ELEVATE YOUR BREW

AROMA RETENTION TIPS FROM A THERMODYNAMICS LEGEND

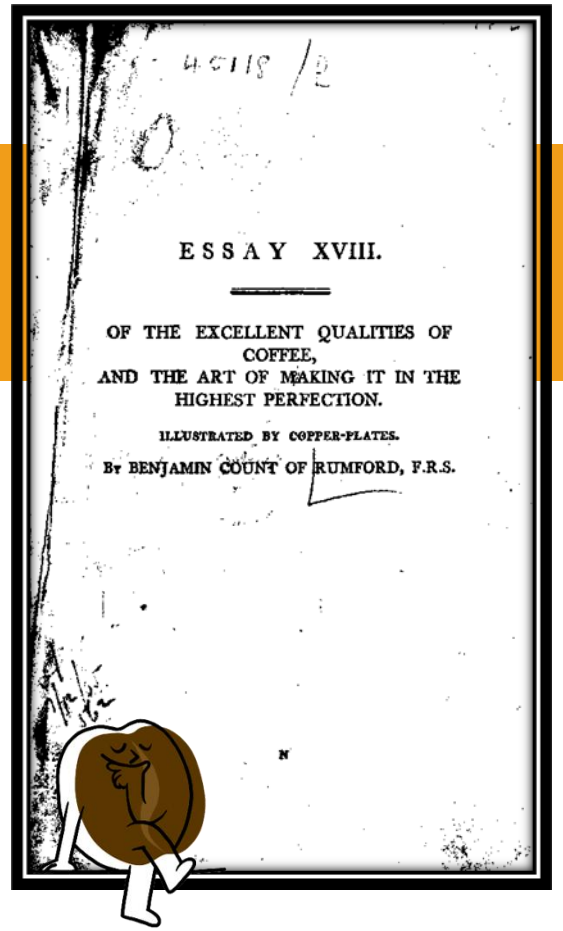
ANJA RAHN PH.D.
www.CuriousAboutCoffeeScience.com

THE LEGEND COUNT RUMFORD

SIR BENJAMIN THOMPSON

1753 - 1814

A FOUNDING FATHER OF THERMODYNAMICS

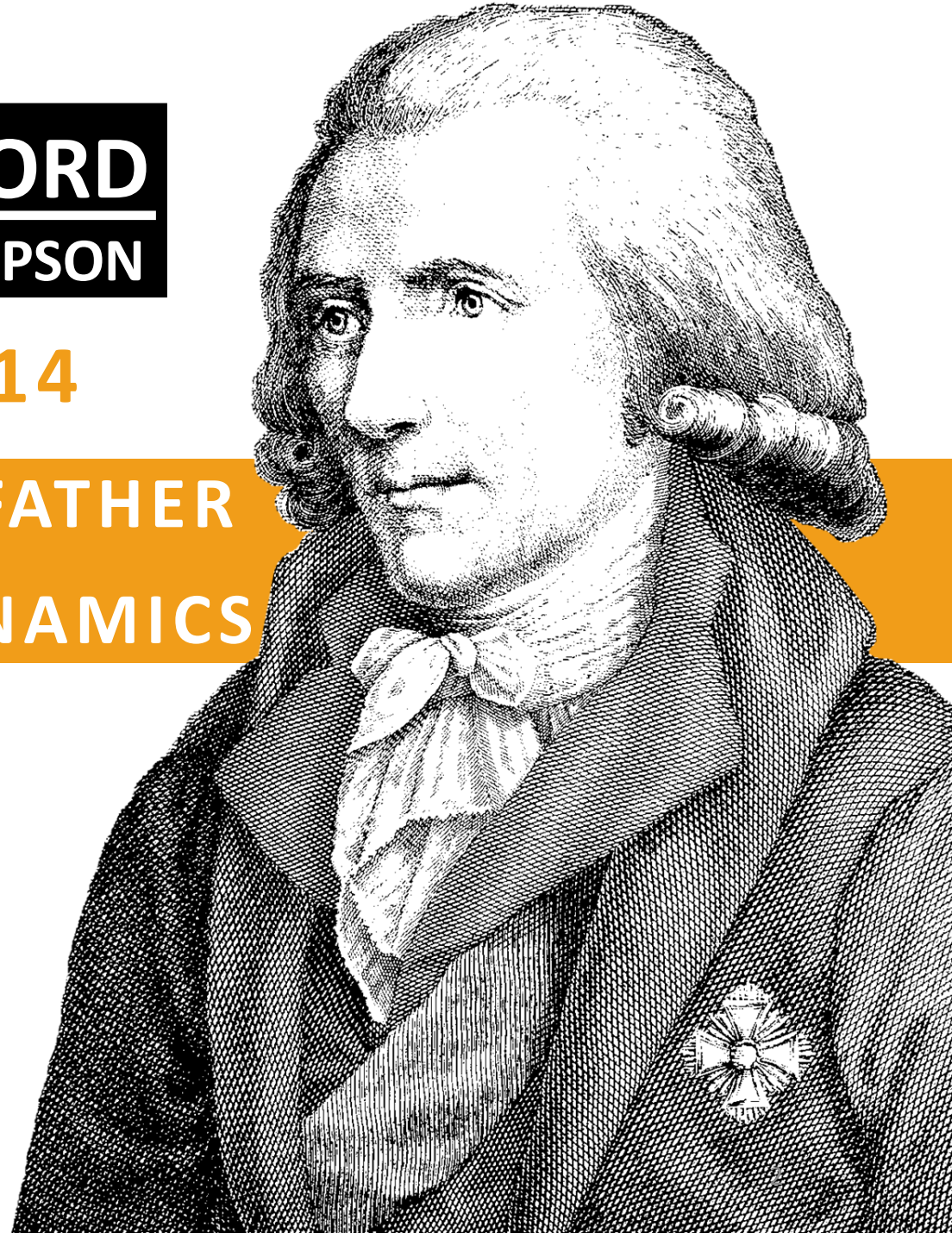


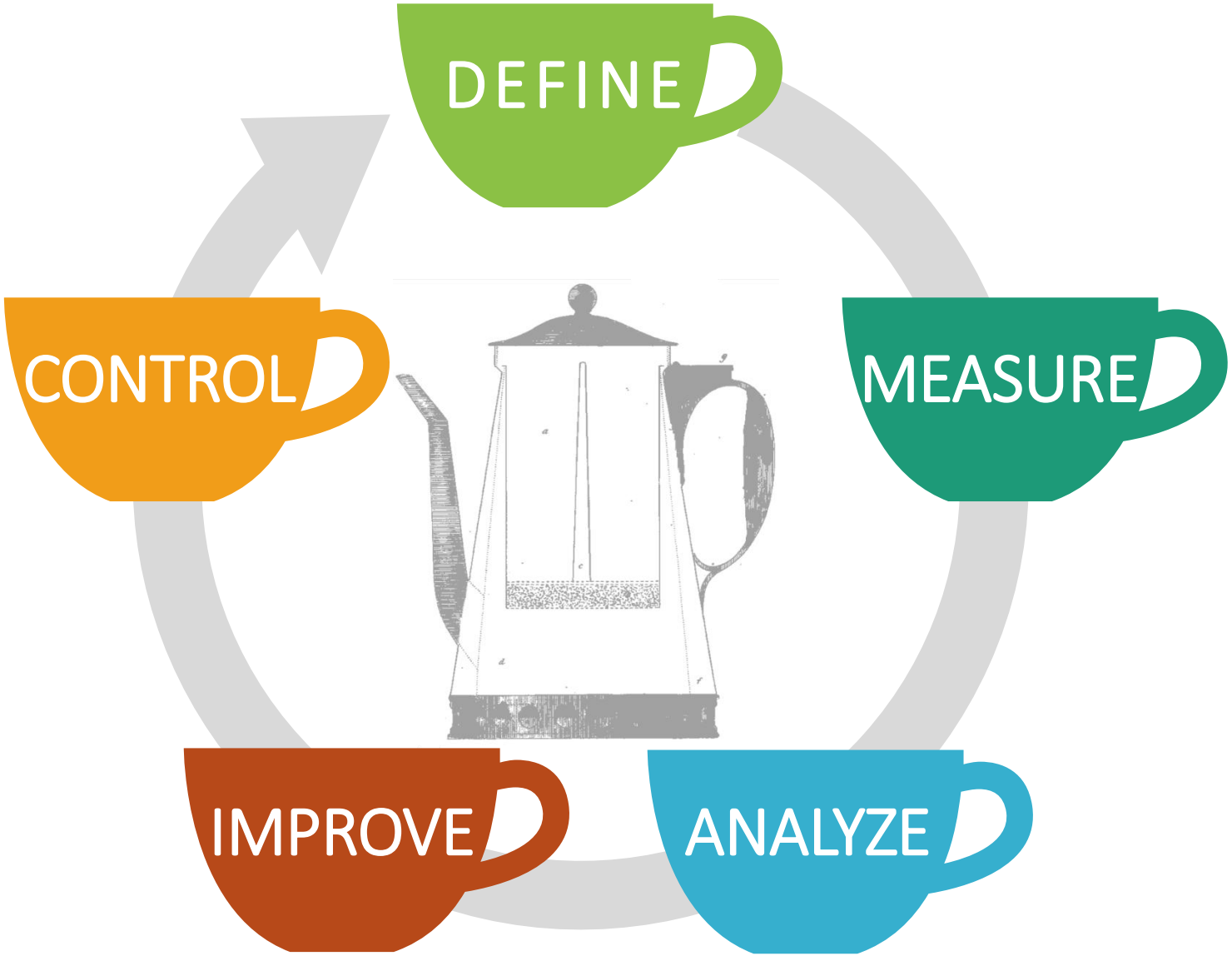
ESSAY XVIII.

OF THE EXCELLENT QUALITIES OF COFFEE,
AND THE ART OF MAKING IT IN THE HIGHEST PERFECTION.

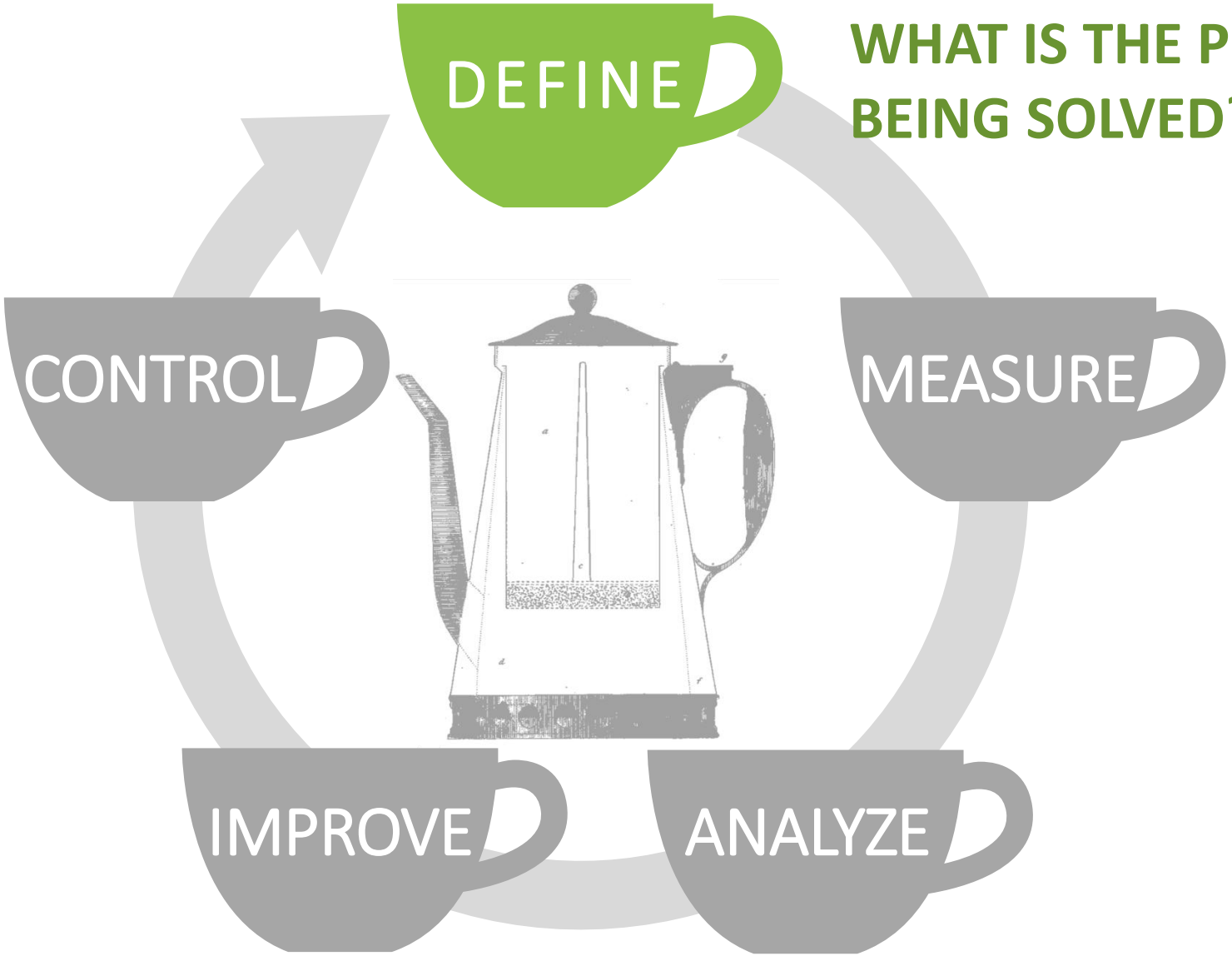
ILLUSTRATED BY COPPER-PLATES.

By BENJAMIN COUNT OF RUMFORD, F.R.S.




DEFINE
MEASURE
ANALYZE
IMPROVE
CONTROL

WHAT IS THE PROBLEM BEING SOLVED?



WHY?

COFFEE

ALTRUISTIC SCIENTIST THAT CONSIDERED COFFEE A PUBLIC GOOD

"The use of science is to explain the operations which take place in the practice of the arts . . .

domestic arts . . . which the progress of industry . . . contribute to the comfort and happiness of great numbers of respectable individuals;

their improvement must be interesting to all those who take pleasure in contemplating the prosperity of mankind, and in contributing to their innocent enjoyments."

WHY?

LOW CONSUMPTION

COFFEE'S PALATABILITY INFLUENCED ITS ADOPTION

"As long as Coffee Shall continue to be made according to the method generally practiced in England, I shall have no hope of its being preferred to tea, for its qualities are so inferior when prepared in that way, that it is hardly possible that it should be much liked."

WHY?

UNPALATABLE

UNAWARE HOW TO PREPARE COFFEE PROPERLY

“There is no culinary process that is liable to so much uncertainty in [its] results, as the making of Coffee . . .

With the same materials, and even when used in the same proportions, this liquor is one day good, and the next bad . . .”

BREWING GUIDANCE WAS LACKING

PROGRESS REQUIRES A DEFINED OBJECTIVE

WHY?

UNKNOWLEDGABLE

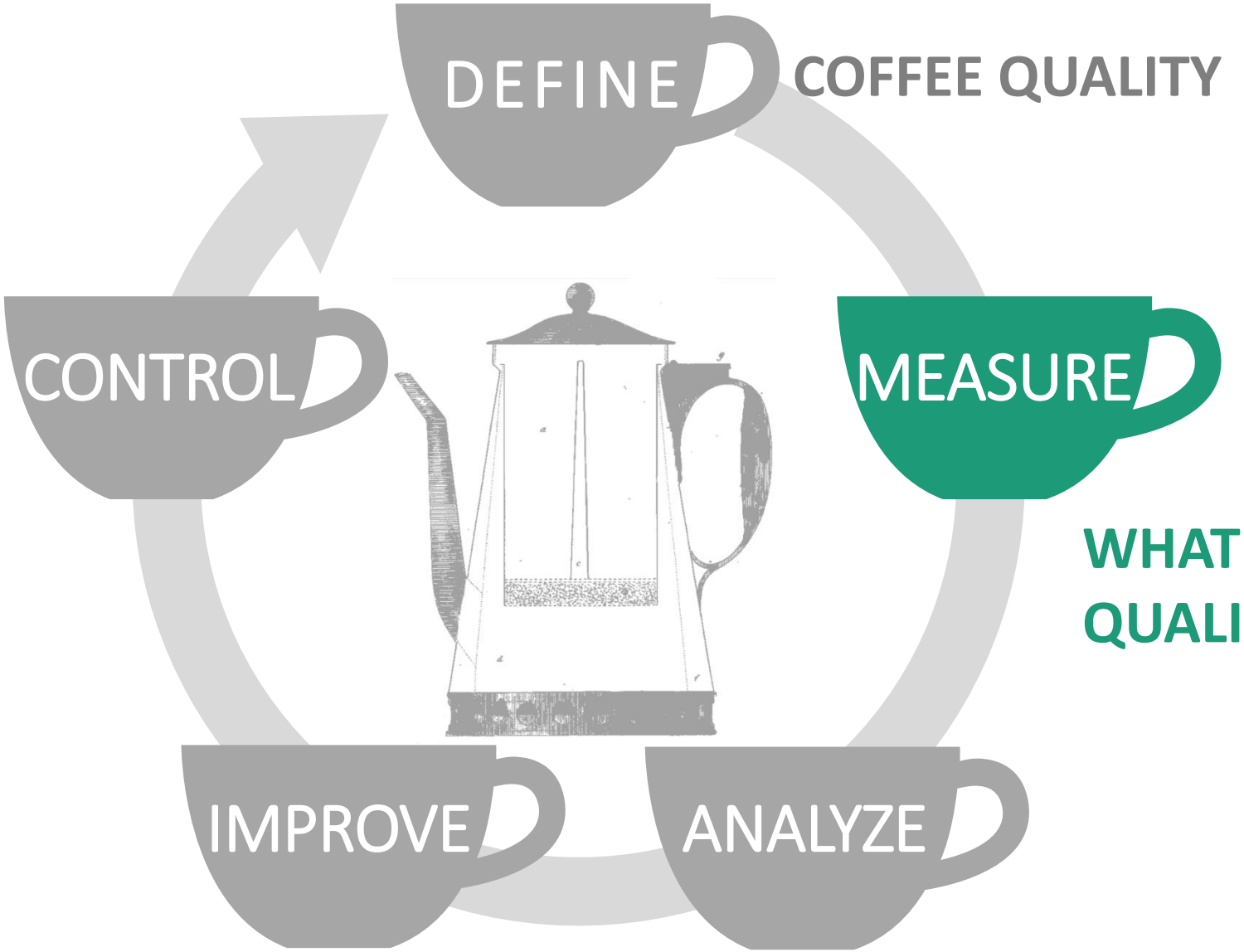
“When the cause of any evil is perfectly known, it is seldom very difficult to find means to prevent it.”

COFFEE QUALITY WAS NOT UNDERSTOOD

WHY?

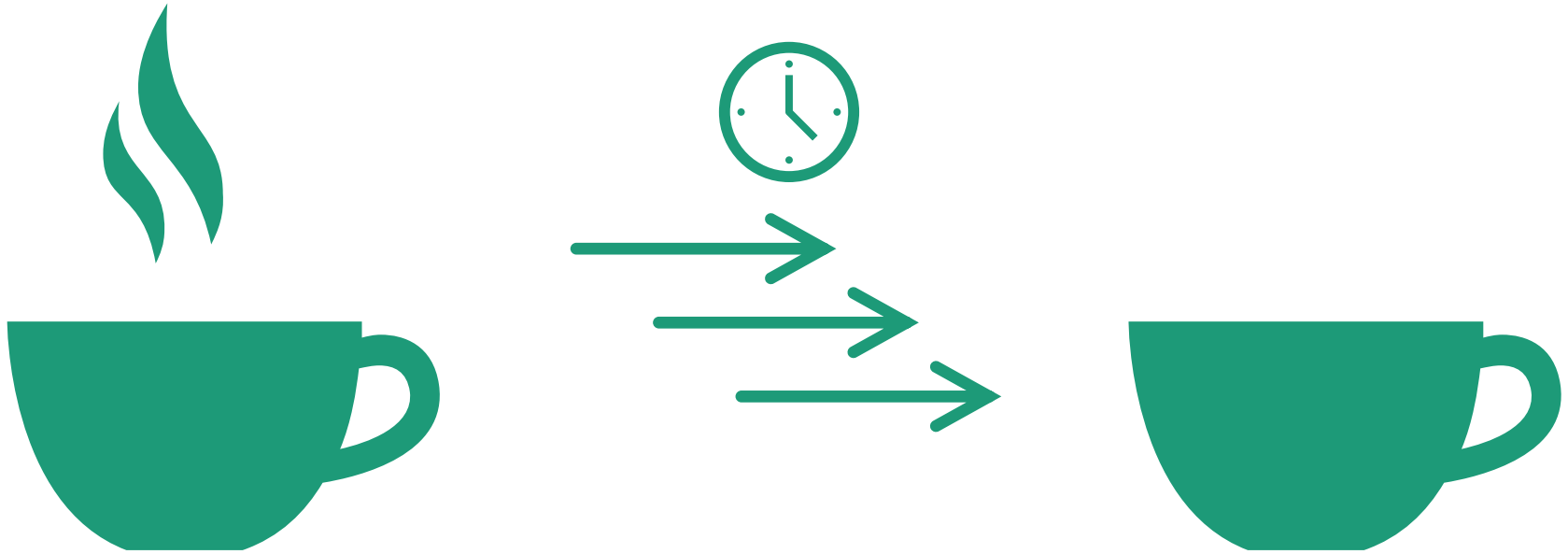
NO OBJECTIVE

BREWING BETTER COFFEE STARTS WITH UNDERSTANDING COFFEE QUALITY.



WHAT IS COFFEE QUALITY?

WHAT IS COFFEE QUALITY ?



"[If a cup of Coffee] be placed on a table, in the middle of a large room, and suffered to cool, it will in cooling ***fill the room with its fragrance;*** *but the Coffee, after having become cold, will be found to have lost a great deal of its flavour."*

WHAT IS COFFEE QUALITY ?

VOLATILE = AROMA

*"Boiling hot water **extracts** from Coffee . . . an aromatic substance, of an exquisite flavour, together with a considerable quantity of astringent matter, of a bitter, **but very agreeable taste**; but this **aromatic** substance . . . is extremely volatile; and is so feebly united to the water, that it **escapes** from it into the air with great facility."*

NON-VOLATILE = ASTRINGENCY, BITTERNESS, STIMULANT (CAFFEINE)

WHAT IS COFFEE QUALITY ?

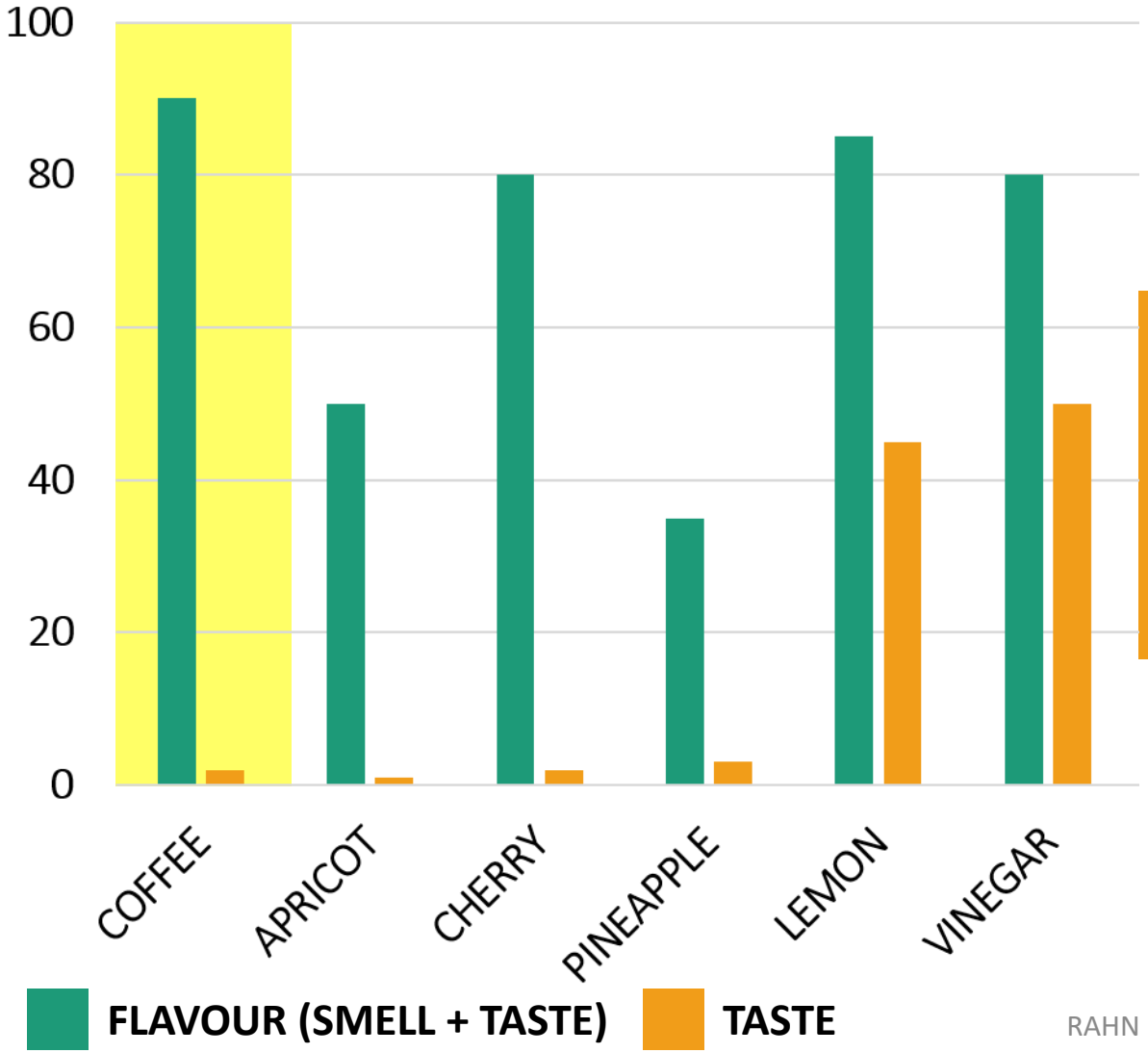
"[I]t would be difficult to persuade me, or any other unprejudiced person, that Coffee is good, which has nothing to recommend it but a strong, bitter, austere taste."

AROMA IS KEY TO COFFEE QUALITY

WHAT IS COFFEE QUALITY ?

*"Coffee may easily be too bitter, **but it is impossible that it should ever be too fragrant**. . . . In short, every thing proves that the volatile, **aromatic matter**, whatever it may be, that gives flavour to Coffee, is what **is most valuable in it, and should be preserved with the greatest care**; and that in estimating the strength, or richness of that beverage, its fragrance should be much more attended to, than either its bitterness or its astringency"*

WHAT IS COFFEE QUALITY ?



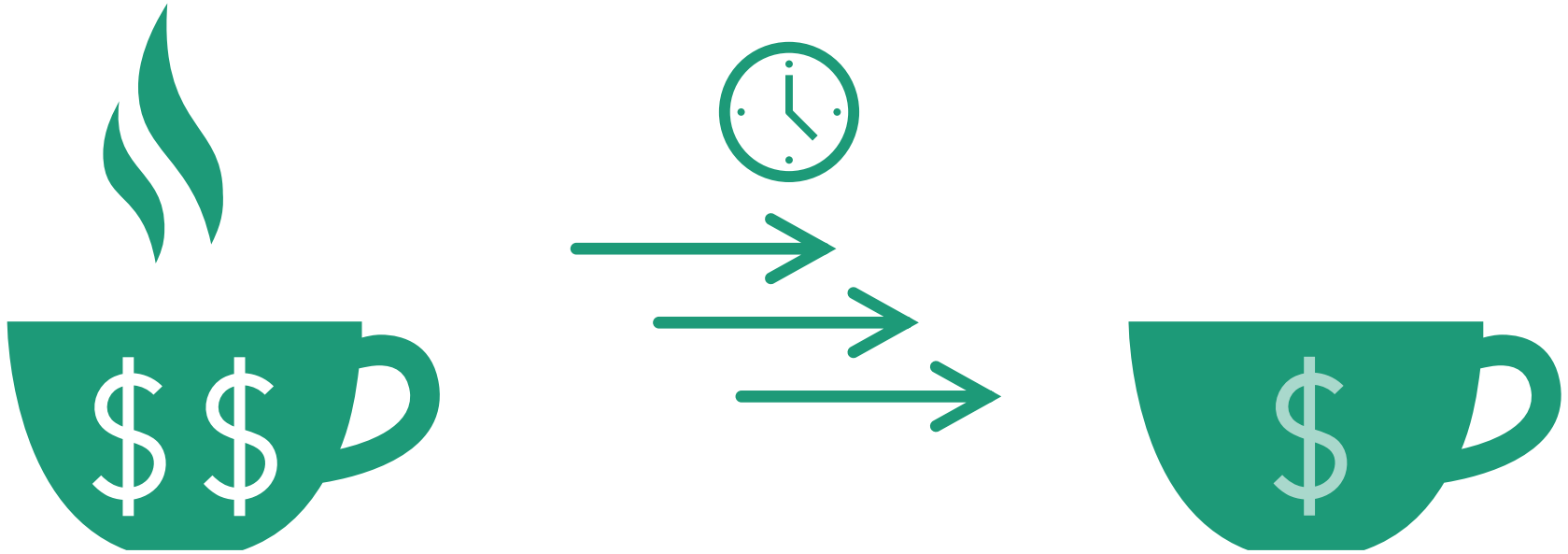
AROMA ISN'T JUST PART OF COFFEE —

IT'S WHAT MAKES IT RECOGNIZABLE, DESIRABLE, AND VALUABLE.

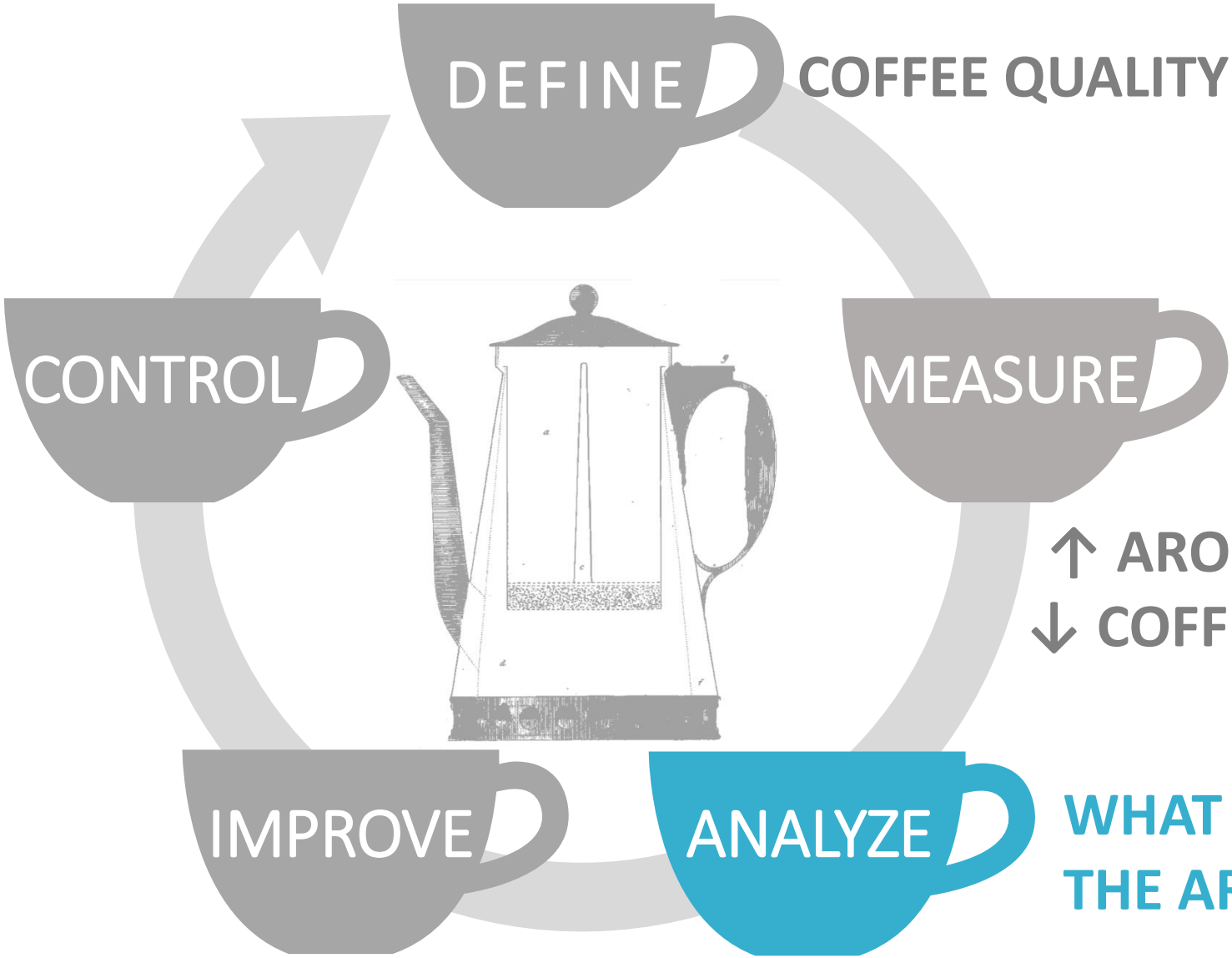
WITHOUT IT, COFFEE BECOMES UNRECOGNIZABLE.

Mozell *et al.*, 1969

WHAT IS COFFEE QUALITY ?



“[W]hen Coffee is bad, when it has lost its peculiar aromatic flavour, which renders it so very agreeable to the organs of taste and of smell; it has lost its exhilarating qualities, and with them, all that was valuable in it.”

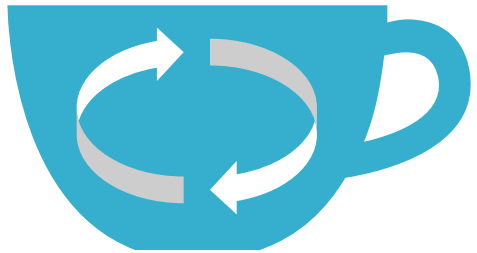

DEFINE
COFFEE QUALITY
MEASURE
↑ AROMA LOSS ≈
↓ COFFEE QUALITY
ANALYZE
WHAT IS CAUSING
THE AROMA LOSS?
IMPROVE
CONTROL

WHY?

AROMA LOSS

BREWED COFFEE IS NOT AT REST

"If the liquid were perfectly at rest, the volatile particles . . . could not escape . . . Those at the surface of the liquid might fly off, but those below the surface would be confined and preserved."



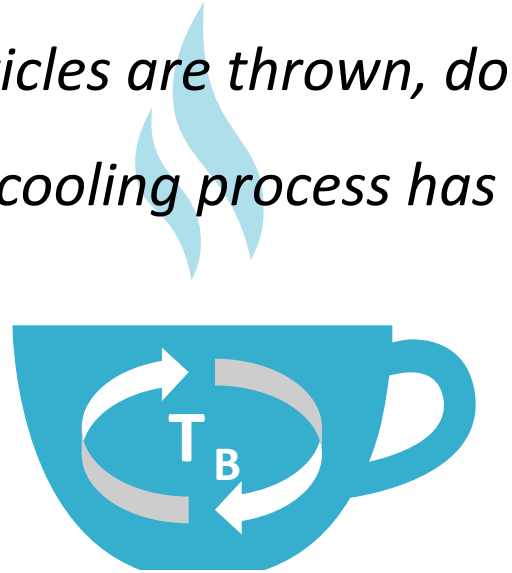
This motion is known as **CONVECTION**

WHY?

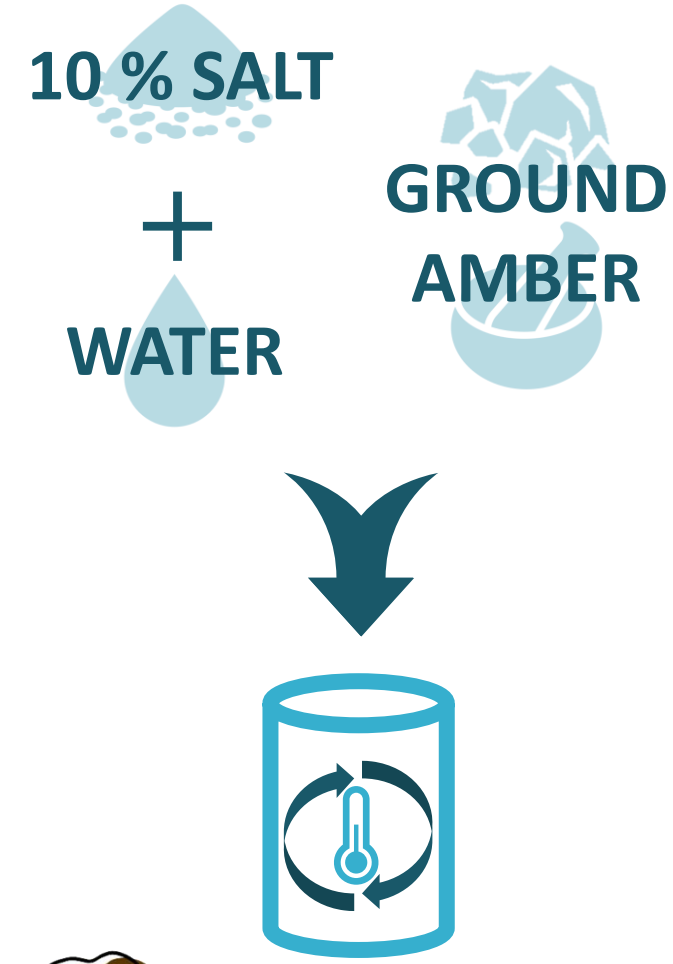
IN MOTION

CONVECTION IS DRIVEN BY TEMPERATURE DIFFERENCES

"Now all liquids, that are either heated or cooled, are necessarily disturbed and agitated; and the internal motions into which their particles are thrown, do not cease, till the heating or cooling process has ceased."



RUMFORD EXPERIMENT



"We may conceive the particles of amber . . . to represent the particles of the aromatic substance . . .

as long as the Coffee remains at rest . . .

as long as its temperature remains unchanged, these aromatic particles cannot escape;

for they cannot come to the surface of the liquid; but when the liquid is put in motion, their escape is greatly facilitated."

WHY?

IN MOTION

MOTION UNIVERSAL DRIVER OF AROMA LOSS

"[A]ll kinds of agitation must be very detrimental to Coffee, not only when made, but also while it is making . . ."

DEFINE

COFFEE QUALITY

MEASURE

↑ AROMA LOSS ≈
↓ COFFEE QUALITY

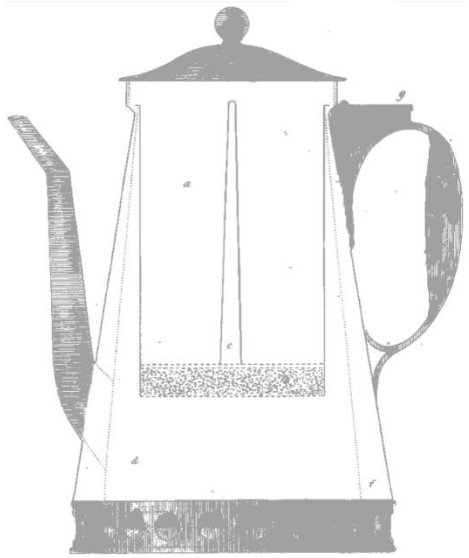
ANALYZE

↑ AGGITATION &
↑ Δ TEMPERATURE≈
↓ COFFEE QUALITY

IMPROVE

IMPLEMENTING SOLUTIONS

CONTROL



IMPROVE

AROMA RETENTION

AROMA RETENTION = MINIMIZE MOTION

*"In order that Coffee may **retain** all those **aromatic particles** which give to that beverage its **excellent qualities**, nothing more is necessary, than to **prevent all internal motions** among the particles of that liquid; by **preventing** its being exposed to any **change of temperature,** either during the time employed in preparing it; or afterwards, till it is served up."*

IMPROVE

AROMA AUDIT

IS THIS DECISION MAKING THE COFFEE BETTER?

ROASTING

GRINDING

BREWING

COFFEE QUALITY

PRESENT FOCUS

WATER TEMPERATURE

HIGH/LOW

HOT

BOILING WATER IS REQUIRED TO EXTRACT DESIRABLE AROMAS

"[T]he temperature of boiling water is preferable to all others for making Coffee . . . on account of its being most favourable to the extraction of all that is valuable in the roasted grain . . ."

ADDING COFFEE **BEFORE/AFTER** BOILING WATER

AFTER
REDUCES AROMA LOSS

"From the results of several experiments . . . to ascertain what proportion of the aromatic and volatile particles in the Coffee escape, and are left in this process, I found reason to conclude, that it amounts to considerably more than half.

This loss may easily be explained . . . by the motions into which the liquid is thrown in being heated, and afterwards on being made to boil . . ."

BREW METHOD
IMMERSION/ PERCOLATION

PERCOLATION
GREATER EXTRACTION CONTROL

IMMERSION

". . . [coffee grinds]. . . are surrounded, not by pure water, but by a solution of Coffee, more or less saturated, [which] is unfavourable to [the coffee]."

PERCOLATION

"[G]radual percolation brings continually a succession of fresh particles of pure water into contact with the ground Coffee . . ."

GRIND SIZE

COARSE/FINE

FINE

GREATER EXTRACTION EFFICIENCY & MORE ECONOMICAL

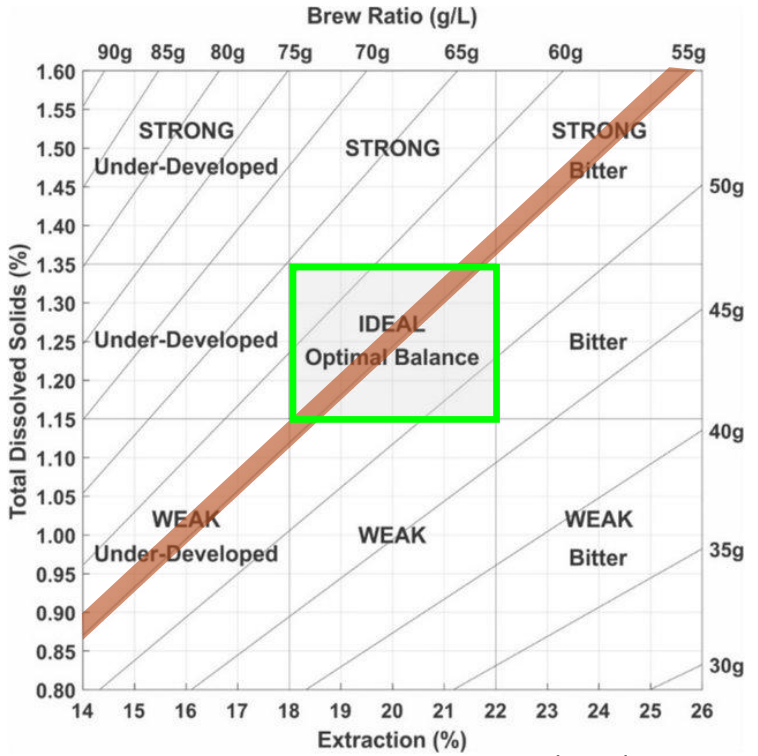
*"In making Coffee . . . Coffee must be **ground fine**, otherwise the hot water will . . . carry away but a small part of those aromatic . . . substances on which the goodness of the liquor entirely depends."*

BREW RATIO

1:18
200 YEARS AGO, FOUND THE "IDEAL BALANCE"

"one quarter of an ounce averdupois [6.3 grams] of ground Coffee is quite sufficient to make a gill [113 ml] of most excellent Coffee."

55-56 grams of coffee/L
1:18 Brew Ratio

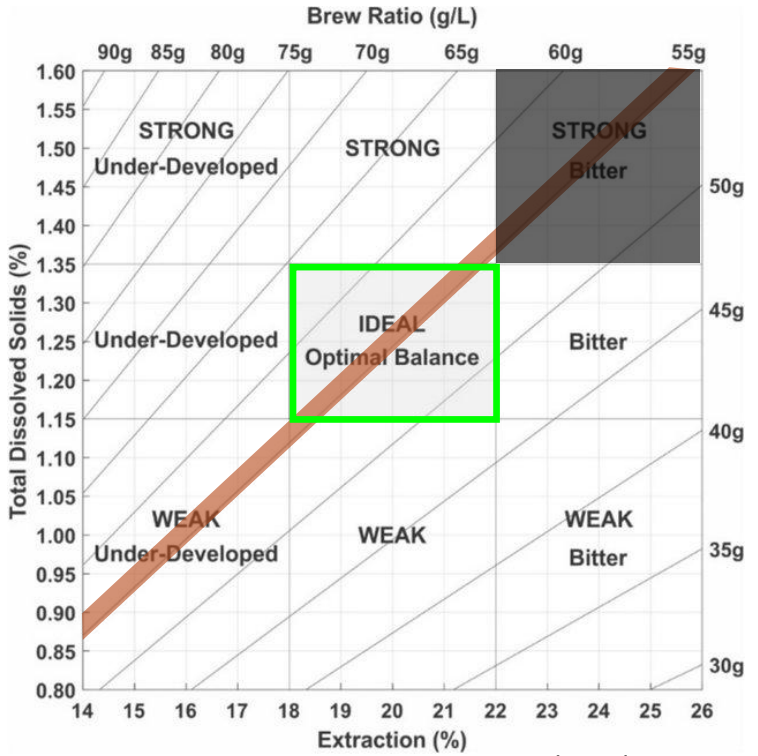


Batali *et al.*, 2020

BREW RATIO

1:18
200 YEARS AGO, FOUND THE "IDEAL BALANCE"

"The fact is . . . when it is made ***very strong****, its* ***taste*** *becomes so* ***very bitter*** *and austere, that it is* ***no longer*** *possible to* ***distinguish that delicate aromatic fragrance*** *which is [present] when the Coffee is properly prepared."*



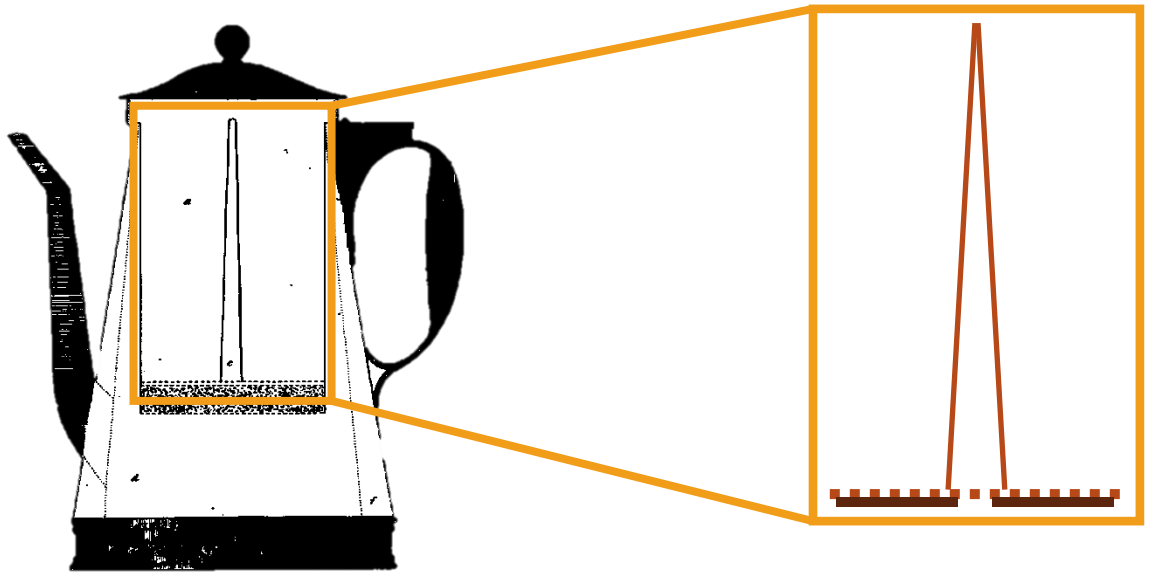
Batali *et al.*, 2020

COFFEE BED DIMENSIONS

1 CUP
DIAMETER: 1.15 INCHES, DEPTH*: 0.5 INCHES
*COMPRESSED

USED 3-IN-1 TOOL TO:

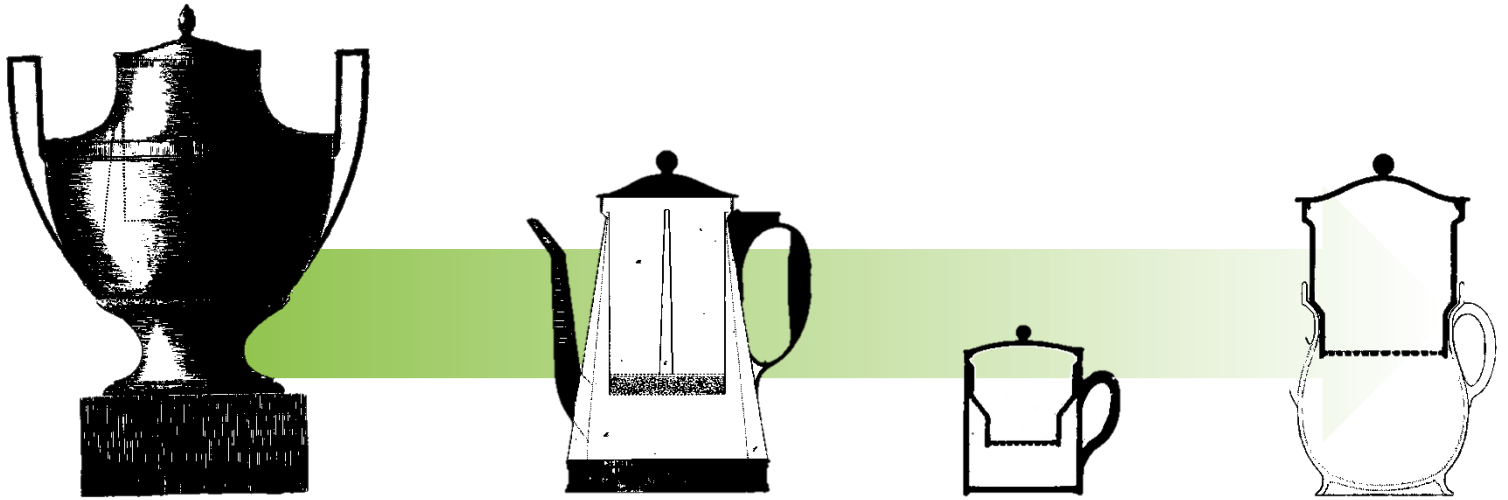
- **DISTRIBUTION OF COFFEE GROUNDS: ENSURING CONSISTENT BED HEIGHT**
- **TAMPING/COMPRESSION: ENSURING CONSISTENT BED RESISTANCE**
- **ANCHOR COFFEE GROUNDS: REDUCE AGGITATION DURING EXTRACTION**



EQUIPMENT

NOTES

- **RUMFORD DESIGNED BREWING SETUPS FOR ALL ECONOMIC CLASSES**
- **HE USED A SIEVE,** NOT FILTER PAPER
- **ALL OF HIS DESIGNS INCLUDED A LID**



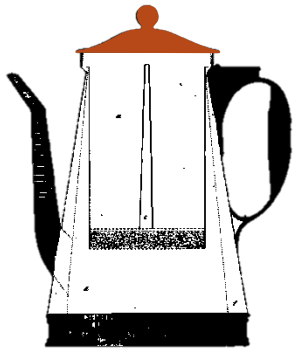
$$$$ $

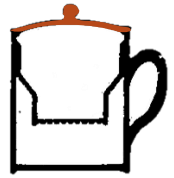
CLOSED
TRAP WARMTH & AROMAS

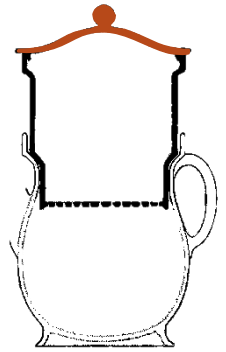
CLOSED/OPEN
VESSEL

ALL OF HIS DESIGNS INCLUDED A LID

"When all the Coffee has passed into the lower part of the [vessel] the strainer may be taken away, and the [vessel] may be covered with the cover of the strainer."

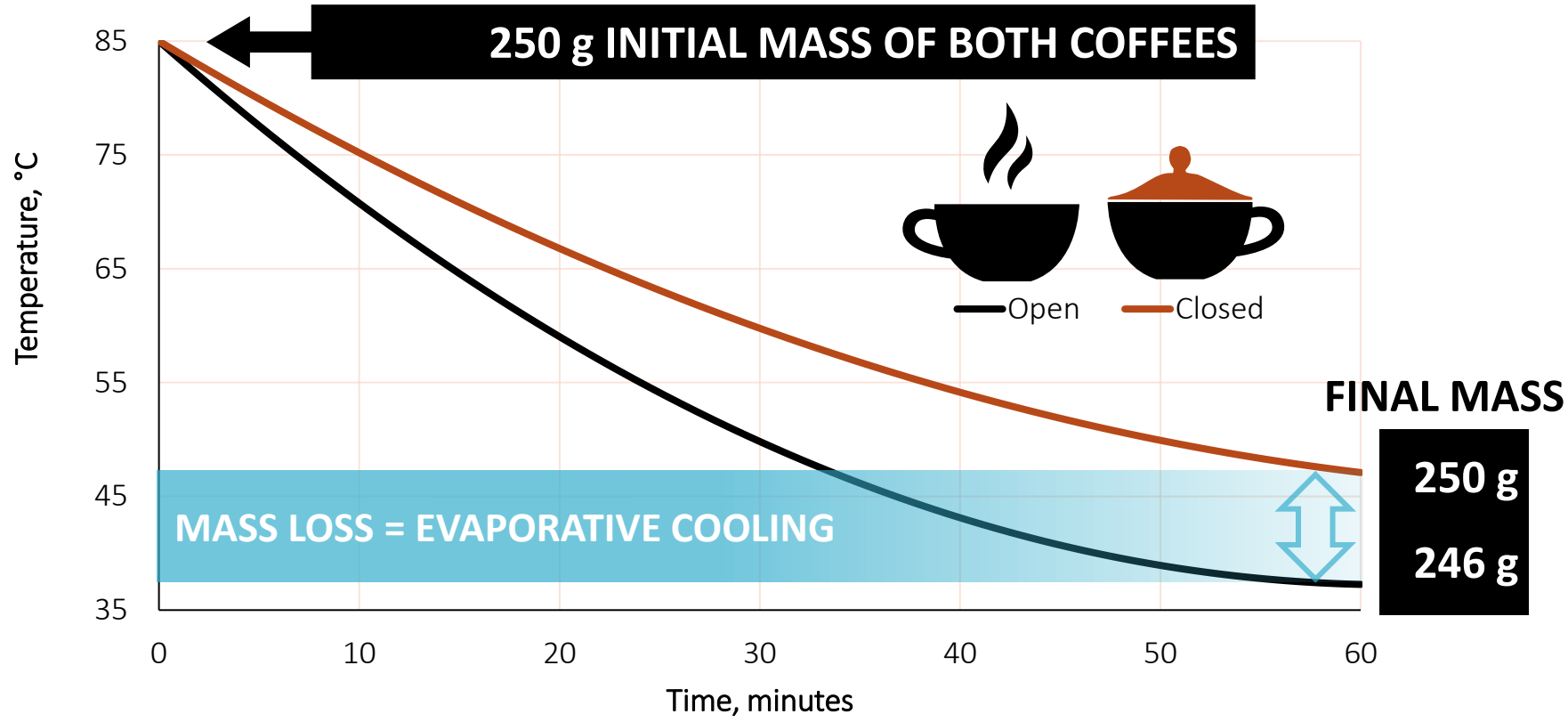






CLOSED
TRAP WARMTH & AROMAS

CLOSED/OPEN
VESSEL



IF YOU ARE LOSING WATER, YOU ARE ALSO LOSING AROMA

CLOSED
TRAP WARMTH & AROMAS

CLOSED/OPEN
VESSEL

OPEN SYSTEMS LOSE:

- **MASS**
- **AROMA**

THUS, COFFEES COOLED WITH & WITHOUT A LID ARE

COMPOSITIONALLY INEQUIVALENT.

THEREFORE, DO NOT SHARE THE SAME COFFEE QUALITY.

CAN WE RETAIN MORE WARMTH & AROMA?

GILD
RETAIN WARMTH & AROMA

GILD/UNGILDED VESSEL

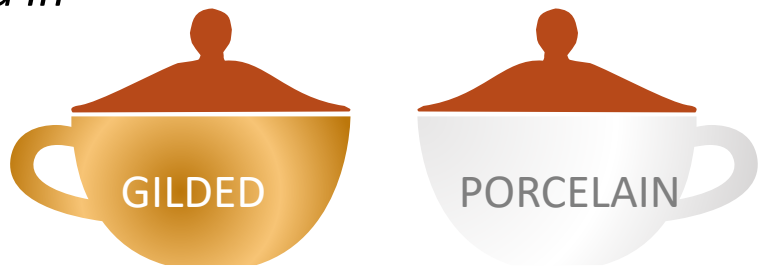
THE INFLUENCE OF GILDING ON QUALITY IS NOT NEW

*" . . . [Pots made] of **silver** are **preferred** to those of porcelain or earthenware, and the reason given for this preference is that the beverage when prepared in the former is of a better quality than when prepared in the latter."*

Rumford, 1807

". . . the metallic properties of the outer surface of the cup in which coffees were evaluated exerted a significant influence over the ratings of both experts and consumers."

Carvalho & Spencer, 2021



GILD/UNGILDED
VESSEL

GILD
RETAIN WARMTH & AROMA

*" I was, for a long time, of the opinion that this idea was owing simply to **prejudice**, and **without foundation**;*

PSYCHOLOGY/ NEUROSCIENCE/ MULTISENSORY PERCEPTION

*but, having discovered . . . that **metallic vessels**, when clean and bright on the outside, possess the property of causing warm liquids . . . to **retain their heat for a very long time**,*

THERMODYNAMICS

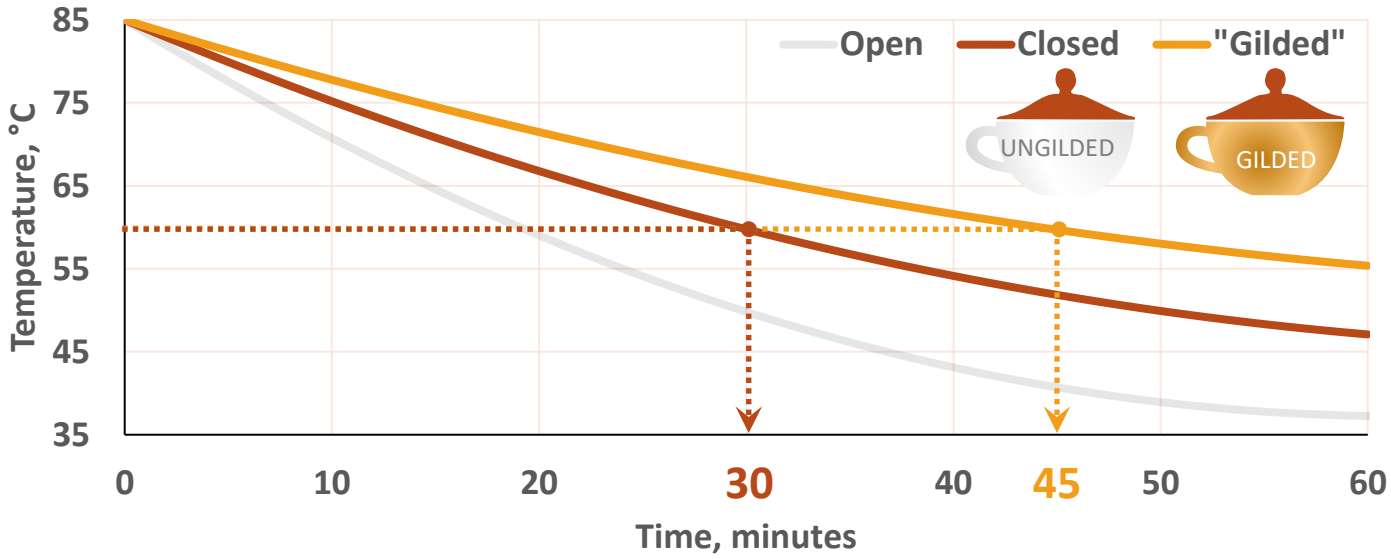
I began to see that the preference in question might be the legitimate result of long experience, as is almost always the case with those preferences which in the end are universally adopted."

Rumford, 1807

GILD
RETAIN WARMTH & AROMA

GILD/UNGILDED VESSEL

"[T]he gilded vessel always cooled more slowly than the plain one in about the proportion of 3 [e.g. 45mins gilded] to 2 [e.g. 30 mins un-gilded]."



GILDING SLOWS THE COOLING RATE OF A CLOSED SYSTEM BY ~50%, BUT WHY?

GILD/UNGILDED
VESSEL

GILD
RETAIN WARMTH & AROMA

RADIATION

"the metals are the most impervious to light, and . . . possess in an eminent degree the power of reflecting the invisible rays or undulations which all objects in nature send off . . . constitut[ing] their temperature."

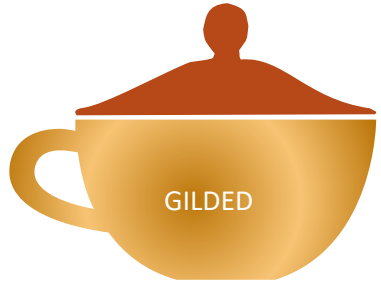
Rumford, 1807

DULL &/ ROUGH* SURFACES

- **LOSE/EMIT MORE HEAT**
- **↑ EMISSIVITY (ε ~1)**

SMOOTH &/ SHINY* SURFACES

- **EMIT LESS/REFLECT MORE HEAT**
- **↓ EMISSIVITY (ε ~0.02)**



*colour can also influence emissivity, but is considered secondary to material properties

GILD
RETAIN WARMTH & AROMA

GILD/UNGILDED VESSEL

GILDED SYSTEMS RETAIN:

- **HEAT**
- **AROMA** – BY SLOWING CONVECTION

THUS, COFFEES COOLED IN GILDED VS UNGILDED VESSELS WILL BE COMPOSITIONALLY INEQUIVALENT, ESPECIALLY IF NOT CLOSED.

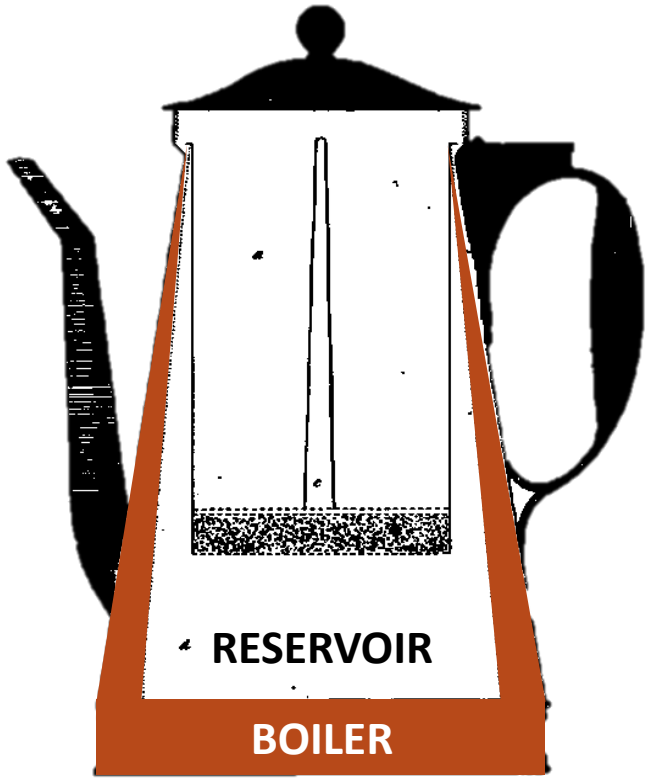
THEREFORE, DO NOT SHARE THE SAME COFFEE QUALITY.

ARE THERE OTHER WAYS OF RETAINING HEAT &/AROMA?

PRESERVATION OF BREW QUALITY

TEMPERATURE ALIGNMENT

BREWED



"[T]he reservoir must be suspended in its boiler . . . The small quantity of water which it will be necessary to [surround the reservoir with steam] . . . in order more effectually to confine the heat."

PRESERVATION OF CUP QUALITY

TEMPERATURE ALIGNMENT

SERVED

RUMFORD'S PREFERENCE

"I use a larger cup, into which the Coffee being poured ***boiling hot****, on a sufficient quantity of sugar half an ounce,* ***I pour into it about one-third of its volume of good sweet cream,*** ***quite cold****. On stirring these liquids together, the Coffee is* ***suddenly cooled****, and in such a manner as not to be exposed to the loss of any considerable portion of its aromatic particles in that process."*

DEFINE

COFFEE QUALITY

MEASURE

↑ AROMA LOSS ≈
↓ COFFEE QUALITY

ANALYZE

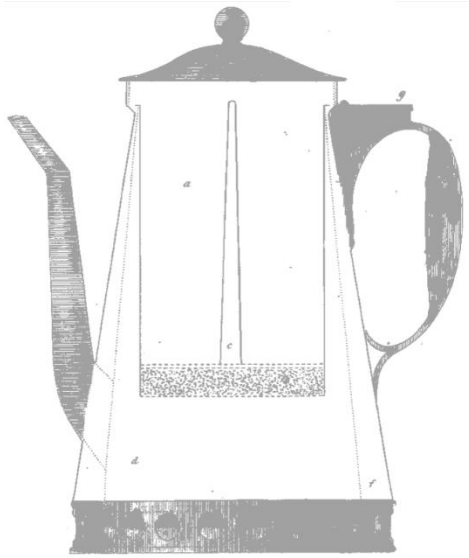
↑ AGGITATION &
↑ Δ TEMPERATURE≈
↓ COFFEE QUALITY

IMPROVE

IMPLEMENTING SOLUTIONS

CONTROL

SUSTAINING THESE IMPROVEMENTS



CONTROL

CARRY KNOWLEDGE FORWARD

UNDERSTANDING THE SCIENCE BEHIND COFFEE QUALITY

ISN'T ABOUT JUST ONE STEP—

IT'S ABOUT RECOGNIZING THAT THE AROMA IN THE CUP IS

THE RESULT OF EVERY DECISION MADE ALONG THE WAY.

CONTROL

CARRY KNOWLEDGE FORWARD

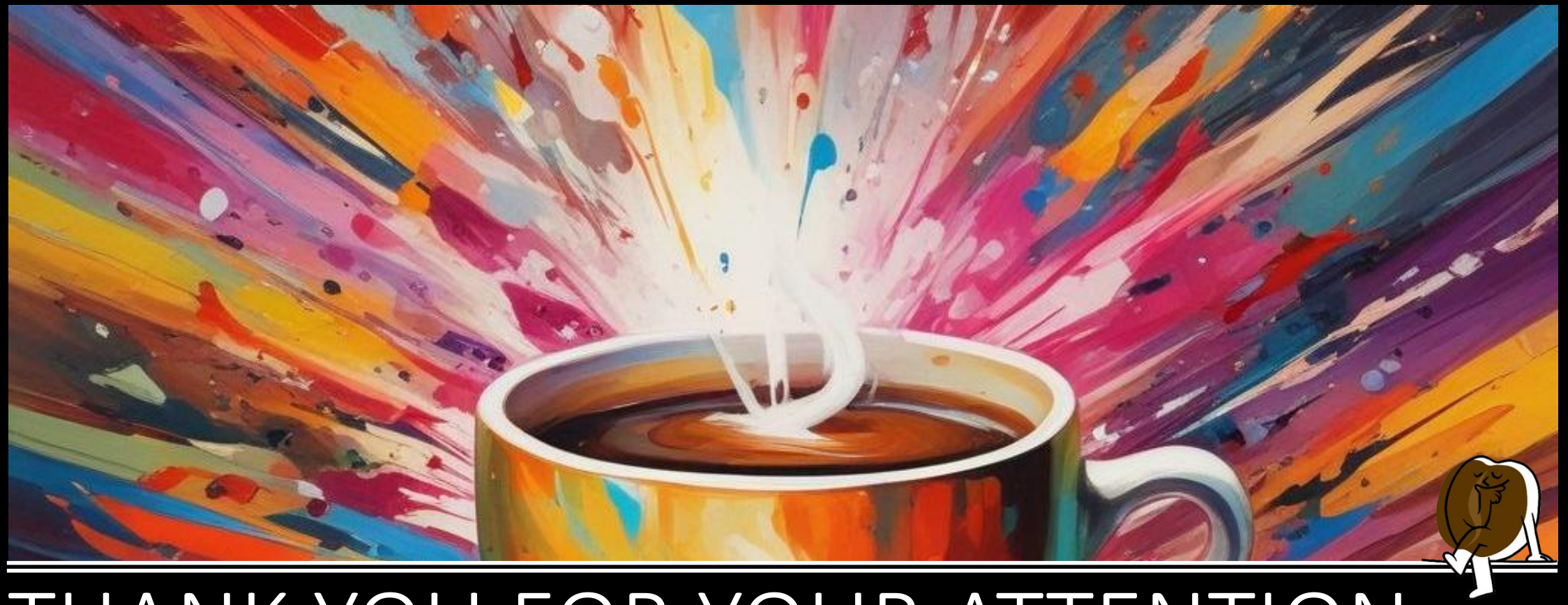
THIS MEANS THAT COFFEE AROMA RESEARCH MUST BE CONDUCTED CONSCIENTIOUSLY, INTEGRATING ESTABLISHED SCIENCE.

FINAL THOUGHTS

DESPITE THERMODYNAMICS BEING IN ITS INFANCY AND COFFEE AROMA UNMEASURABLE, RUMFORD APPLIED HIS KNOWLEDGE FOR THE GREATER GOOD, GROUNDING HIS ADVICE IN LASTING SCIENTIFIC PRINCIPLES.

INSPIRED BY RUMFORD

- **CUSTOMER (OR COFFEE) SPECIFIC DRINKING TEMPERATURES**
  - **Use temperature-controlled cups to manage final drinking temperature.**
- **MAINTAIN CUP AT OPTIMUM DRINKING TEMPERATURE**
  - **Lidded, gilded, or double-walled cups help maintain ideal temperature.**



THANK YOU FOR YOUR ATTENTION

DO YOU HAVE ANY QUESTIONS?

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