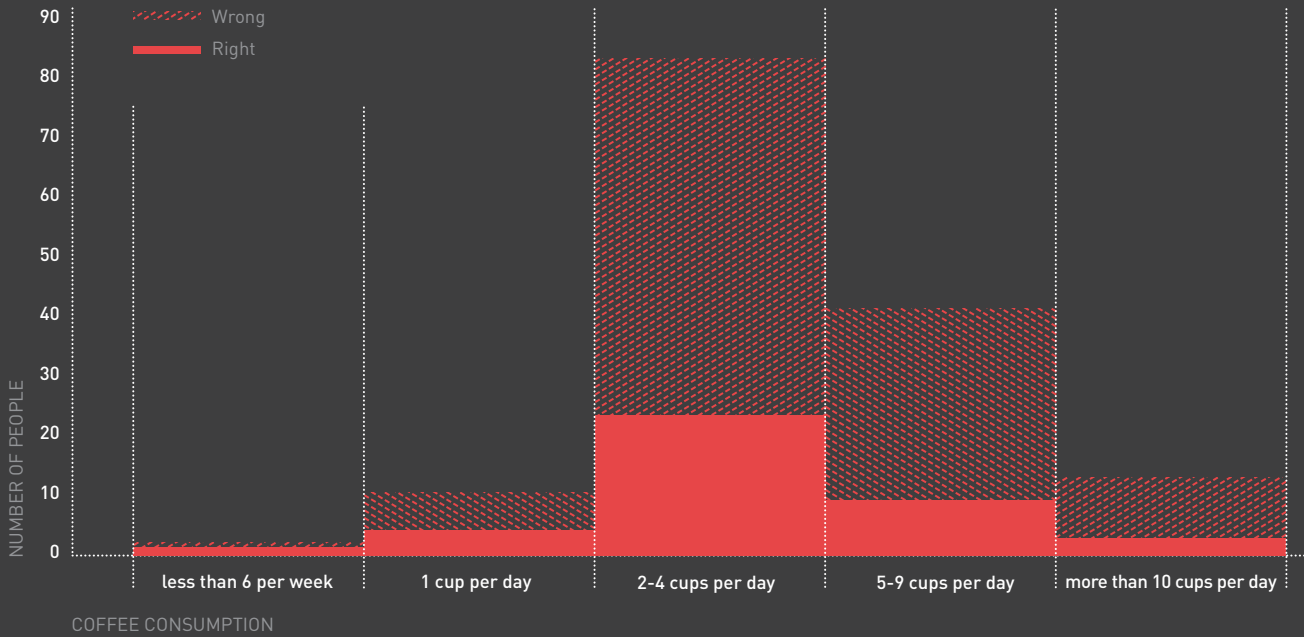


Figure 6. Daily intake of coffee

CONCLUSION TRIANGLE TEST NICE, FRANCE

Since only 48 persons of the 164 coffee professional got the right “odd cup” of the three served it is significantly concluded that COFFEE PROFESSIONALS COULD ACTUALLY NOT TASTE THE DIFFERENCE BETWEEN FLAT AND CONICAL BURRS (48 out of 164 → $p < 0,001$)

The poor result was somewhat unexpected to the research team, although no one assumed it was easy. The result was an actual shock to the coffee community itself and was received with disbelief.

THE SENSORY PROFILING TEST

Since the taste differences between coffees from flat versus conical burrs are extremely small and not possible to detect in a triangle test another approach was needed. The minor variances in the profile due to the grinder used was to be described by a sensory panel.

An expert sensory panel consisting of people working professionally with coffee (roaster, previous coffee bar owner, Cup of Excellence judge, barista and coffee consultant) was gathered in Copenhagen.

Since these people were accustomed to evaluating coffee by classic cupping a challenge was upon the panel leader. Could Francisca Listov-Saabye “teach old dogs new tricks”? The training sessions began and the line scale was introduced along with physical references. The panel agreed upon following sensory attributes describing the coffee spectrum:

| CATEGORY | INDICATION IN PLOT | ATTRIBUTES |
|-----------|--|--|
| SMELL | S_XXXX Eg S_tobacco is smell of tobacco | Citrus, floral, chocolate, tobacco, caramel |
| TASTE | T_XXXX Eg T_citrus is taste of citrus | Acidic, sweet, bitter, citrus, fruit, floral, roasted, liquorice, tobacco, caramel |
| MOUTHFEEL | | Mouth feel |

The profile sessions took place at the NBC Coffee lab, at individually tables. Brewing area was out of sight. The panel members were served coffee in individual order and at their own pace. They received no information about the aim of the project so they had no background facts connected to the coffees and did not know what differentiated the samples (that being the different grinders but the same coffee).

The results were analysed and displayed by multivariate statistics.

| TEST | PROFILING (DESCRIPTIVE) #1 |
|------------|---|
| JUDGES | 6 |
| SETTING | NBC Coffee Lab, Copenhagen |
| 5 GRINDERS | Marzocco MD5 (conical) Faema MC99 (conical) Nuova Simonelli Mythos (flat) Mahlkönig Vario (flat) Mahlkönig K30 (flat) |
| REPLICATES | 2 |
| BREW | Wilfa Svart Presisjon |
| TDS | 1,43% (21% extraction) |

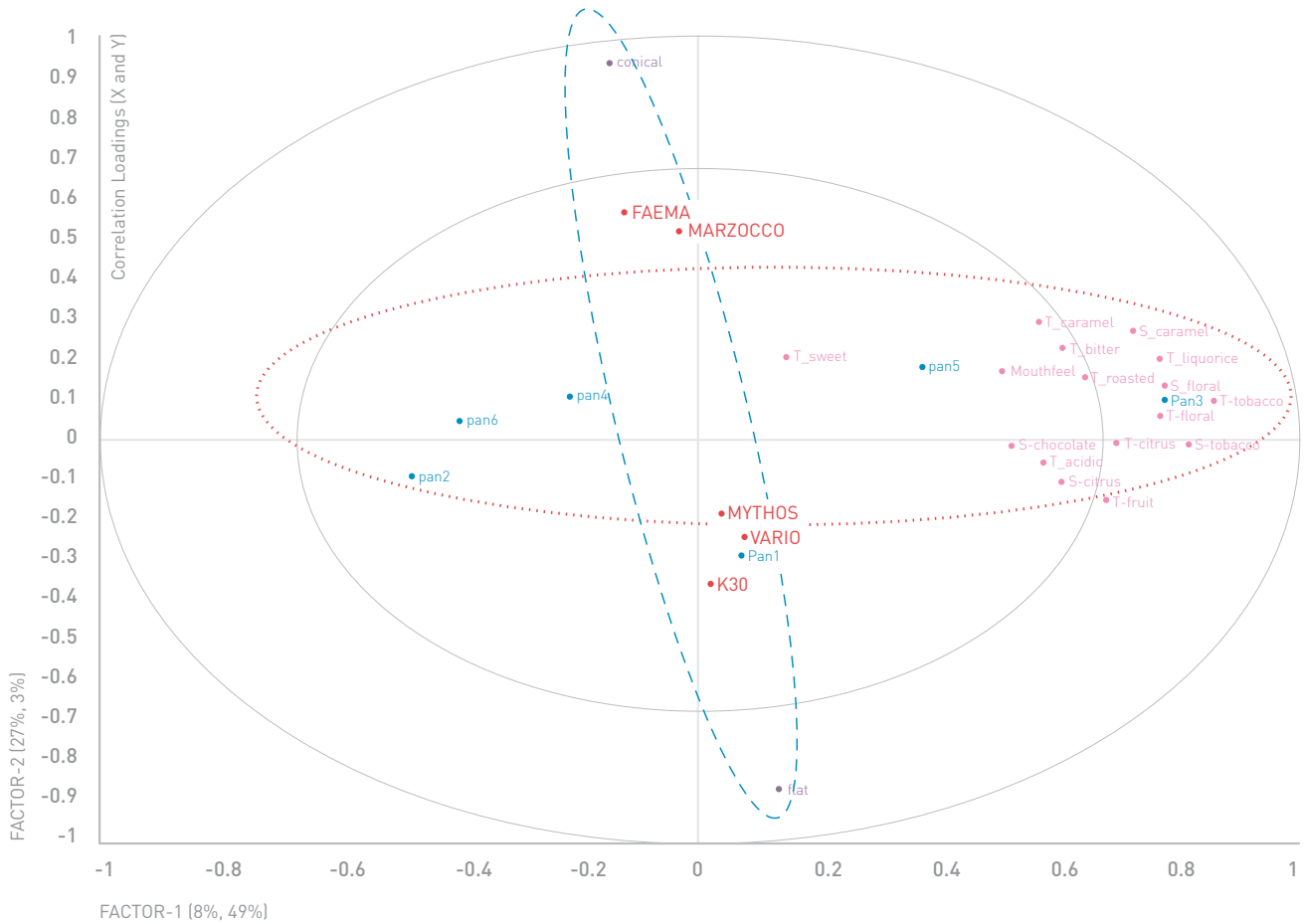


Figure 7. PLS plot. Coffee expert panel profiling

| | | |
|-------------------|--|---|
| JUDGES | PAN1-PAN6 | The sensory judges: Panel member no. 1-6 |
| BURRS | CONICAL, FLAT | The location of the grinders having flat or conical properties |
| GRINDERS | K30, FAEMA, MARZOCCO, VARIO, MYTHOS | Position of the grinder in the “sensory world of the Ethiopian coffee” position |
| ATTRIBUTES | SENSORY ATTRIBUTES EG T_SWEET | Location of sweet taste in the sensory profile |

The plot (figure 7) shows that all the sensory attributes (in red) describing the coffee are located in one side. This is due to the fact that the judges (pan1 – pan6) themselves actually accounts for the biggest explanation of the model-marked by the red dotted ellipse. The grinders have a much narrower variance- marked by the blue ellipse.

The position of the attributes and the panel members indicates that they were not able to use the scale in the same way and that e.g. panel member no. 3 consistently graded the coffees higher intensities that panel member 2 and 6.

Looking into the raw data it seems that the panel members, all being coffee experts or professionals, can’t help to evaluate more than the plain attributes-one at a time. They will start to guess where the coffee is from, how it is brewed and so on. They can’t put the coffee nerd aside!

Is it all bad then, trying to get coffee people to use traditionally sensory science? No – there are some tendencies:

If a new multivariate model is computed to distinguish between the grinders there is a clear tendency towards the conical grinders – marked by the red dotted ellipse in figure 8- are described by sweet taste whereas the flat grinders –marked by the red dashed ellipse - are described by more acidic taste.

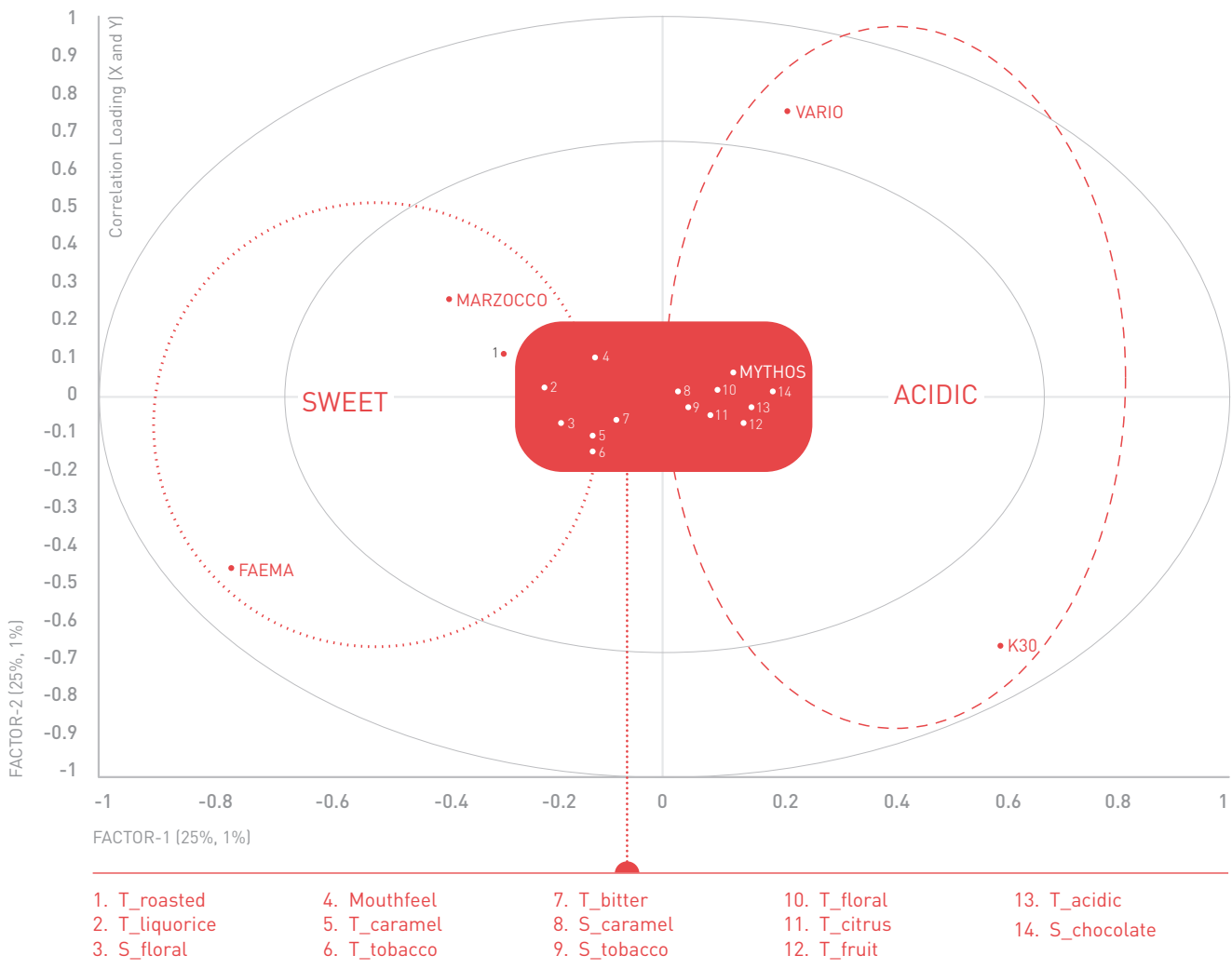

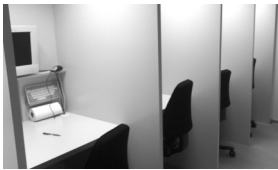


Figure 8: PLS model flat versus conical grinders

These tendencies are worth looking into. Therefore a similar sensory profiling was conducted. This time by a sensory panel consisting of food science researchers and master students. All located at the Food Science Department of Copenhagen University. The panel members had prior experience with sensory profiling of different food stuffs and are all familiar with drinking coffee.

SENSORY PROFILING, UNIVERSITY PANEL

| | | |
|-------------------|---|--|
| Test | Profiling (descriptive) #2 |  |
| Judges | 6 | |
| Setting | Sensory Lab, Copenhagen University, FOOD (Accredited) | |
| 6 Grinders | Marzocco MD5 (conical) Faema MC99 (conical) Mazzer Robur (conical) Nuova Simonelli Mythos (flat) Mahlkönig Vario (flat) Mahlkönig K30 (flat) | |
| Replicates | 3 | |
| Brew | Wilfa Svart Presisjon | |
| TDS | 1,43% (21% extraction) | |



The sensory lab at the University is an accredited sensory evaluation lab consisting of individual booths in a closed, neutral, sound proof and odour free environment. The randomised samples were served to the judges from a hatch.

Again, the samples we served individually at each sensory judge's own pace. Serving was randomised across judges to eliminate carry-over effects.



During the training sessions the university panel came up with similar sensory attributes to describe the coffees although not exactly the same words as the sensory panel consisting of coffee professionals. Some words were added, such as sour and burnt, and some words were specified, such as citrus becoming lemon.

| CATEGORY | INDICATION IN PLOT | ATTRIBUTES |
|------------------|---|--|
| SMELL | S_XXXX Eg. S_lemon is smell of lemon | Hazelnut, lemon, chocolate, floral, tobacco, caramel, |
| TASTE | T_XXXX Eg T_bitter is bitter taste | Sweet, acidic, bitter, sour, tobacco, lemon, chocolate, liquorice, hazelnut, roasted, burnt, caramel |
| MOUTHFEEL | M_astringency | astringency |

The sensory judges rinsed their palates in between samples with still and sparkling water.

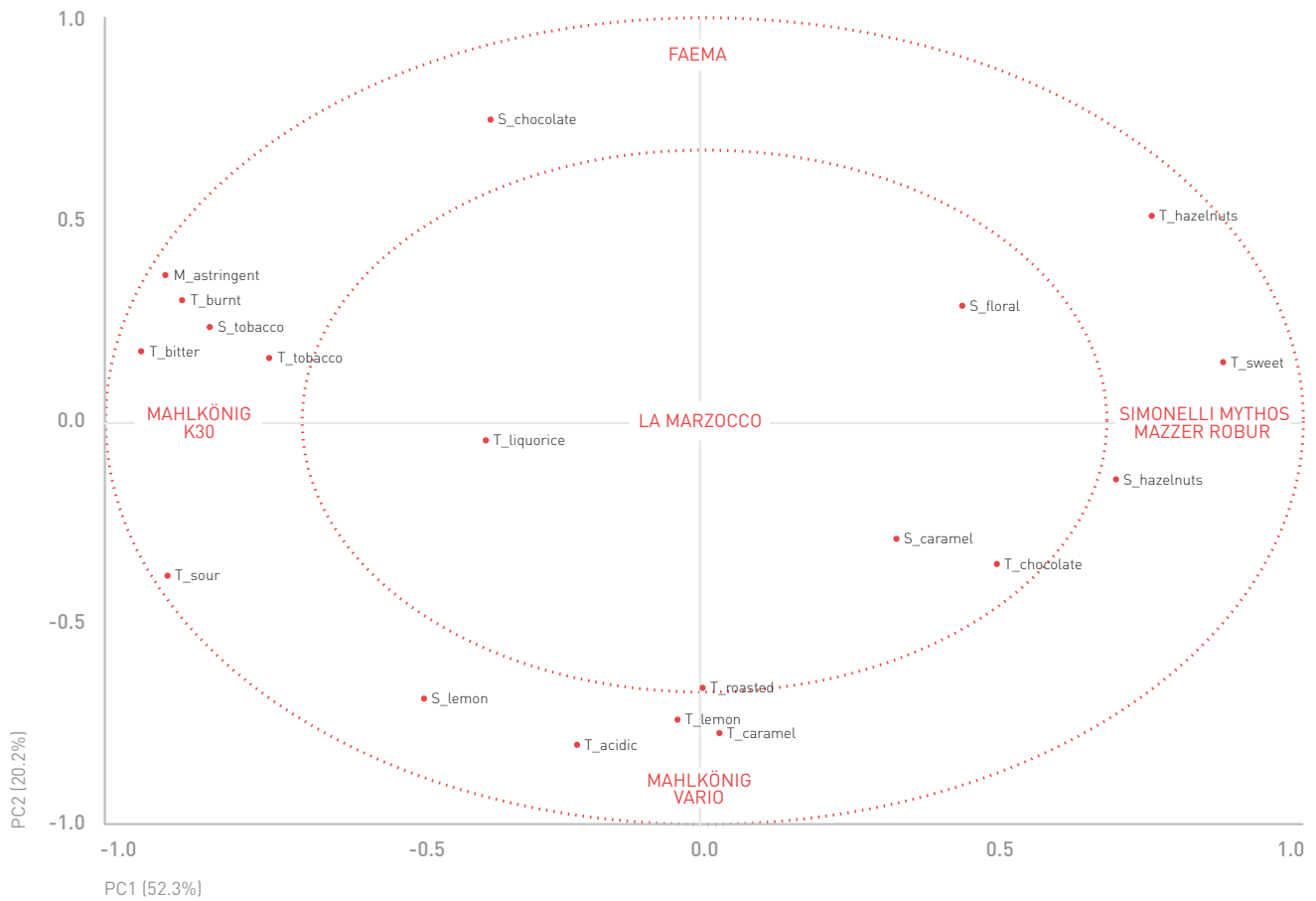


Figure 9. Principal component 1 versus principal component 2. For further explanation of multivariate statistics see references

Figure 9 shows the correlation between the grinders- written in red- and the sensory attributes – written in black. Hence it shows that the Mahlkönig K30 grinder produces a coffee that has a higher intensity of bitter, burnt and tobacco notes whereas opposite both the Simonelli Mythos and the Mazzer Robur grinder gives a coffee described as more sweet, with both hazelnut smell and taste.

The Faema C99 grinder evaporates a more intense smell of chocolate compared to Mahlkönig Vario which has a more roasted and acidic profile. The location of La Marzocco MD5 in the middle indicates that the grinder, in this study, did not have a profound characteristics compared to the other five grinders.

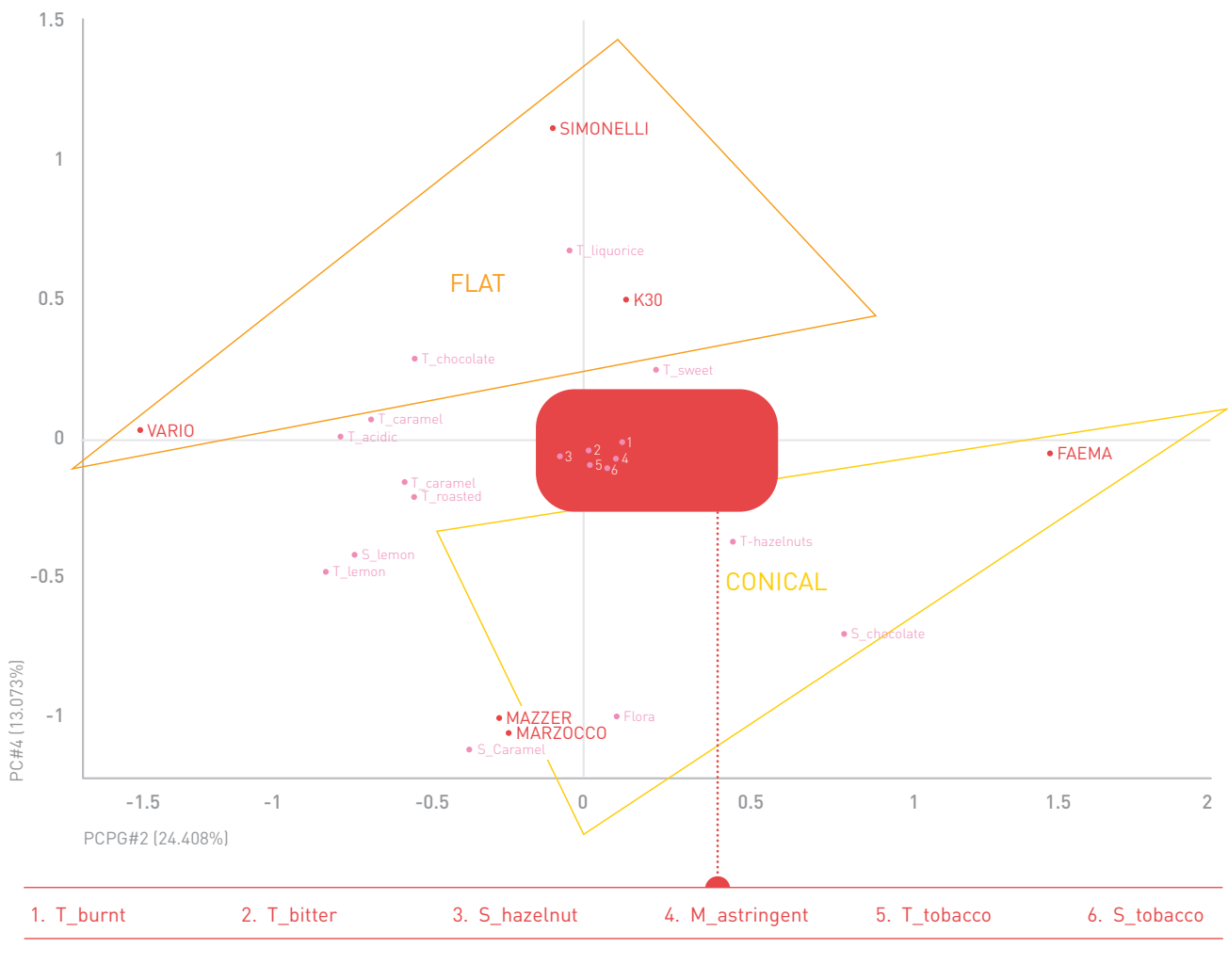


Figure 10.

| | |
|---|--|
| Vario, K30, Simonelli | Flat grinders |
| Mazzer, Marzocco, Faema | Conical grinders |
| T_chocolate, T_liquorice, T_hazelnuts, S_caramel etc. | The sensory attributes describing the coffee |

The above figure 10 displays a model computed to differentiate between the flat and the conical grinders. This reveals that the flat grinders in this study enhances the Ethiopian coffee’s liquorice and chocolate taste notes where the conical grinders on the other hand enhances smells of flowers, chocolate and caramel.

PARTICLE SIZE DISTRIBUTION

The Nuova Simonelli R&D Lab in Italy kindly provided particle size distribution analysis on blind coded samples from grinders in the study.

The technique for the individual analysis of the ground coffee uses Hemispherical Randomic Distributor with compressed air injector. The vision system was developed by UNIVPM for Nuova Simonelli.

The samples were prepared at the NBC Coffee Lab in Copenhagen by finding the individual setting of each grinder which produced a brewed coffee with identically %TDS. The results of the analysis did not reveal a grouping in flat or conical grinders. It's not a black and white picture. The overall view of the grinders in figure 5 are all based on the same beans: A light roasted Ethiopian coffee.

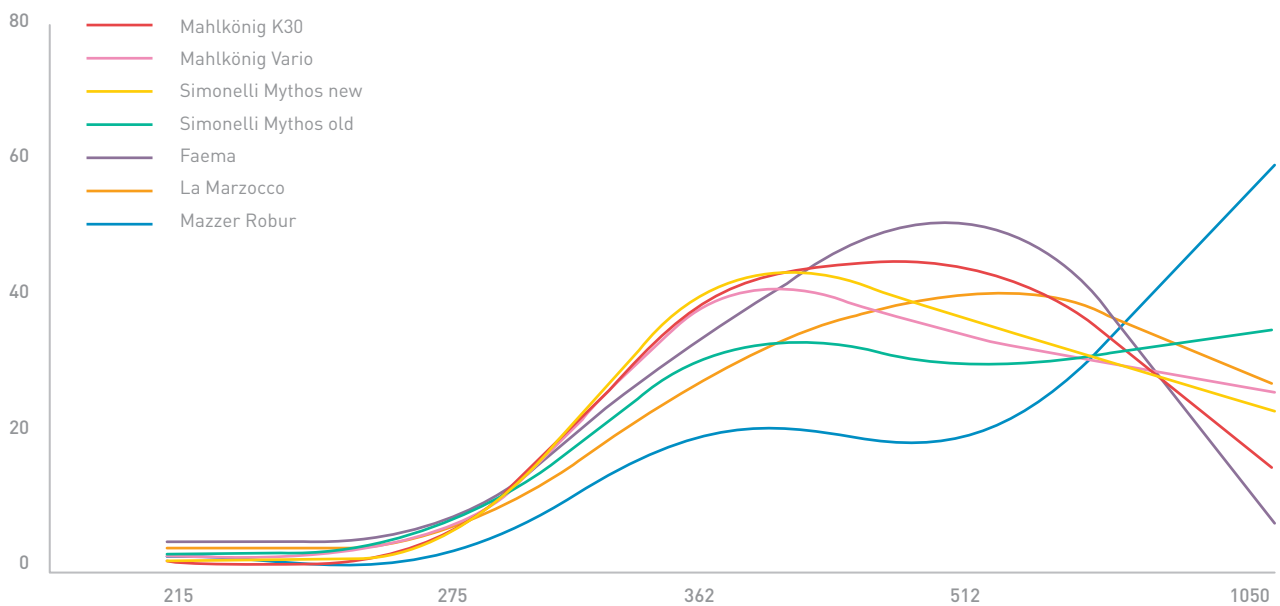


Figure 11. Overall view of particle size distribution [% of sample vs. particle size mean diameter [µm]]

Looking into the overall picture of the grinders some resemblances are seen. The Mahlkönig Vario and the new Simonelli Mythos have almost identical curves as do the Faema MC99 and Mahlkönig K30 curves show similarities.

So some grinders seem to resemble each other in particle size distribution despite of burr type being flat or conical. This curve resemblances are not repeated in the sensory profile!

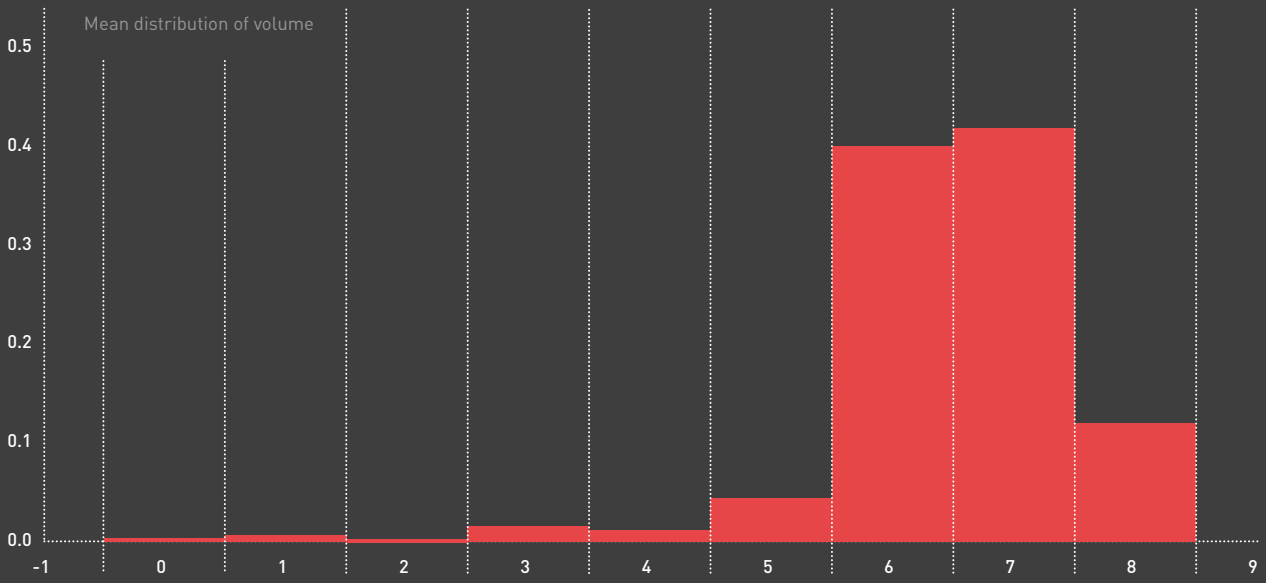
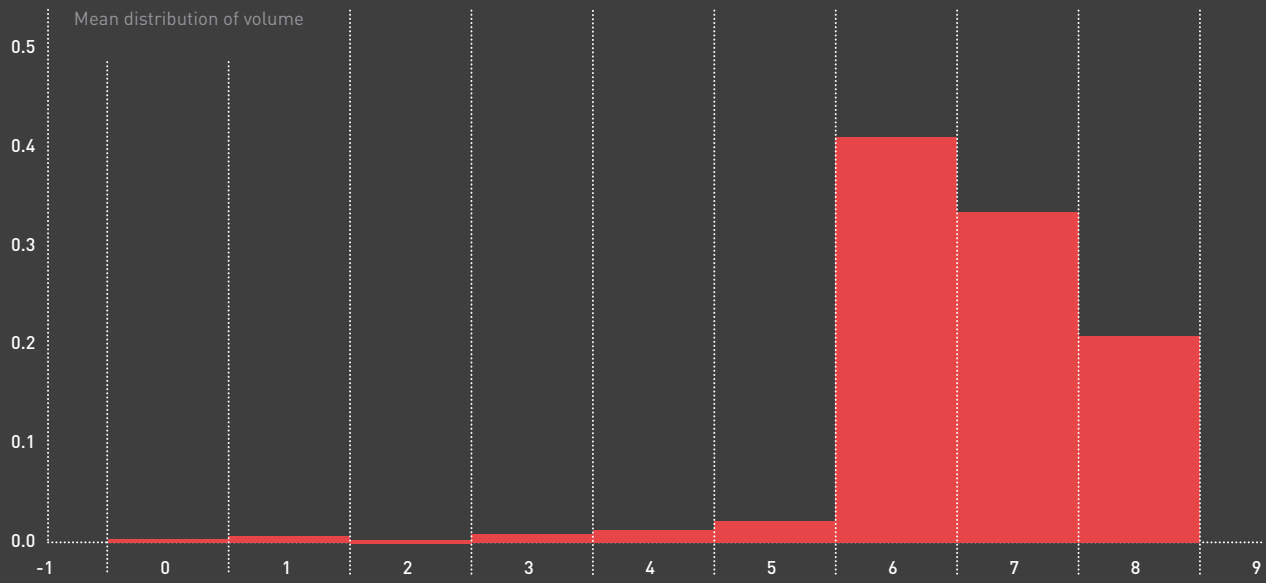


Figure 12. Mean particle size distribution

The above two plots of particle distribution are the same grinder [the new Simonelli Mythos], same setting but light roast above and dark roast below which just confirms the complexity of the grinder topic.

DISCRIMINATIVE CUPPING TEST AT THE NBC 2013

In the sensory profiling the academic panel at the university found that the attributes BURNT and SOUR were significantly differentiating between the grinders. The cupping session during the Nordic Barista Cup in Oslo, Norway in September 2013 was based on this finding. The 147 attendees were given a test to find the odd sample out of three. Two different tests were conducted: One with respect to SOUR (“which sample differs from the two others in sourness?”) and BITTER (“which sample differs from the two others with respect to bitterness?”)

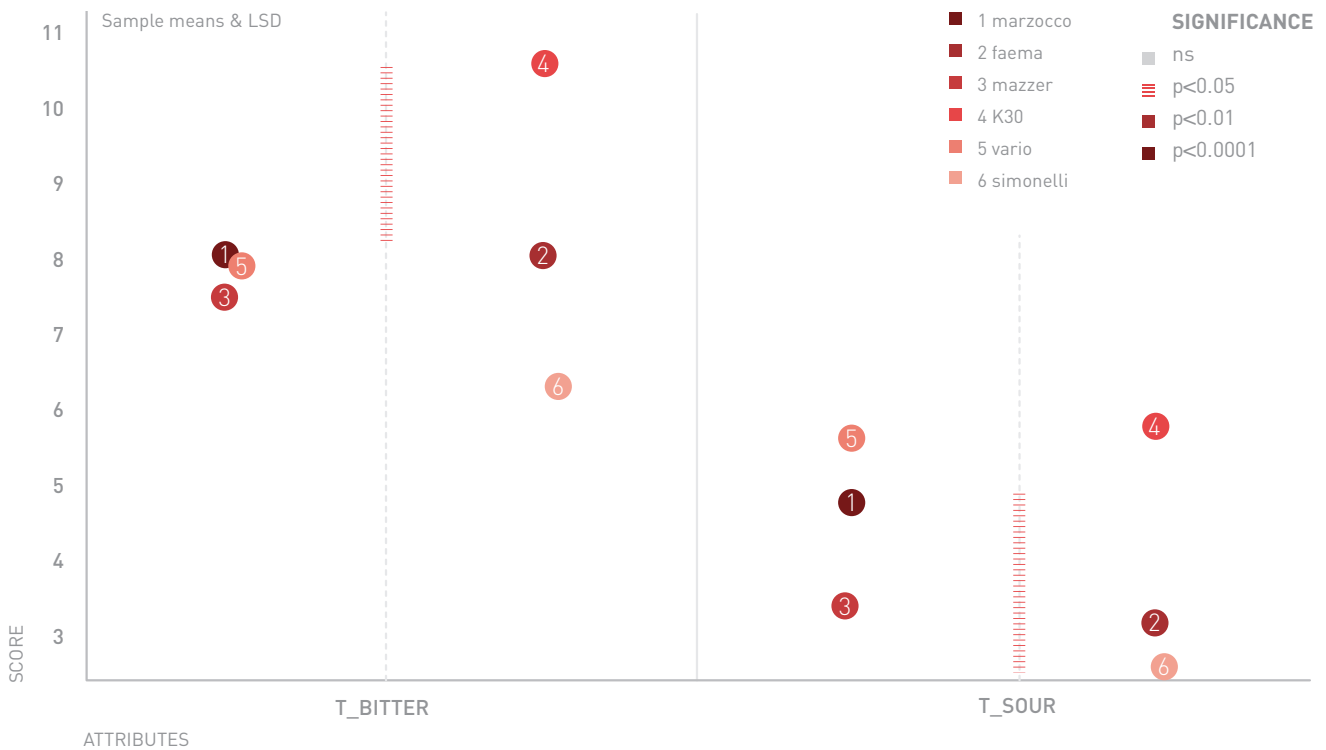


Figure 13. The sensory attributes sour and bitter differentiate the grinders. University profiling

| | |
|--------------------|--|
| Test | Triangle (discriminative) #3&4 |
| Respondents | 147 |
| Setting | Cupping tables, NBC Oslo 2013 |
| Grinders | Mazzer Robur (conical) Dalla Corte DC-one (flat) |
| Brew | Programmable Bunn filter ICB brewer |
| TDS | 1,43% (21% extraction) |
| Coffee | Etiopian Tade, Solberg & Hansen |

The NBC attendees found it slightly easier to discriminate the samples when referring to SOUR rather than concentrating on BITTER taste. But only 20 of the 147 persons participating the grinding cupping got both tests right. The attendees, being coffee professionals from all over the world, WERE NOT ABLE TO TASTE THE DIFFERENCE BETWEEN FLAT AND CONICAL BURRS.

CONCLUSION

The NBC/SCAE Gold Cup Grinding Research project set out to find out if there really was a detectable taste difference between coffees from a flat burr grinder compared to a conical burr grinder.

Nothing in grinders is black and white. More like a thousand shades of grey. The differences are so small that it is hard to detect. And given a triangle test neither consumers nor coffee professionals were able to find the difference. Not even when a descriptive word exists to focus the mind when tasting.

Grinders are so much more than the set of burrs. Not only does the type (flat or conical) matter, but also the size of the burrs, the size and speed of the motor, the feeding angle into the grinder, the retention and regrind as well as the physical appearance itself.

Grinders are individuals – having an affect on the coffee as well as the operating barista.

FUTURE

There are still a lot of scientific research opportunities waiting to be discovered in speciality coffee. Francisca hopes to be part of the myth busting as well as the revelation of truths in the future.

Francisca's dream is to get a PhD in coffee research. But partners and sponsors are needed in order to plan and have a three year project approved.

Multiple ideas for smaller or bigger research projects are available however for cooperation and ventures immediately:

- Can you actually taste the difference between washed and dry filters in a pour over coffee?
- What is the connection between degree of roasting and particle size distribution?
- What is the link concerning the age of the burrs and taste effect in the coffee?
- How does the speed of the grinder affect the taste of coffee and the particle size distribution?
- Sensory profiling of different origin of coffee
- How does the teeth pattern of the burrs affect the taste of the coffee?

Please don't hesitate to contact **Francisca Listov-Saabye**.

THANKS TO THE RESEARCH PARTNERS & SPONSORS

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As well as the co-operation with the **University of Copenhagen, SCIENCE; Faculty of Life Science Department of Food Science.**

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APPENDIX & REFERENCES

SET UP TRIANGLE TESTING:

| | | |
|------------|------------|------------|
| AAB | ABA | BAA |
| ----- | | |
| BBA | BAB | AAB |

Testing two different coffees A and B. In this study being from flat and conical burr grinder respectively.

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