

THE SCOVILLE SPLICE LIBRARY · VOLUME XXXVII

# Cocktails & Botanicals

## Astringent, cooling, bitter, hot — in a glass. *Poured by the numbers.*

A bartender's reference to the eight axes in liquid — astringency as the structure of a serious drink, bitterness turned down to a signature, cooling and heat laddered by dilution and temperature — and the designed botanicals that let a glass say exactly what we mean. Mocktails are not an afterthought here; they are the proof. Every pour is scored on the Iyengar Flavor Index.

SCOVILLE SPLICE · GROWN BY OUR FAMILY. ENGINEERED FROM SCRATCH.

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# Opening essay · The glass as a receptor experiment

There is a moment, most evenings, when the light in the greenhouse goes the color of weak tea and someone in our family reaches for a glass. Not always alcohol — more often a shrub over ice, or cold steeped tea gone slightly tannic, or soda cut with a cordial we pressed that afternoon. The glass sweats. Condensation beads and runs. Somebody says *try this* and hands it across, and for a few seconds nobody talks, because the drink is doing the one thing a drink does better than any plate of food: it is delivering flavor to the mouth in a form so thin, so fast, so completely surrounded by water, that the receptors have nowhere to hide.

That is the secret this book is built on. A drink is the purest instrument we own for reading taste, because a drink is already a dilution series. A stew holds its flavors in fat and protein and the slow architecture of a sauce; it buffers, it hides, it releases over minutes. A cocktail hides nothing. It is water and a little ethanol and a handful of molecules, chilled to a temperature you chose, carrying exactly as much of each compound as made it off the ice. When you swallow, you are running a titration against your own tongue. We have spent a decade learning to design what goes into that titration on purpose.



The hour the family reaches for a glass — dusk over the research greenhouse, where most of what became this book was first tasted out loud.

The Iyengar Flavor Index was built to end a silence ten thousand years long: the inability to say *how much*. How much warmth, how much of the puckering grip of a tannin, how much cool, how much of the round savory weight that makes a broth feel like care. Each axis of the Index is a single number anchored not to how much of a compound a food contains but to how *loudly* that compound speaks to its receptor:

$$\mathrm{IFI}(c) = 1000 \cdot \mathrm{EC}_{50}(\mathrm{ref}) \,/\, \mathrm{EC}_{50}(c)$$

$\mathrm{EC}_{50}$ is the concentration at which a stimulus drives its receptor to half of full response. Invert it against a fixed reference, scale by a thousand, and loudness becomes a score you can read a grape, a

sprig of mint, and a shot of chili tincture against on one page. For solid food the Index is a measuring tool. For a drink it is almost a recipe, because in liquid the two things that separate a score on paper from a sensation in the mouth — *how much you deliver* and *at what temperature* — are exactly the two knobs a bartender already turns. Dilution and chill are not nuisances to be controlled out. They are the instrument's dials.

This is a book for people who make drinks and want to know why they work. It is organized the way we actually think about a glass: first the axes, receptor by receptor, because you cannot balance what you cannot name; then the botanicals, the living sources we have tuned to speak each axis on command; then the drinks themselves, spirit-forward and sour and spicy and — the part we are proudest of — entirely zero-proof, where there is no alcohol to carry the aroma or soften the tannin, and the designed plant has to do all of the work alone.

Astringency runs down the spine of the whole volume, and not only because it is this book's accent color. Astringency is the axis the cocktail world has always felt and almost never named. It is the grip of a tannic red, the dry pull of over-steeped tea, the clean architectural finish that keeps a sweet drink from collapsing into syrup. It is not, strictly, a taste. When a tannin meets saliva it cross-links the proline-rich proteins that keep your mouth slick, the aggregates fall out of solution, and the brain reads the sudden loss of lubrication as *dry*. On the Index that grip has a number at last — IFI-A, anchored to the half-saturation of salivary binding — and once a drink's astringency has a number, you can build around it the way a composer builds around a bass line.

We write as *we* because that is the truth of it: a family that reveres what it grows, doing the slow work of turning a plant into a flavor you can count on. The computing — the protein models, the flux math, the edits written in with CRISPR — came from one pair of hands. The table it all comes back to belongs to all of us. Nothing in these pages is a health claim; a drink is a pleasure, and we treat it as one. But the quiet thing that hums under every chapter is the same thing that hums under everything we plant: that what you put in a glass can be grown to carry the most of what it should, and the least of what it shouldn't, and still taste like something you want to hand across a table at dusk.

A word on reading what follows, since a drink engages more of the body than a plate does. Most of what you call a drink's "flavor" is in fact *aroma*, read **retronasally** — the volatiles rising from the back of the mouth to the olfactory bulb as you swallow — which is why a drink held at the nose and a drink swallowed are two different experiences, and why a very cold drink, its volatiles quieted, seems to taste of less until it warms in the glass. The eight axes of the Index measure *taste and trigeminal* sensation, the things the tongue and its nerves read directly; aroma rides alongside them, carried by ethanol's volatility or, in a zero-proof drink, by an expressed oil or a slapped herb. Throughout this book a scorecard — the eight-line block beside each drink — reports the axes as they land in the glass,

chilled and diluted and built. Read it as a *shape*, not a sum: a single tall bar is a drink with a clear spine; a spread of middling bars is a drink built on balance; a gap where you expected a bar is a space you can still fill. Learn to read the shape and you can taste a recipe before you build it.

Pour something. We'll measure it together.



PART I OF IV

# The Glass as Instrument

IFI-A · IFI-B · IFI-C · IFI-H · and the mathematics of a diluted drink

# Chapter 1 · Astringency — *the spine of a serious drink.*

Begin with the grip, because the grip is what a great drink is built against. Pour a young tannic red and hold the first sip; the wine does not taste of much for a half-second, and then the sides of your tongue and the inside of your lips go taut, as though the surface of your mouth had been very gently sanded. That sensation is astringency, and it is the most misunderstood thing in a glass. People call it bitter. It is not bitter. Bitterness is a taste, read by a family of receptors on the tongue; astringency is a *feeling*, a change in the mechanics of your own mouth, and it is produced by molecules — tannins — that never need to touch a taste receptor at all.

Here is what actually happens. Saliva is slippery because it is full of proline-rich proteins, or PRPs, long floppy molecules evolved for exactly one job: to coat the inside of your mouth and keep everything sliding. Tannins — the condensed proanthocyanidins of grape skin and seed, the galloylated catechins of tea, the ellagitannins of pomegranate — are molecular flypaper for those proteins. A tannin's phenolic rings hydrogen-bond and stack against the open coils of a PRP, and because a single tannin has many such faces, it staples several proteins together at once. The cross-linked tangle grows until it can no longer stay dissolved, and it precipitates, stripping lubrication off the mucosal surface as it falls. Your trigeminal mechanoreceptors register the sudden rise in friction. The brain, having no dedicated word for *my saliva just lost a fight with a flavonoid*, files it under *dry*.

Two families of tannin produce that dryness by slightly different routes, and a drink-maker gains from telling them apart. **Condensed tannins** — the proanthocyanidins of grape, sorghum, and cacao — are polymers of flavan-3-ol monomers, and their grip scales with their **mean degree of polymerization**, the average number of units in a chain: a longer chain presents more protein-binding faces, precipitates more saliva per molecule, and grips harder and longer. A mean degree near 3 reads soft and velvety; near 10, firm and food-friendly; past 20, a green-persimmon ferocity. **Hydrolyzable tannins** — the gallotannins and ellagitannins of pomegranate, tea's gallated catechins, the wood of an oak-aged spirit — are sugar cores hung with gallic or ellagic acid, and they tend to grip cleaner and sharper and finish faster. The lexicon of astringency, so often dismissed as sommelier's poetry, is in fact a reproducible mapping onto these molecular features: a short condensed tannin reads *soft*; a long one reads *drying* and *puckering*; a galloylated or hydrolyzable one reads *grainy* or *chalky*. The Index lets us aim for one and not another, at the gene, before a single fruit is pressed.

There is also a fact of saliva that every bartender has felt without naming. Astringency *accumulates*. Your mouth holds only so much proline-rich protein, and a tannic drink spends it; each successive sip meets a less-lubricated mouth and grips harder, until a pause lets the salivary glands replenish. This is why a tannic drink must be built to be *sipped* — with acidity and a little effervescence to stimulate flow, and with sweetness or kokumi weight to cushion the climb — and why a flight of tannic pours with no water between turns punishing by the third glass. Designing astringency is never only designing the grip of one sip. It is designing the arc of a whole drink, the way the dryness builds and resolves and builds again, which is exactly the kind of thing a number held steady at CV ≤ 7% lets you compose on purpose rather than discover by accident.



Grape, in cross-section — seed and skin are where the condensed tannins live, and where IFI-A is designed.

The Index anchors IFI-A to the half-saturation point of that binding — the tannin concentration at which salivary PRP precipitation reaches half of its maximum — and inverts it against a reference tannin the way every other axis inverts against its reference agonist. A number near 200 is the barely-there grip of a ripe table grape; 1,200 is the firm, food-friendly structure of a cru-level red or a well-steeped Assam; past 2,000 you are in the territory of green walnut and unripe persimmon, a grip so total it can feel almost numbing. Grape, our most tannin-literate organism, carries **1,610 engineered constructs** across the bitter, astringent, and multi-axis libraries, and the lever we pull to design its astringency is a single branch of the flavonoid pathway.

That branch is worth drawing, because it is the whole game. Every vascular plant runs the general phenylpropanoid trunk — **PAL → C4H → 4CL** — turning phenylalanine into the activated cinnamic acids that feed almost all of plant chemistry. The flavonoid spur runs off that trunk through chalcone synthase and a short series of reductions and hydroxylations down to the flavan-3-ols, the monomers of condensed tannin. Two enzymes set the character of the tannin that results:

| ENZYME | FULL NAME | PRODUCT | WHAT IT DOES TO THE GRIP |
|---|---|---|---|
| LAR | leucoanthocyanidin reductase | (+)-catechin | softer, rounder astringency; shorter grip |
| ANR | anthocyanidin reductase | (−)-epicatechin | firmer, more persistent astringency; longer grip |
| LDOX/ANS | anthocyanidin synthase | anthocyanidins | color; the substrate ANR draws from |

The *ratio* of catechin to epicatechin units, and the average length of the chains they polymerize into, is the difference between a tannin that grips and lets go and one that grips and holds. Longer polymers — higher mean degree of polymerization — bind more PRPs per molecule and precipitate harder; more galloylation (gallic-acid decorations, as in tea's epigallocatechin gallate) sharpens the grip further. By tuning the expression ratio of ANR against LAR, and the oxidative polymerization that follows, we move a cultivar's astringency the way a winemaker moves it with skin contact and oak — except we move it at the gene, before the fruit is ever pressed, with a batch-to-batch coefficient of variation at or under **7%**. A tannin you can count on is a tannin you can build a cordial around.

For the drink-maker, three facts about astringency change everything, and all three are physics, not opinion:

**pH sharpens it.** Tannin-protein binding is stronger at low pH, and astringency rises as a drink gets more acidic. A squeeze of citrus does not only brighten a tannic shrub; it tightens the grip. Balance the two on purpose.

**Ethanol softens it.** Alcohol disrupts the tannin-PRP aggregation — it competes for the hydrogen bonds and keeps the complexes in solution — which is why a 15% red feels rounder than its tannin load predicts, and why the same tannin in a zero-proof drink reads *harder*. This is the single most important fact in the back half of this book: strip the alcohol and the astringency you designed comes forward. The mocktail is where tannin earns its living.

**Sweetness and body buffer it.** Sugar, glycerol, and the γ-glutamyl richness of the kokumi axis all drape a kind of soft weight over the grip. A tannic drink with nothing to cushion it reads austere; the same grip over a touch of designed sweetness reads *structured*. That interplay — astringency as the architecture, sweetness and kokumi as the upholstery — is the oldest trick in wine and the first thing we teach a new cordial.

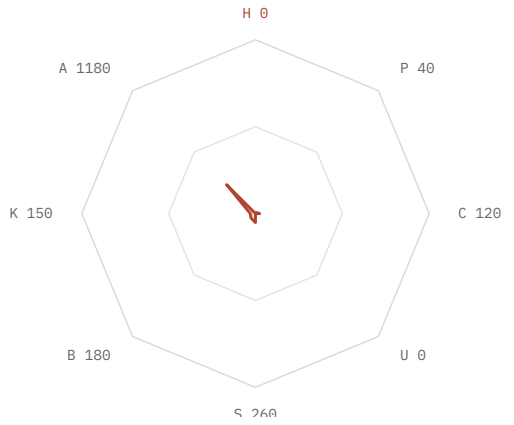
Here is the grip, standing almost alone, so you can taste the axis itself before we start balancing it against the others. A two-ingredient aperitif built on designed verjus — the pressed juice of unripe grapes, the most elegant astringent base we grow.

```
THE SPINE — a verjus aperitif            serve · coupe · no ice
2.0 oz   designed verjus (grape, IFI-A ≈ 1,450)
0.5 oz   white-grape cordial (light, barely sweet)
2 dashes saline solution (20% — four drops)
top      chilled soda, ~1.5 oz
         express a grapefruit peel, discard
```

1. Combine verjus, cordial, and saline in a mixing glass with ice; stir ten seconds only — you want it cold, not dilute.

2. Strain into a chilled coupe. Top with the soda for lift.
3. Express the oils of a grapefruit peel over the surface and discard the peel. The bitterness of the oil frames the grip without adding sugar.

IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 40 |
| IFI-C | 120 |
| IFI-U | 0 |
| IFI-S | 260 |
| IFI-B | 180 |
| IFI-K | 150 |
| IFI-A | 1,180 |

Note the readout: nearly silent on every axis but one. That lone tall bar on astringency is the sensation of structure with almost nothing else in the glass — the architectural skeleton you will spend the rest of this book hanging flavor on. Learn its number by mouth. Once you can feel the difference between an 800 and a 1,300, you can build anything.

# Chapter 2 · The bitter channel, turned down — *keep the signature, lose the wince.*

Bitterness is the taste the cocktail owes its soul to and the one it most often gets wrong. An amaro, a gentian aperitif, a quinine tonic, the iso-acid snap of a hoppy beer — these are the drinks adults learn to love precisely because they are a little difficult, a little bracing. But there is a line, and every bartender knows it, between bitterness that *frames* and bitterness that *flinches*. On one side, the long dry farewell of a well-made Negroni. On the other, the chemical wince that makes a first-timer set the glass down. The difference is not quantity. It is *which* bitterness, and how much, and whether anything is there to carry it.

Unlike astringency, bitterness is a true taste, and it is read by the largest, strangest receptor family on the tongue: the **TAS2Rs**, twenty-five of them in a human mouth, a sensory early-warning system evolved to flag the alkaloids and glycosides that plants make to avoid being eaten. The canonical one, **TAS2R38**, is the receptor the Index anchors IFI-B to — the famous PTC/PROP receptor whose two common forms, the sensitive *PAV* and the near-blind *AVI*, explain why your friend recoils at the tonic you find refreshing. But the bitter world of the bar is spread across many TAS2Rs at once, and that is both the problem and the opportunity.



Hops — the iso-alpha-acids that bitter a beer are among the most studied TAS2R agonists we grow.

Consider the bartender's bitter larder as a set of molecules, each with its own receptor signature:

| BITTER PRINCIPLE | SOURCE | RECEPTOR SIGNATURE | CHARACTER |
|---|---|---|---|
| Amarogentin · gentiopicroside | gentian | TAS2R43/46/50 | the deepest, cleanest bitter; amaro's backbone |
| Quinine | cinchona | TAS2R4/7/10/39/40/43/44/46 | tonic's sharp, lingering grip |
| Isohumulone (iso-α-acids) | hops | TAS2R1/14/40 | beer's resinous snap |
| Chlorogenic acid · caffeine | coffee | TAS2R7/10/43/46 (caffeine); others | roast bitterness, the astringent edge |
| Naringin · limonin | citrus pith | TAS2R39/40/43 | pith bitterness, grapefruit's bite |
| Absinthin | wormwood | TAS2R30/46 | the long bitter of a vermouth |

Amarogentin, from gentian, is worth pausing on: its detection threshold sits near **0.06 micromolar**, which makes it one of the most intensely bitter substances known to the mouth. A quantity you could not see bitters an entire bottle. That potency is why a dash of gentian tincture can structure a whole drink — and why, when we engineer bitterness *down*, a small change in the plant goes a long way.

It helps to know how strange the bitter sense really is. Where sweetness has a single receptor and umami essentially one or two, bitterness has **twenty-five** — a panel of TAS2Rs ranging from broadly tuned generalists that answer to dozens of unrelated compounds to narrow specialists that recognize almost one thing. A given bitter molecule lights its own subset; quinine alone activates at least nine of the twenty-five. This is why bitterness cannot be turned down with a single master switch, and why the **20–65% attenuation** we offer runs along two genuinely different roads. The first is **agonist reduction**: lower, at the plant, the concentration of the specific bitter principle that winces without flavoring — the harsh chlorogenic fraction of a coffee cherry, the excess naringin of a citrus pith — while leaving the aromatic and structural compounds that make the ingredient taste like itself untouched. The second is **receptor-level masking**: certain flavanones (the homoeriodictyol family), several γ-glutamyl peptides, and even sodium ions blunt the TAS2R signal or the brain's weighting of it, lowering perceived bitterness without removing the compound.

The distinction we never blur is that masking a bitterness with *sugar* is a third thing entirely — not a receptor event at all but a cognitive one, the sweetness out-shouting the bitter rather than quieting it. It is why an over-sweetened bitter drink tastes faintly dishonest: the bitterness is still firing at full volume, merely out-competed for attention, and a careful palate feels the trick. Our attenuation lowers the firing itself. And there is a population argument for doing it: roughly a quarter to a third of people carry the super-sensitive *PAV* form of TAS2R38 and taste bitterness far more intensely than the rest, so a drink attenuated to a measured target lands *more consistently across a room* than an un-attenuated one, which the sensitive find undrinkable and the insensitive find perfect. A number is how you pour for everyone at the table at once.

The Zero-Bitter program delivers a documented **20–65% attenuation** of perceived bitterness, and the honest description of how matters, because there is a cheap version of this and a real one. The cheap version drowns bitterness in sugar; the drink gets easier and worse. The real version works at two levels. First, at the plant: we lower the load of the specific bitter principals that wince without carrying flavor — the harsh chlorogenic fraction in a coffee cherry, the excess naringin in a citrus pith — while leaving the aromatic and structural compounds that make the ingredient *taste like itself* untouched. Second, at the receptor: certain small molecules and peptides act as TAS2R antagonists or competitive maskers, blunting the signal at the channel rather than the source. The combination lets us turn a bitterness down by a measured percentage the way you turn down a volume knob — keeping the shape of the sound, lowering only the hurt.

The arithmetic of attenuation is just the Index run backward. If a reference tonic reads IFI-B 1,600 and we attenuate it 40%, the designed version reads:

```
IFI-B(designed) = 1600 × (1 − 0.40) = 960
```

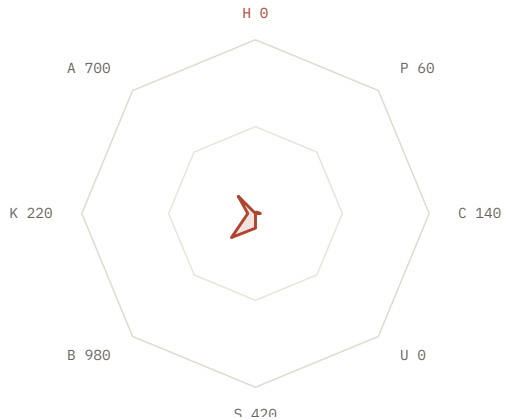
— still unmistakably a tonic, still structured and dry, but landed on the friendly side of the line. The point is never to erase bitterness. Bitterness is the adult pleasure at the center of the cocktail. The point is to put the dial where you want it and have it stay there, cultivar after cultivar, at CV ≤ 7%, instead of praying the batch of gentian you bought this month tastes like the last.

Here is the channel, turned down just enough: a two-ounce bitter aperitivo, built on an attenuated gentian so the drink finishes long and dry without the chemical sting.

```
TURNED DOWN — a bitter aperitivo          serve · rocks · one large cube
1.5 oz   designed bitter aperitivo (gentian base, IFI-B ≈ 980)
1.0 oz   designed grape vermouth (IFI-A ≈ 700)
0.25 oz  orange cordial (zero-bitter orange, IFI-B ≈ 300)
top      soda, ~2 oz
         orange half-wheel
```

1. Build over a single large cube in a rocks glass.
2. Add soda, lift once with the bar spoon, and garnish with the orange.
3. Taste for the finish: you want a dry, gentian farewell that arrives *after* you swallow and stays pleasant — not a bitterness that shouts on the way in.

## IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 60 |
| IFI-C | 140 |
| IFI-U | 0 |
| IFI-S | 420 |
| IFI-B | 980 |
| IFI-K | 220 |
| IFI-A | 700 |

# Chapter 3 · Cool-burn and the long finish — *the axis that makes a drink feel cold after it's warm.*

Every other axis in this book is about something arriving. Cool-burn is about something *staying*. It is the menthol glow that outlasts the ice, the reason a julep feels cold on the third breath after you set it down, the mechanism behind the paradox of a warm toddy that still manages to finish clean. And it is the axis most purely about receptor physics, because the receptor it speaks to was built by evolution to do exactly one job: tell the brain the temperature dropped.

That receptor is **TRPM8**, a cation channel on the cold-sensing fibers of the trigeminal nerve. It opens when the tissue cools below roughly 26 °C — and it also opens when menthol binds it, regardless of the actual temperature. This is the trick at the heart of cooling flavor: menthol is a *chemical lie about temperature*. It does not lower the temperature of your mouth by a single degree. It lowers the threshold at which TRPM8 fires, so the channel reports cold that is not there. The Index anchors IFI-C to the half-activation of TRPM8, which means a cooling score is, almost literally, a measurement of how convincingly a molecule can fake a cold front.

How convincingly, it turns out, is a property you can engineer apart from flavor — and that separation is the quiet frontier of cooling design. Menthol binds TRPM8 at a defined site near the channel's voltage-sensing domain, and its cooling potency and its *aroma* ride on different features of the molecule, which means a plant can in principle be tuned to cool hard while smelling faintly, or to smell intensely of mint while cooling little. The flavor industry has long exploited this split through the synthetic "cooling agents" — menthol relatives like WS-3 and WS-23, built to fire TRPM8 with almost no minty smell — which we cite not to pour but to understand, because they are the proof that cooling and mint-aroma are separable dials. In a designed peppermint we can lean the chemistry toward a clean, high-menthol cool with restrained aroma, for a drink that must feel *cold* without tasting of a candy cane, or the reverse, for a garnish that announces mint and barely cools. At the far end of the scale sits **icilin**, a synthetic TRPM8 agonist many times more potent than menthol, useful as a reference anchor for the ceiling of IFI-C — the cold a plant could reach if pushed to the channel's limit. Knowing where the ceiling is tells you how much headroom a cultivar still has, which is the sort of thing you want to know before you build a whole menu on its cool.

Cooling also has a secret relationship with heat, and the two together make a sensation neither makes alone. Menthol does not only fire TRPM8; at higher concentrations it mildly *desensitizes* TRPV1, which is why a strong mint can take the edge off a burn — the cooling channel quieting the hot one. Run both at once, a

measured menthol against a measured capsaicin, and you get the paradoxical *cool-hot* that a great spicy-minty drink lives on: the cool arriving first and bright, the heat blooming underneath it, the mouth unable to decide and so paying close attention to both. The frontier organism Cucumber *Contradiction* of Chapter 18 is exactly this sensation designed into a single fruit. Until it arrives, a bartender builds it by hand — a peppermint cordial and a drop of chili tincture in one glass — and the Index is what holds the two in the proportion that reads as intrigue rather than confusion.



Peppermint — 2,360 constructs, and the richest menthol chemistry we grow.

Peppermint is our most engineered cooling organism — **2,360 constructs** across the cool and multi-axis libraries — and the reason is that the road to menthol is long, branched, and exquisitely tunable. It is a monoterpene pathway, six enzymatic steps from a universal terpene precursor to the molecule that lies about the cold:

| STEP | ENZYME | INTERMEDIATE |
|---|---|---|
| 1 | limonene synthase (LS) | `(−)-limonene` |
| 2 | limonene-3-hydroxylase (L3H, a P450) | `(−)-trans-isopiperitenol` |
| 3 | isopiperitenol dehydrogenase (IPD) | `(−)-isopiperitenone` |
| 4 | isopiperitenone reductase (IPR) | `(+)-cis-isopulegone → (+)-pulegone` |
| 5 | pulegone reductase (PR) | `(−)-menthone` |
| 6 | menthone reductase (MMR) | `(−)-menthol` |

The whole chain is a lesson in why engineering beats selection. **Pulegone**, the intermediate at step four, is pungent, slightly medicinal, and undesirable above trace levels; a mint that stalls there tastes harsh. Spearmint, peppermint's cousin, branches away entirely at limonene toward carvone and never makes menthol at all, which is why it cools so much more gently. By controlling the flux through pulegone reductase and menthone reductase, we can drive a cultivar cleanly to menthol and hold the pulegone low — a purity a field-grown mint rarely achieves — or we can deliberately leave a little carvone-side character for a softer, rounder cool. The score follows the chemistry: a whisper of garden mint reads IFI-C near 300; a designed high-menthol peppermint pushes past 1,800, cold enough to feel on the back of the throat on an inhale.

Two cousins fill out the cooling garden and belong in any bar that takes the axis seriously. **Lavender** (160 constructs) cools through linalool, a gentler TRPM8 story wrapped in floral aromatics — a cool that reads as calm rather than sharp. **Eucalyptus** (80 constructs) works through 1,8-cineole, which touches TRPM8 but also brushes the warm and pungent channels, giving a cool with a faintly camphoraceous lift. And one caution lives here too: **camphor** itself, which the uninitiated reach for expecting cold, actually agonizes the *warm* receptor TRPV3 and desensitizes TRPV1. It can read cool in low doses by contrast and confusion, but push it and it turns medicinal and warm. The Index catches this where the nose cannot — camphor's IFI-C is low and its behavior non-monotonic — which is exactly the kind of mistake a number saves you from.

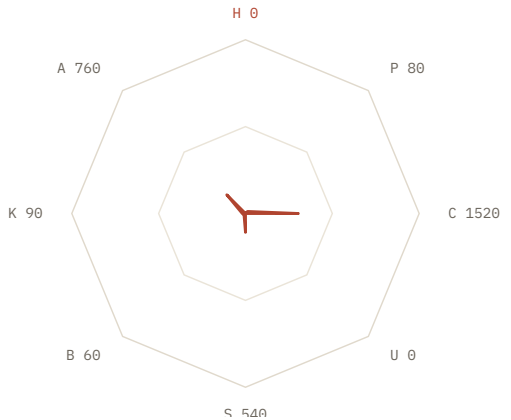
For the drink-maker, the governing fact of cool-burn is **temperature co-agonism**, and it is a genuine lever, not a metaphor. TRPM8 responds to menthol *and* cold, and the two add. Chill a menthol drink and the same dose of menthol reads louder, because the channel is already near its thermal threshold and the chemical push tips it over. Serve the identical cordial warm and the cool recedes. This is why cooling botanicals belong in cold drinks and sparkling ones — carbonation evaporates off the tongue and drops the surface temperature a degree or two, lending TRPM8 a free assist — and why a cooling note in a warm drink has to be dosed up to be felt at all. The effective $EC_{50}$ of menthol is a function of serving temperature; a serious cooling program accounts for it.

A long-finishing cooler, built to demonstrate the effect: minimal sugar, so the cool stands naked, served as cold as you can make it.

```
THE LONG FINISH — a cooling cooler        serve · highball · crushed ice
0.75 oz  cooling cordial (peppermint, IFI-C ≈ 1,600)
0.5 oz   verjus (grape, IFI-A ≈ 1,100)
0.5 oz   lime
0.25 oz  light cane syrup
top      chilled soda, 3 oz
         mint crown, slapped
```

1. Short-shake cordial, verjus, lime, and syrup with two cubes — just to integrate and chill.
2. Pour unstrained into a highball packed with crushed ice. Top with soda.
3. Slap a mint crown to wake its surface oils and set it on top. Serve with a straw and drink it cold; let it warm in the glass and watch the cool quietly leave — that departure *is* the temperature co-agonism, happening in real time.

## IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 80 |
| IFI-C | 1,520 |
| IFI-U | 0 |
| IFI-S | 540 |
| IFI-B | 60 |
| IFI-K | 90 |
| IFI-A | 760 |

# Chapter 4 · Heat, dissolved — *why a spicy drink is harder than a spicy plate.*

Heat in a glass behaves differently than heat on a plate, and every bartender who has ever watched a chili margarita come out either flat or ferocious has felt the reason without being able to name it. The reason is solubility. Capsaicin — the molecule that lies to your warmth receptor the way menthol lies to your cold one — is a lipophilic compound. Its logP sits near 3.8, which is a chemist's way of saying it would far rather be in oil or ethanol than in water. In a stew it dissolves into the fat and spreads evenly through every bite. In a drink that is mostly water, it has nowhere comfortable to go, and what happens next is governed by where the alcohol is.

The receptor is **TRPV1**, the same channel gated by genuine heat above 43 °C and by acid. Capsaicin binds in a pocket on its inner face and lowers the channel's thermal threshold, so the trigeminal nerve reports a fire the tissue does not actually have. The Index anchors IFI-H to the half-activation of TRPV1, and on that scale the engineered superhots we built as proof-of-concept are almost unimaginably loud — our flagship **Phoenix** reads **IFI-H 4,200**, with our model predicting approximately 2.95 million Scoville Heat Units — a plant we designed gene by gene because no plant that could reach it existed. You will not put a whole Phoenix in a drink. You will put a measured trace of its tincture in a drink, and understanding the dilution between those two facts is the subject of Chapter 6. Here, the chemistry of the glass itself.



The cross-section of a designed superhot — the placental tissue, pale and blistered, is where capsaicin is made and concentrated.

Three facts of physics decide whether your spicy drink works:

**Ethanol is both solvent and co-agonist.** Alcohol dissolves capsaicin and keeps it in true solution, so more of it reaches the receptor; and ethanol itself sensitizes TRPV1, lowering its threshold independent of the capsaicin. This double action means the *same* dose of chili reads

hotter in a spirit-forward drink than in a low-proof or zero-proof one. A tincture made in high-proof neutral spirit is the correct way to carry heat into a cocktail precisely because the ethanol holds the capsaicin until the moment of the sip — but it also means you are dosing two heat sources at once. Account for the alcohol.

**Warmth turns the burn up.** Because TRPV1 is a heat sensor first and a capsaicin sensor second, serving temperature is a volume control on heat. A warm toddy with chili reads far hotter than an iced michelada carrying the same capsaicin, because the warmth of the drink is itself pushing the channel toward threshold. This is the mirror image of cool-burn's temperature trick — where cold potentiates menthol, warmth potentiates capsaicin — and it means the two axes have opposite temperature preferences. A cooling drink wants to be cold; a heat-forward drink can be built warm to amplify, or cold to restrain.

**Dilution precipitates.** As you add water and ice to a capsaicin tincture, you eventually cross the point where the water can no longer hold the capsaicin in solution, and it begins to come out — clouding the drink and, worse, distributing unevenly, so one sip scorches and the next is tame. The fix is to keep a little solvent in play (a sugar syrup, a touch of glycerol, or a small alcohol fraction all help hold capsaicin in suspension) and to carry heat as a *finely dosed* tincture rather than muddled fresh chili, whose capsaicin loads are wildly variable. A designed cultivar's heat comes with a batch CV at or under 7%; a bird's-eye you bought at the market can vary by 40% fruit to fruit on the same plant. If you want a laddered heat program — a menu that climbs predictably from warm to fierce — you cannot build it on produce. You build it on tinctures of cultivars whose numbers hold.

The shape of the burn matters as much as its size, and it too is designed. Capsaicin is made at the end of a dedicated spur — vanillylamine, drawn off the phenylpropanoid trunk by **pAMT**, condensed with a branched-chain fatty acid by **Pun1/CS** (the capsaicin synthase, an acyltransferase) — and the length and saturation of that fatty-acid arm set the ratio of capsaicin to dihydrocapsaicin, which in turn sets whether the heat arrives at the front of the mouth and fades, or creeps to the back of the throat and lingers. For a drink, a front-loaded, quick-fading heat profile is usually what you want: a flash of warmth that clears before the next sip, not a slow build that stacks to misery by the bottom of the glass. We can dial that at the gene. It is the difference between a spicy drink you want a second of and one you endure.

How a plant reaches a number no plant had reached is itself worth the telling, because it is the method under every cultivar in this book. We did not find the heat of Phoenix by crossing hot peppers and hoping the genotype followed the phenotype; we designed it. A **genome-scale flux-balance model** first mapped where metabolic control actually sits in the capsaicinoid pathway: upstream, at 4CL and HCT/CCoAOMT in the phenylpropanoid trunk, not at the terminal Pun1/AT3 step. Pun1 is the final capsaicin synthase; it labels the product, it does not govern the rate. Working within that flux architecture, an **ESM2 protein language model** — 650 million

parameters, trained on the shape-grammar of proteins the way a language model is trained on text — scored every possible single-residue substitution in the capsaicin synthase **Pun1/AT3** by its predicted effect on catalytic efficiency weighed against fold stability. Two substitutions emerged and were written into the shipped construct with CRISPR:

| EDIT | EFFECT | ΔΔG (KCAL/MOL) | STATUS |
|---|---|---|---|
| S39L | binding affinity ↑ at the N-terminus | −2.1 | shipped |
| L345G | steric relief in the active-site cleft | −1.8 | shipped |
| C175S | prevents a disulfide misfold (structural annotation) | −0.9 | not in final construct |

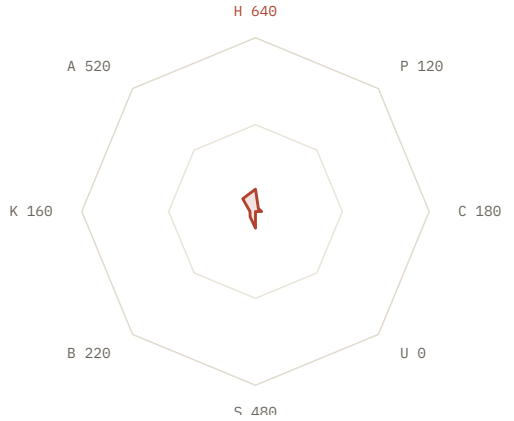
The double variant S39L+L345G is designed to lift predicted output to approximately **2.95 million SHU** at a batch-to-batch coefficient of variation design target at or under **7%**, against a wild-type variability near 42%. For a bartender that last pair of numbers is the entire point. The headline Scoville figure is a party trick; the CV is the tool. A chili whose heat varies 42% fruit to fruit cannot anchor a laddered menu — one margarita scorches, the next is tame, and no guest can order twice with confidence. A chili whose heat holds to 7% can be extracted into a standardized tincture and dosed in drops to a known in-glass number, night after night. The science that reached an impossible figure is the same science that makes an ordinary one hold still, and it is the second achievement, not the first, that a drink is actually built on.

A restrained, front-loaded warming aperitif — heat as seasoning, not challenge — to close the opening survey of axes:

```
DISSOLVED — a warming aperitif            serve · rocks · one cube
1.5 oz   designed blanco-style spirit or clear verjus base
0.25 oz  agave or light cane syrup (holds the capsaicin)
0.5 oz   lime
2 drops  laddered chili tincture, Band II (see Ch. 15)
pinch    flaky salt
         grapefruit peel
```

1. Shake spirit, syrup, lime, and the measured chili tincture with ice. The syrup is not only for balance — it keeps the capsaicin in suspension so the heat is even sip to sip.
2. Strain over a single cube. Add the salt pinch directly to the surface.
3. Express grapefruit oil over the top. Taste: the warmth should arrive at the front, bloom once, and be gone before you want the next sip.

IFI PROFILE




| | | |
|---|---|---|
| IFI-H | | 640 |
| IFI-P | | 120 |
| IFI-C | | 180 |
| IFI-U | | 0 |
| IFI-S | | 480 |
| IFI-B | | 220 |
| IFI-K | | 160 |
| IFI-A | | 520 |

That IFI-H of 640 is a computed estimate from a plant our model predicts reads 4,200 at the fruit — the whole art of heat in a glass is the distance between those two numbers, and that distance is pure, calculable dilution. Which is where we turn next.

# Chapter 5 · The other four axes in the glass — *pungency, sweetness, umami, kokumi.*

A drink is rarely about one axis. The four we have not yet met do quieter work — they season, they sweeten, they add savor and weight — and a bartender who understands them can build flavors the cocktail canon has barely touched. Take them in turn, because each speaks to a different receptor and each answers to a different botanical.

**Pungency — IFI-P, the sharp channel.** Pungency is heat's cousin and its opposite in temperament. Where capsaicin binds TRPV1 slowly and lingers, the pungent molecules hit **TRPA1**, the so-called wasabi receptor, fast and bright and often *up the nose*. TRPA1 is gated by electrophiles — reactive molecules that covalently tweak a cysteine on the channel's inner face — and the bar's pungent larder is a catalog of them. Mustard and wasabi and horseradish carry **sinigrin**, a glucosinolate that is odorless until the enzyme **myrosinase** meets it on crushing and releases **allyl isothiocyanate**, volatile and nose-filling. Garlic carries **alliin**, which **alliinase** converts to **allicin** the instant a clove is cut. Cinnamon brings **cinnamaldehyde**; ginger brings **gingerol**, which on drying and gentle heat dehydrates to the sharper **shogaol**. The Index anchors IFI-P to TRPA1 half-activation, and the key distinction for a drink is volatility: the isothiocyanates flash and fade and go to the sinuses, which is thrilling in a Bloody Mary and disastrous in a delicate spritz, while ginger's gingerols stay in the mouth and give a clean oral prickle that carbonation loves. Ginger carries **120 constructs**; garlic, which lives on the pungent-and-kokumi border, carries **560**.



Ginger — gingerol and shogaol, the pungent aromatics a highball is built to carry.

**Sweetness — IFI-S, without the sugar.** Sweetness is read by a single heterodimer, **TAS1R2 paired with TAS1R3**, two receptors clasped together whose large clamshell-shaped domains close around a sugar molecule like a Venus flytrap. The interesting thing — and the whole basis of the sweetness program — is that sucrose is not the only key that fits. The high-potency sweeteners our

organisms make bind the same receptor at a fraction of the concentration: the **steviol glycosides** of stevia (rebaudioside A and the cleaner rebaudioside M) read 200 to 350 times as sweet as sugar by weight; the **mogrosides** of monk fruit, near 250 times; and the sweet proteins brazzein and thaumatin bind a different part of the receptor entirely, the big extracellular domain, with a sweetness that builds slowly and lasts. Stevia carries **910 constructs**, monk fruit **80**, sugarcane **200**. The engineering challenge is never making a plant sweet — it is making it *cleanly* sweet, because steviol glycosides drag a lingering bitterness (through TAS2R4 and TAS2R14) and a faint cooling-licorice off-note behind them. This is where the axes cooperate: selecting for the rebaudioside-M profile and layering a measured Zero-Bitter attenuation strips the off-notes and leaves the sweetness alone. We describe this plainly and never otherwise: a cultivar that makes its sweetness as glycoside rather than sucrose is an *attribute* of the plant, not a benefit we promise your body. The glass is a pleasure; we leave the claims off the menu.

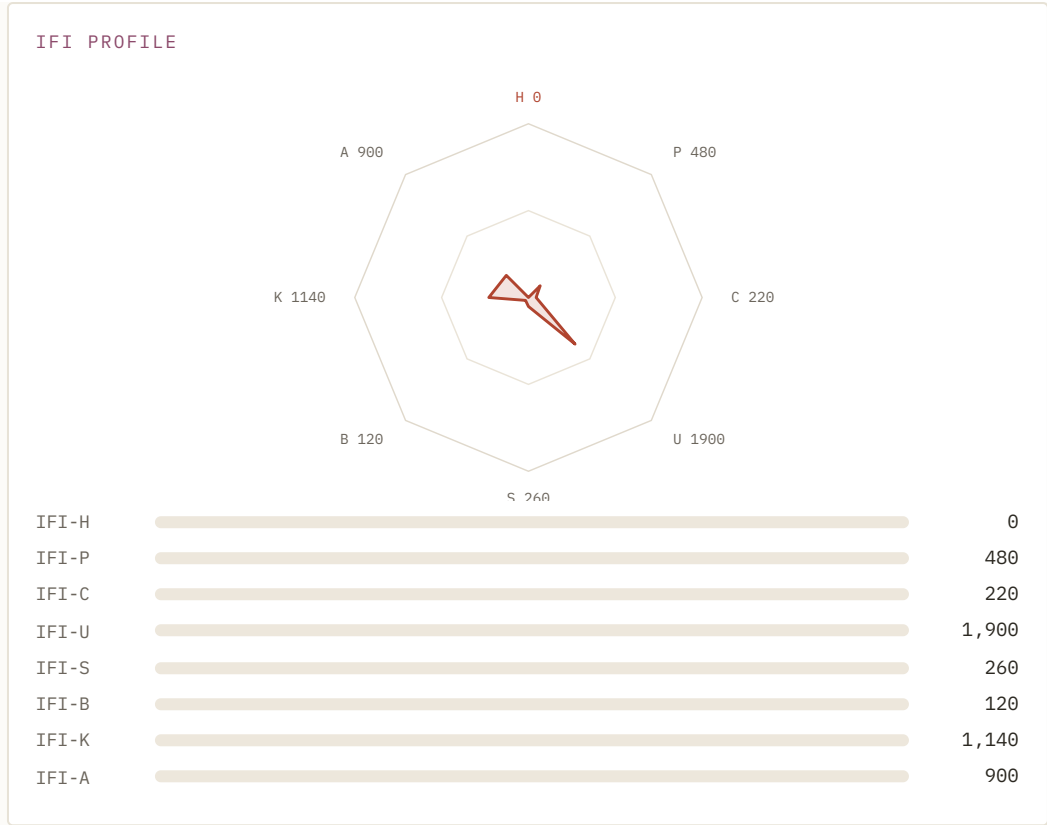
**Umami — IFI-U, savor in a glass.** The savory cocktail is an underexplored country, and umami is its passport. Glutamate, free and unbound, activates **mGluR1** and the **TAS1R1·TAS1R3** heterodimer, and it does something no other taste molecule does: it *synergizes*. Add a 5′-ribonucleotide — **inosine monophosphate (IMP)** from aged and cured things, **guanosine monophosphate (GMP)** from mushrooms — and the nucleotide wedges into the receptor's flytrap and stabilizes the glutamate already there, multiplying the perceived savor severalfold from the same glutamate load. Tomato, our most savory fruit at **2,040 constructs**, is remarkable precisely because it makes *both* halves — free glutamate and ribonucleotides together — which is why a well-made tomato drink tastes so much deeper than its parts. Shiitake (**80 constructs**, GMP-dense) and the koji and yeast organisms round out the savory shelf. A tomato-water martini or a measured, cold michelada is umami doing in a glass what it does in a broth: making the drink taste like it was made for you.

**Kokumi — IFI-K, the weight you can't name.** Kokumi is the axis you have always felt and never had a word for. It is not a taste at all. The **calcium-sensing receptor, CaSR**, responds to **γ-glutamyl peptides** — glutathione, γ-Glu-Val-Gly, and their kin, abundant in garlic, onion, aged cheeses, long ferments, and vanilla — and what they produce is not flavor but *flavor behavior*: more continuity, more mouthfulness, a longer and rounder finish, the sense that every other taste in the glass has been given more body and more time. In a drink, kokumi is the difference between a thin syrup and a round one, between a spirit that stops short and one that is *long*. It is the upholstery laid over astringency's architecture. Garlic (**560 constructs**) and vanilla (**40**) are its most drink-friendly sources; a few drops of a γ-glutamyl-rich tincture will make a cocktail feel aged without aging it.

Here is the savory country, charted: a low, cold, umami-forward sip built on designed tomato, with a pungent lift and a kokumi weight that makes it drink like something far richer than its calorie-thin contents.

```
GARDEN SAVORY — an umami aperitif          serve · rocks · cubed ice
2.0 oz    clarified designed-tomato water (IFI-U ≈ 1,900)
0.5 oz    verjus (grape, IFI-A ≈ 900)
0.25 oz   celery-and-horseradish tincture (IFI-P lift)
2 drops   γ-glutamyl kokumi tincture (garlic-derived)
pinch     flaky salt · 1 drop saline
          cucumber ribbon
```

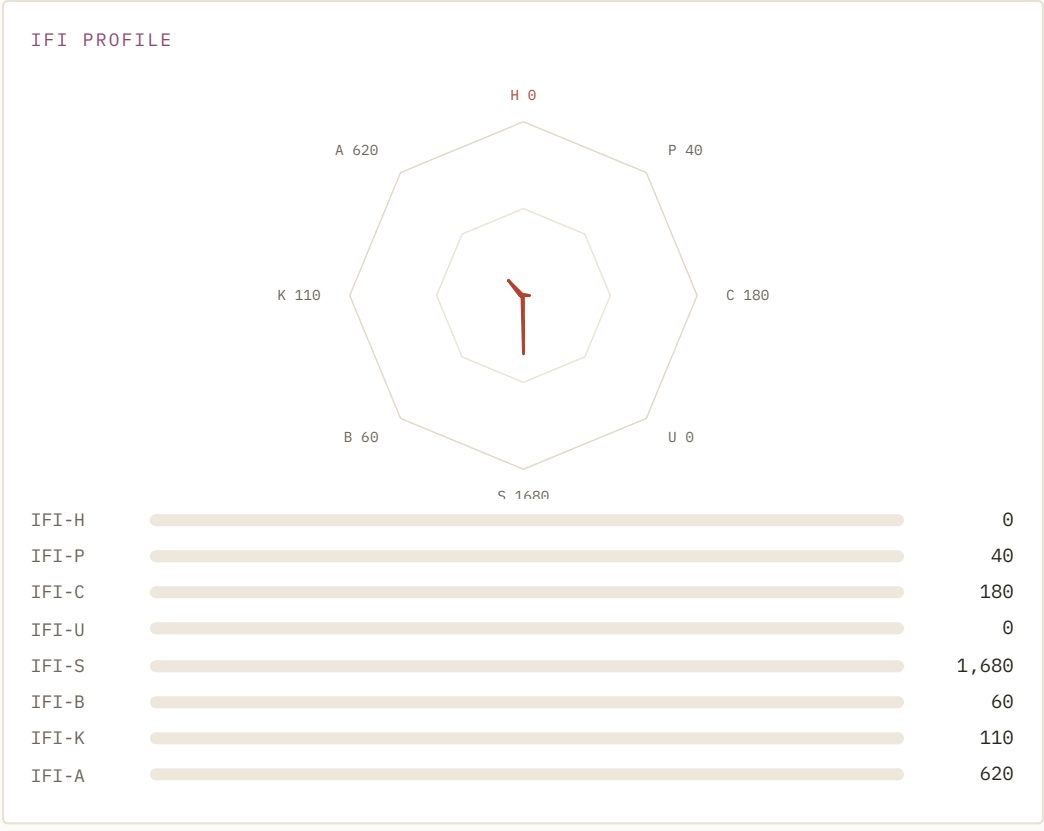
1. Stir tomato water, verjus, and tinctures over ice until very cold; the salt wakes the glutamate.
2. Strain over fresh cubes. The kokumi drops do their work under the surface — the drink will feel longer and rounder than it has any right to.
3. Garnish with a cucumber ribbon for a cool green top note. (For a savory *spirit* version, float a half-ounce of a clean blanco; the ethanol will extend the finish further.)




And its sweeter mirror, to close the survey where the savory began it — a sugar-free cooler built to show the sweetness axis standing nearly alone, the way the aperitif in Chapter 1 showed astringency:

```
SUGAR-BRIGHT COOLER — a sweetness study   serve · highball · tall ice
0.5 oz    stevia-and-monk-fruit concentrate (clean reb-M + mogroside)
0.75 oz   designed verjus (grape, for structure)
0.5 oz    lime
4         designed strawberries, lightly pressed
top       soda, 4 oz
          strawberry fan + basil
```

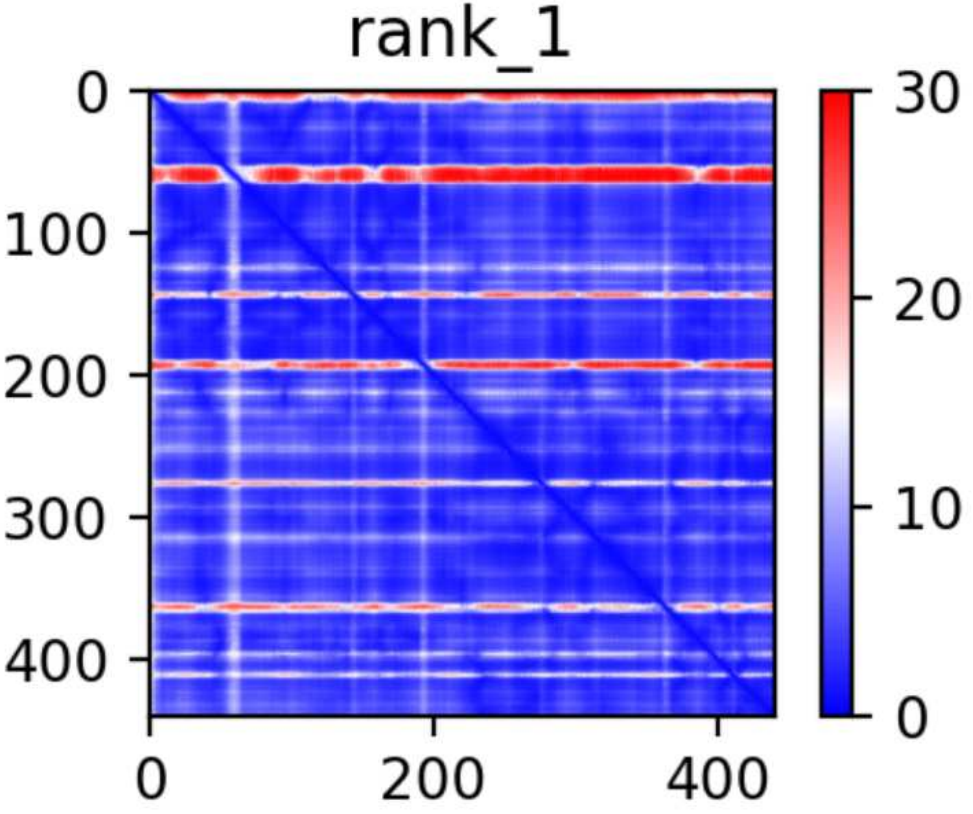
1. Press the strawberries with the lime and the sweet concentrate; add the verjus.
2. Strain into a tall glass of fresh ice; top with soda; garnish with a strawberry fan and a basil leaf.
3. The sweetness is real and rounded and made by the plant, not spooned in — bright on the front, held upright by the verjus so it never cloys. An attribute of the cultivars, stated plainly and left there.




Four axes, four receptors, four botanicals — and with the four from the opening chapters, the full eight now sit on the bar. What remains before we meet the plants themselves is the thing that turns eight numbers into one drink: the arithmetic of dilution.

# Chapter 6 · The mathematics of a mixed drink — *dilution, chill, and the shape of occupancy.*

A cocktail is a calculation performed with ice. Every choice a bartender makes — the pour, the stir count, the cube versus the crush, the temperature of the glass — is a term in an equation whose answer is how loudly each axis speaks at the moment of the sip. The Index gives us the loudness of the ingredients. This chapter gives us the arithmetic that turns those loudnesses into the thing in the glass. It is the most technical chapter in the book, and the most useful, because once you can do this math you can design a drink on paper and trust the result.




The predicted-aligned-error map of the Pun1/AT3 model — the kind of computational object underneath every number in this book.

Start from the receptor, because the receptor is where perception is actually decided. A taste or trigeminal channel does not report concentration linearly; it reports **occupancy**, the fraction of receptors currently bound and firing, and occupancy follows the Hill equation:

$$\theta(C) = C^n / (C^n + EC_{50}{}^n)$$

Here C is the delivered concentration of the agonist at the receptor, $EC_{50}$ is the half-activation constant that defines the axis, and n is the Hill coefficient — the steepness of the response, the cooperativity of the channel. θ runs from 0 (silent) to 1 (saturated). To put a drink on the same 0–5,000 scale as a cultivar scorecard, we read each axis as scaled occupancy:

$$R(\text{axis}) = 5000 \cdot \theta(C_{\text{delivered}})$$

This is the honest meaning of a recipe's IFI readout: not the loudness of the loudest ingredient, but how full the receptor actually is once the drink is built, chilled, and sipped. And it explains the single most counter-intuitive fact in spicy and tannic drink-making — that **loud ingredients make quiet drinks**, because the Hill curve is steep near $EC_{50}$ and flat far below it. Deliver a hundredth of the $EC_{50}$ and occupancy is not a hundredth of full; with a typical Hill coefficient near 1.5 it is far less. Dilution is not linear. It is merciful on the way down and brutal on the way up.

Put numbers on it, because the arithmetic *is* the argument. Take a channel with a Hill coefficient n = 1.5 — a representative value for these taste and trigeminal receptors — and ask what occupancy you get at various fractions of its $EC_{50}$. Deliver one-hundredth of the $EC_{50}$ and $\theta = (0.01)^{1.5} \div ((0.01)^{1.5} + 1) \approx$ **0.001**: one-thousandth of saturation, from one-hundredth of the concentration. Deliver one-tenth and $\theta \approx (0.1)^{1.5} \div ((0.1)^{1.5} + 1) \approx$ **0.031**, three percent. Deliver half and $\theta \approx$ **0.26**; deliver the $EC_{50}$ exactly and θ = 0.5 by definition.

| C ÷ $EC_{50}$ | θ (N = 1.5) | SCALED READING (×5000) |
|---|---|---|
| 0.01 | 0.001 | ~5 |
| 0.10 | 0.031 | ~155 |
| 0.30 | 0.141 | ~705 |
| 0.50 | 0.261 | ~1,305 |
| 1.00 | 0.500 | 2,500 |
| 2.00 | 0.739 | ~3,695 |

Read down that table and the lesson jumps out: the curve is flat and forgiving far below the half-point, then rears up steeply as you approach it. From one-tenth of $EC_{50}$ to the $EC_{50}$ itself, occupancy climbs from 3% to 50% — a seventeen-fold jump in sensation from a ten-fold change in concentration. This is why a drop too many of a loud tincture is a disaster and a drop too few is nothing: near the half-point you are climbing the steep face of the Hill curve, where small pours are large perceptions. A measured dose is not fussiness. It is the only way to stand on that slope and not fall off either side.

Watch it work on heat. Our flagship **Phoenix** fruit reads IFI-H 4,200 — effectively a saturating agonist. A high-proof tincture of it, dosed into a drink, is diluted by a factor you can compute from the pour. Two drops of tincture (about 0.1 mL) in a four-ounce drink (about 120 mL) is roughly a **1:1,200 dilution** of the tincture, and the tincture was already a controlled extract, not neat capsaicin. Run that delivered concentration back through the Hill equation and the in-glass reading lands not at 4,200 but in the low hundreds — a seasoning, a warmth, a single bloom. The table every spicy-drink program should keep pinned behind the bar is the dilution ladder of its own tincture:

| TINCTURE DOSE (IN 120 ML) | APPROX. DILUTION | IN-GLASS IFI-H (COLD) | SENSATION |
|---|---|---|---|
| 1 drop | 1 : 2,400 | ~180 | a whisper at the finish |
| 2 drops | 1 : 1,200 | ~360 | a clean front-of-mouth bloom |
| 4 drops | 1 : 600 | ~720 | a confident, lingering warmth |
| 8 drops | 1 : 300 | ~1,250 | assertive; eyes-open heat |
| 0.25 oz | 1 : 16 | ~2,400 | a dare, not a drink |

Now layer the two modifiers a drink adds that a plate does not: **temperature** and **ethanol**. Both act by shifting the *effective* $EC_{50}$ of a channel — the concentration it takes to reach half-activation under the actual conditions of the sip. We model it as a product of correction factors:

$$EC_{50}(\text{effective}) = EC_{50}(\text{reference}) \cdot g(T) \cdot h(\text{ABV})$$

For the thermal channels this is not a fudge factor; it is the channel's own biophysics. **TRPM8** (cooling) and **TRPV1** (heat) are thermosensors, so their effective $EC_{50}$ moves with serving temperature in opposite directions:

| AXIS | CHANNEL | COLD SERVE (−5 °C) | WARM SERVE (+45 °C) |
|---|---|---|---|
| IFI-C cooling | TRPM8 | $EC_{50}$ *down* → cool reads **louder** | $EC_{50}$ up → cool reads softer |
| IFI-H heat | TRPV1 | $EC_{50}$ up → heat reads **softer** | $EC_{50}$ down → heat reads fiercer |

This is why a julep must be frozen and a toddy may be hot: cold is a free co-agonist for menthol and a suppressor of capsaicin, and warmth is the reverse. The same cordial, the same dose, read differently by a dozen degrees. Ethanol, meanwhile, lowers the effective $EC_{50}$ of TRPV1 and TRPA1 — it sensitizes the heat and pungency channels while also dissolving their lipophilic agonists — and it *raises* the effective threshold of astringency by breaking up tannin-protein aggregation. One number captures the back half of this book: **strip the ethanol and heat and pungency recede while astringency comes forward.** The zero-proof drink is not a weaker cocktail. It is a differently balanced one, and it has to be built that way on purpose.

Two more terms finish the model. **Carbonation** is not merely texture: dissolved $CO_2$ is converted at the nerve ending by **carbonic anhydrase IV** into protons that activate the acid and TRPA1 pathways, so a sparkling drink carries a baseline pungent-sour tingle that a still one does not — a free few hundred points of IFI-P floor you must account for when a drink goes from shaken to spritzed. And **cross-axis interaction** means the eight readings are never simply additive as *sensation*: sweetness and kokumi buffer bitterness and astringency (sugar and γ-glutamyl weight drape over the grip); acidity sharpens both astringency and the perception of heat; umami lengthens everything. The scorecard reports occupancy axis by axis, honestly. Reading the *drink* means knowing which axes lean on which.

The buffering can be put on a number too, and the number changes how a drink is built. Sweetness raises the *detection threshold* for bitterness — a measured sucrose load can lift a bitter threshold by a third or more, which on the Index reads as an apparent IFI-B reduction of several hundred points *without touching the bitter compound at all*. It is the cognitive cousin of the receptor-level attenuation of Chapter 2, and the distinction matters: the bitterness is still firing, the brain simply weighs it less against the sweetness beside it. This is why the honest way to soften a bitter drink is to attenuate the bitter principle at the plant and keep the sugar low, rather than bury a harsh bitterness under syrup — the first lowers the signal, the second only distracts from it, and the palate learns the difference by the second sip. Acidity runs the other way: a lower pH sharpens both astringency (stronger tannin-protein binding) and the apparent heat (protons are themselves a TRPV1 co-agonist), so a squeeze of verjus does not merely brighten a spicy, tannic drink — it *tightens* it, and must be dosed as deliberately as the heat. And kokumi is a third mechanism again: the γ-glutamyl peptides change no single axis's occupancy but extend the *time course* of all of them, so a drink with kokumi reads longer and rounder on every axis at once. Three distinct levers — cognitive masking, co-agonist sharpening, temporal extension — and a designer who knows which is which can place a flavor precisely instead of chasing it with sugar.

Put it together and the design loop is clean: choose the axes you want the drink to speak; pick cultivars whose catalog IFI gives you headroom on each; compute the delivered concentration from your build and dilution; apply the temperature, ethanol, and carbonation corrections; read the occupancy; taste; adjust the pour, not the plant, because the plant's numbers already hold at CV ≤ 7%. The rest of this book is that loop, run again and again, on real botanicals and real drinks.



PART II OF IV

# The Botanicals

Grape · tea · the cooling garden · the aromatics · the dark fruits · the bitter larder

# Chapter 7 · Grape, verjus & the tannin spine — *1,610 ways to build structure.*

If this book has a home organism, it is the grape. No other plant we grow is so completely a drink waiting to happen, and none carries so much of the astringent axis this volume is built on. Grape holds **1,610 engineered constructs** across the bitter, astringent, and multi-axis libraries — a number that reflects how many different structures a single species can be tuned to, from the barely-gripping sweetness of a table fruit to the architectural tannin of something built to age. The grape is where we learned that astringency is not a flaw to be bred out but a material to be shaped.



Grape — the most tannin-literate organism in the library, and the base of half the drinks in this book.

The tannin lives in the skin and the seed, as we saw in Chapter 1, and its character is set by the balance of **ANR** and **LAR** — epicatechin against catechin — and by the degree to which those monomers polymerize into long condensed chains. The lever we pull most often in grape is the ratio of the two, because it changes the *shape* of the grip more than its size. An ANR-weighted cultivar gives a firm, persistent astringency that lingers architecturally through a long drink; a LAR-weighted one gives a rounder, shorter grip that suits a bright spritz. We can also tune the galloylation — the gallic-acid decorations that sharpen tannin into something almost grippy enough to feel on the teeth — which is how a designed grape can be pushed toward the structure of tea without ever being tea.

Where in the fruit the tannin sits matters as much as how much there is. **Seed tannins** are shorter, more galloylated, and harsher — the aggressive grip of a crushed pip — while **skin tannins** are longer, softer, and more aromatic. A winemaker separates the two by how hard and how long the juice sits on the solids; we separate them at the source, tuning which tissue expresses which, so a designed grape can offer skin-structure without seed-bite or deploy a controlled seed grip where a drink wants ferocity. The final chain length is then set by **oxidative polymerization** — the plant's own polyphenol oxidases and laccases stitching monomers into longer

and longer chains — which we can bias toward firm, persistent tannin or hold short and velvety. Across the grape's **1,610 constructs** the library spreads over the bitter, astringent, and multi-axis programs, from near-tannin-free table cultivars through the verjus and vermouth bases to the deep-structure cultivars built for shrubs and bitters. One species, pressed green or pressed ripe, is the backbone of half of this book.

But the grape's real gift to the bar is **verjus** — *verjus*, green juice, the pressed juice of unripe grapes — because it offers the one thing a bartender almost never has: acidity and tannin *without sugar and without alcohol*. A ripe grape is mostly sugar. An unripe grape is mostly acid and structure, and when we press a designed grape at the green stage we get a base liquid that is tart, faintly astringent, and infinitely more versatile than citrus, because it does not dominate. Citrus shouts; verjus structures. A designed verjus tuned to IFI-A near 1,400 is the single most useful non-alcoholic base in this book, the thing we reach for whenever a drink needs a backbone and nothing else should change.

| GRAPE EXPRESSION | IFI-A | IFI-B | BEST USE |
|---|---|---|---|
| Table-sweet | 180 | 90 | eating; soft sweet cordials |
| Soft structured (LAR-weighted) | 620 | 240 | spritzes, bright highballs |
| Firm structured (ANR-weighted) | 1,180 | 360 | stirred drinks, vermouth base |
| Green verjus | 1,420 | 300 | the universal non-alcoholic backbone |
| Deep tannic (high DP, galloylated) | 2,050 | 480 | shrubs, bitters, long-aged cordials |

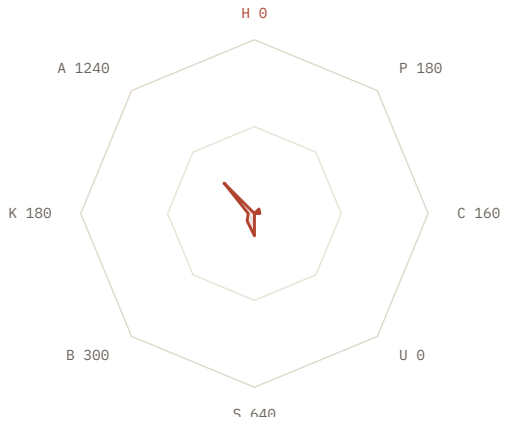
From the grape we also make the designed **vermouth and aperitivo bases** that structure the stirred drinks of Part III — a fortified, aromatized grape wine whose tannin we set at the gene rather than at the barrel. And here is the plant-reverent heart of it: everything the winemaker achieves through skin contact, oak, and years, we can offer as a starting point the morning you press, holding the structure steady at CV ≤ 7% so a drink tastes the same in January and July. We are not replacing the slow art. We are giving it a reliable floor.

A shrub to put the deep tannic grape to work — the drinking vinegar that is the oldest non-alcoholic cocktail there is, and the best showcase for designed astringency:

```
GRAPE-TANNIN SHRUB — a base (makes ~500 mL)
300 g     deep-tannic designed grapes (IFI-A ≈ 2,050), crushed
200 g     raw cane sugar
200 mL    apple-cider or white-wine vinegar
1 strip   lemon peel · 2 black peppercorns
```

1. Toss crushed grapes with the sugar; cover and rest refrigerated 48 hours, stirring twice, until a dark syrup draws out.
2. Stir in the vinegar, peel, and peppercorns. Rest a further 3 days.
3. Strain, pressing the solids firmly — that last press is where the tannin lives. Bottle; keeps a month refrigerated.
4. To serve: 1 oz shrub, 4 oz soda, over ice. The readout below is the serve, not the shrub.

IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 180 |
| IFI-C | 160 |
| IFI-U | 0 |
| IFI-S | 640 |
| IFI-B | 300 |
| IFI-K | 180 |
| IFI-A | 1,240 |

# Chapter 8 · Tea as a base — *the spirit alternative that is also a tannin.*

Tea is the one botanical that could run a bar by itself. It is bitter, it is astringent, it is faintly savory, it is endlessly aromatic, and — crucially for the back half of this book — it delivers all of that stone-cold sober. A great many of the best zero-proof drinks begin as tea, because tea is the only common non-alcoholic liquid with the *structure* of a spirit: a body, a grip, a bitterness to balance against, a finish that lasts. Our tea organism carries **280 constructs** across the umami, bitter, and astringent axes — the only three-axis organism on our botanical shelf, which is exactly why it is so useful. Tea is a chord, not a note.



Tea — bitter, astringent, and savory at once; the only three-axis botanical in the bar.

The grip and the bitterness both come from the **catechins**, the flavan-3-ols made down the same flavonoid branch we met in the grape — epicatechin (EC), epigallocatechin (EGC), and their galloylated forms epicatechin gallate (ECG) and the famous **epigallocatechin gallate (EGCG)**, which is both the most abundant catechin in green tea and the most astringent, because its two gallate-rich faces bind salivary proteins with unusual strength. Oxidize those catechins — as happens when a tea is "fermented" into black tea, the leaf's own polyphenol oxidases polymerizing the monomers into **theaflavins and thearubigins** — and the astringency softens and deepens into the round, brisk grip of a good Assam. The Index reads all of this: a gentle green might sit at IFI-A 600 and IFI-B 500, a hard-steeped black at IFI-A 1,300, an over-steeped anything in the puckering 1,800s.



Tea in cross-section — the leaf structure that holds catechin, theanine, and caffeine in balance.

The savor is the surprise. Tea's umami comes from **L-theanine**, an amino acid nearly unique to the plant, which lends the smooth, brothy, almost marine quality of a fine gyokuro — and theanine also softens the perception of bitterness, so a tea bred high in theanine reads gentler than its catechin load alone would predict. This is the kind of internal balance we tune: lift theanine and attenuate the harsh catechin fraction, and a tea becomes approachable without losing its structure; push the galloylated catechins and leave theanine low, and it becomes a grippy, architectural base built for a spirit-free Negroni.

The catechins themselves come down the full flavonoid cascade, the same one the grape runs: **chalcone synthase** and **chalcone isomerase** build the flavanone scaffold, **flavanone-3-hydroxylase** and the flavonoid hydroxylases decorate it, **dihydroflavonol reductase** and **anthocyanidin synthase** carry it toward the anthocyanidins, and then **ANR and LAR** turn those into the epicatechin and catechin that polymerize into tea's astringency. Every step is a place we can tune. Push the gallated branch and the grip sharpens; lift theanine — made in the root by **theanine synthetase** from glutamate and ethylamine, then carried up to the leaf — and the bitterness softens as the savor rises; dial down the purine pathway that ends in **caffeine** and you keep all of the structure while losing the stimulant, a genuinely useful thing for an evening drink. And the leaf's own **polyphenol oxidase** is the processing lever the tea maker has always known by hand: leave it idle and the tea stays green, grassy, and sharply astringent; let it run and the catechins oxidize into **theaflavins and thearubigins**, the grip rounding into the brisk, deep, red-brown structure of a black tea; arrest it partway and you have oolong. We can set a leaf's oxidative potential at the gene, so it arrives already inclined toward the character you want — the whole spectrum from gyokuro to Assam available as a starting point rather than a gamble on weather and timing. The third lever is **caffeine**, which is itself bitter and which we can raise or lower independently — a decaffeinated designed tea that keeps every bit of its catechin structure is a genuinely useful thing for an evening drink.

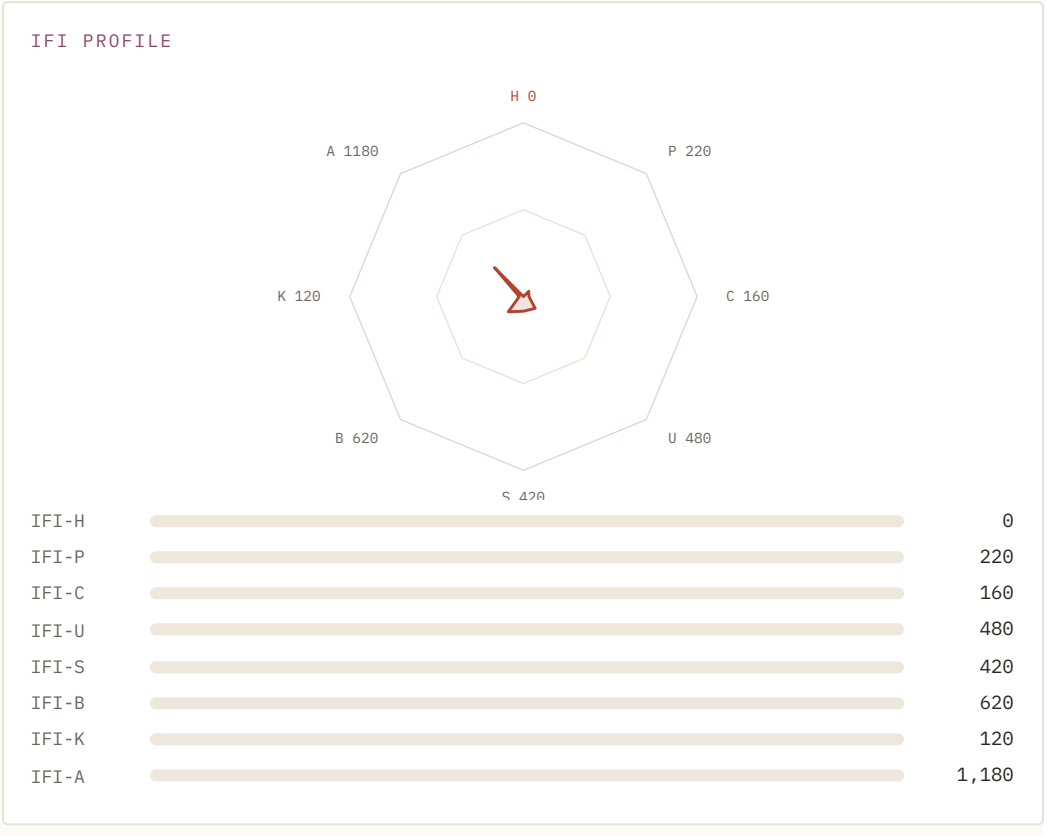
For the bar, three techniques unlock tea's potential:

- **Cold-brew** (steep 6–12 hours in cold water) extracts catechin and theanine while leaving much of the harsh, fast-releasing tannin and caffeine behind — a softer, sweeter, less astringent base. Use it when tea is the whole drink.
- **Hot-brew, flash-chilled** extracts hard and fast, pulling maximum structure — a grippy, bitter base to balance sweetness against. Use it when tea is the backbone and something sweet is the body.
- **Kombucha and tea-vinegar** take a brewed tea into acidity and faint effervescence, turning the astringent axis sparkling — the tea equivalent of a shrub.

A tea highball to show the plant doing a spirit's job — structured, dry, adult, and entirely zero-proof:

```
TEA HIGHBALL — zero-proof                  serve · highball · tall ice
2.5 oz   hard-brewed designed black tea, chilled (IFI-A ≈ 1,250, IFI-B ≈
620)
0.5 oz   verjus (grape)
0.25 oz  honey or light cane syrup
3 dashes designed aromatic bitters (zero-bitter base)
top      soda, 2 oz
         lemon peel, expressed and dropped
```

1. Build tea, verjus, syrup, and bitters over a tall column of ice.
2. Top with soda; stir once, gently, to preserve the carbonation's pungent lift.
3. Express a lemon peel over the top and drop it in. Dry, brisk, and long — a drink that drinks like a spirit because, on the Index, it is built like one.



# Chapter 9 · The cooling garden — *mint, lavender, eucalyptus, and the art of faking cold.*

No family of botanicals is more useful to a drink-maker, or more easily overused, than the cooling plants. A single cordial from this garden can make a drink feel ten degrees colder than the ice alone can manage; two cordials too many and the whole thing tastes of toothpaste. The discipline the Index teaches here is restraint with a number on it — knowing that IFI-C climbs steeply and that cold potentiates it, so a little, served frigid, goes a long way.



Lavender — a floral TRPM8 story; cool that reads as calm rather than sharp.

We met the menthol pathway in Chapter 3; here is the garden it grows into, each plant a different accent on the cold:

| PLANT | CONSTRUCTS | COOLING MOLECULE | CHARACTER ON THE PALATE |
|---|---|---|---|
| Peppermint | 2,360 | (−)-menthol | sharp, throat-deep cold; the loudest cool |
| Spearmint | 80 | (−)-carvone (not menthol) | gentle, green, rounded; barely cools |
| Lavender | 160 | linalool, linalyl acetate | soft floral cool; reads as calm |
| Eucalyptus | 80 | 1,8-cineole | cool with a camphoraceous lift |
| Camphor | 40 | camphor | *warns:* agonizes warm TRPV3 — use with care |

The split between **peppermint and spearmint** is the most instructive thing in the garden, because it is a single enzymatic fork with a huge sensory consequence. Peppermint drives its monoterpene flux all the way down to menthol through pulegone reductase and menthone reductase; spearmint branches off early toward carvone and never makes menthol at all. The result is that spearmint, for all its bright minty aroma, barely touches TRPM8 — it *smells* cooling without *being* cooling — while peppermint delivers a genuine, measurable cold. A bartender who reaches for spearmint expecting a julep's chill and reaches for peppermint expecting a gentle garnish will be wrong both times. The Index separates aroma from cooling where the nose cannot.

**Lavender** cools more gently, through linalool, and brings its floral aromatics along, which is why it reads as *calm* — a quality worth designing toward for an evening drink. We tune lavender to hold its linalool high and its camphor low, because wild lavender often carries enough camphor to turn soapy; a designed lavender cordial is cleaner and rounder than anything you can steep from a dried bundle. **Eucalyptus** works through 1,8-cineole, a molecule that touches TRPM8 but also brushes the warm and pungent channels, giving a cool with a faint medicinal lift that can be glorious in a small dose and overwhelming in a large one. And **camphor** is the cautionary tale of the whole garden: it feels cold to the unschooled because it is sharp and volatile, but it actually activates the *warm* receptor TRPV3 and desensitizes TRPV1, and pushed past a trace it turns hot and medicinal. Its IFI-C is low for a reason. We grow it, we respect it, and we dose it in drops.

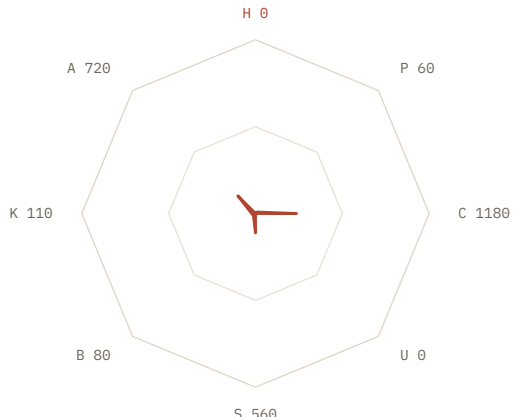
The governing craft lesson, from Chapter 6's math: **serve cooling drinks cold and, where you can, sparkling.** Cold lowers menthol's effective $EC_{50}$ so the same dose reads louder; carbonation evaporating off the tongue drops the surface temperature another degree and lends TRPM8 a free assist. A cooling cordial in a warm drink is almost wasted — you would have to dose it so high the aroma turns synthetic. Build the cool into the cold.

A lavender-and-eucalyptus cooler that uses the softer end of the garden — floral and calm, with just enough peppermint to give the cold a spine:

```
CALM GARDEN — a floral cooler              serve · coupe over nothing, then
poured on ice
0.5 oz   lavender cordial (IFI-C ≈ 700, floral)
0.25 oz  peppermint cordial (IFI-C ≈ 1,600, for backbone)
1 drop   eucalyptus tincture (no more)
0.75 oz  verjus (grape)
0.5 oz   light cane syrup
top      chilled soda, 2.5 oz
         lavender sprig
```

1. Short-shake the two cordials, eucalyptus drop, verjus, and syrup with ice — briefly, to chill and marry without over-diluting.
2. Strain into a chilled coupe, then pour over a highball of fresh ice (or serve straight up if you drink quickly). Top with cold soda.
3. One lavender sprig, slapped once. The drink should read floral first and cold second, the eucalyptus a ghost you notice only on the exhale.

IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 60 |
| IFI-C | 1,180 |
| IFI-U | 0 |
| IFI-S | 560 |
| IFI-B | 80 |
| IFI-K | 110 |
| IFI-A | 720 |

With the cooling garden in hand, the botanical shelf turns toward the sharp and the dark — the aromatics that prickle, and the fruits that stain and grip.

# Chapter 10 · Citrus, ginger & the pungent aromatics — *the prickle that is not heat.*

There is a whole register of sensation in a drink that lives between flavor and pain — the prickle of ginger, the nose-clearing sharpness of a horseradish-spiked Bloody Mary, the warm resin of cinnamon, the clean bite of carbonation itself. None of it is heat in the TRPV1 sense. All of it is **pungency**, the TRPA1 register, and it is the most underused tool behind most bars, because fresh pungent ingredients are so wildly inconsistent that a bartender learns to fear them. A designed cultivar, with its prickle held steady at CV ≤ 7%, turns pungency from a hazard into an instrument.

The anchor of the pungent bar is **ginger**, **120 constructs** strong. Its sensation comes from **gingerol**, which gives a bright, oral, clean prickle — and here is a fact worth designing around: when ginger is dried or gently warmed, gingerol dehydrates to **shogaol**, which is noticeably sharper and more pungent. A fresh-ginger drink and a dried-ginger drink are not the same drink, and knowing which molecule you want lets you choose the preparation. For a long, carbonated drink — a mule, a switchel, a buck — gingerol's oral prickle is perfect, because it stays in the mouth and rides the bubbles rather than flashing up the nose. We tune our drink-ginger toward a high, clean gingerol with a controlled shogaol fraction, so the prickle is lively but never acrid.



Orange, in cross-section — the pith is where the pungent-bitter aromatics the bar fears, and we attenuate, actually live.

The other aromatics each bring a different TRPA1 agonist, and the Index lets us place them precisely:

| AROMATIC | CONSTRUCTS | PUNGENT MOLECULE | REGISTER IN A DRINK |
|---|---|---|---|
| Ginger | 120 | gingerol → shogaol | bright oral prickle; loves carbonation |
| Cinnamon | 40 | cinnamaldehyde | warm, round, lingering; a spiced-drink spine |
| Watercress | 120 | gluconasturtiin → PEITC | green, peppery, nose-forward |
| Thyme | 120 | thymol (and its aromatics) | herbal, faintly medicinal, savory |
| Black mustard | 2,790 | sinigrin → allyl isothiocyanate | volatile, nasal, fierce — a Bloody Mary's bite |

Note the split that Chapter 5 promised: the **isothiocyanates** of mustard and watercress are volatile and go straight to the sinuses, which is thrilling in a savory, umami-heavy drink and wrong in anything delicate, while **cinnamaldehyde** and **gingerol** stay in the mouth and give a warmth you taste rather than inhale. Black mustard's enormous construct count — **2,790**, among the highest in the whole library — reflects how much engineering a pungent, nasal, fast-flashing molecule demands to be made reliable; it is a frontier botanical for the savory bar, used in drops.

The mechanism under all of this is worth one close look, because it explains why pungency behaves so unlike heat. TRPA1 is gated by **covalent chemistry**: its electrophilic agonists — allyl isothiocyanate, allicin, cinnamaldehyde — do not merely dock in a pocket the way capsaicin docks in TRPV1; they form reversible covalent bonds with specific cysteine residues on the channel's inner face. That is why pungency arrives *fast* and can feel almost metallic or electric — the signal is a chemical reaction, not a fit. The **glucosinolate-myrosinase** system that makes the isothiocyanates is one of the plant kingdom's most elegant weapons: the glucosinolate (sinigrin, gluconasturtiin) and its activating enzyme are stored in separate compartments of the intact cell, inert, until the tissue is damaged and the two meet and release the volatile isothiocyanate in a burst. This is why mustard and wasabi and watercress must be crushed *fresh* to bite, why their pungency fades within minutes as the volatile escapes, and why a designed cultivar's worth is partly in holding its glucosinolate load steady so the burst is the same strength every time. For a drink the rule follows straight from the chemistry: build nasal pungency to order and serve it at once; reach for oral pungency — ginger's gingerol, cinnamon's cinnamaldehyde — whenever you need the prickle to last.

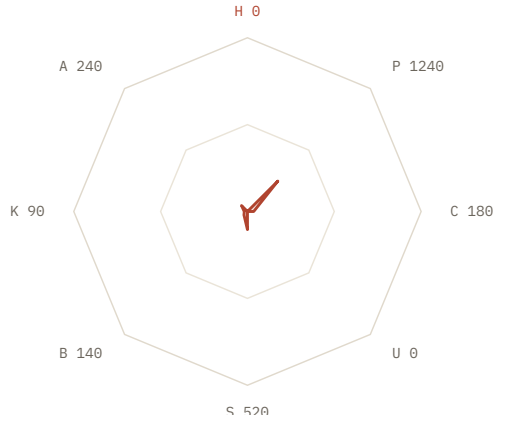
**Citrus** sits slightly apart, and our **orange** (**120 constructs**, tuned on the bitter and cool axes) is the citrus we have engineered most deliberately. The bitterness and faint pungency of citrus live in the pith and oil — **naringin, limonin**, the flavedo terpenes — and the classic bartender's move is to fight them: supreme the segments, avoid the pith, express the oil carefully. We take the other road, lowering the harsh naringin fraction while keeping the aromatic oil intact, so a designed orange can be used whole — peel, pith, and all — for a rounder, less aggressive bitterness and a cleaner cool-adjacent lift. A citrus you can muddle without wincing is a genuinely new tool.

A ginger switchel — the farmhouse cooler that is pungency's purest showcase, sharpened with cider vinegar and nothing else, zero-proof by nature:

```
SHOGAOL SWITCHEL — a base (makes ~600 mL)
80 g     designed ginger (high gingerol), grated
60 mL    cider vinegar
50 g     honey or cane sugar
500 mL   cold water
pinch    salt · 1 strip lemon peel
```

1. Steep grated ginger in the cold water 12 hours, refrigerated — a cold steep keeps the prickle bright and the extract clean.
2. Strain, then whisk in vinegar, honey, salt, and lemon peel until dissolved. Rest 2 hours.
3. Serve 3 oz switchel over ice, topped with 2 oz soda; the carbonation's own TRPA1 tingle stacks on the ginger's for a drink that prickles twice. Readout is the serve.

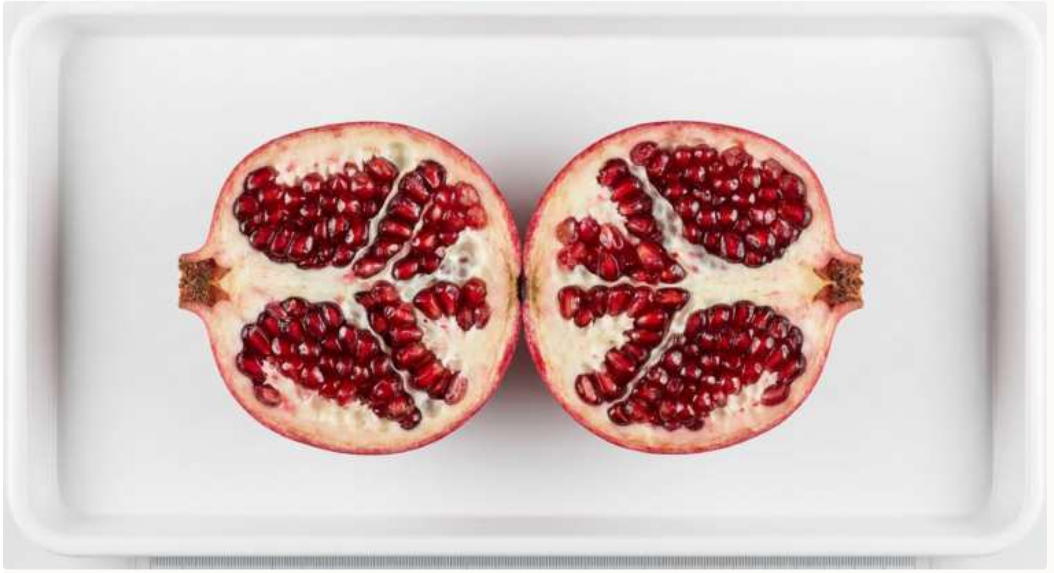
IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 1,240 |
| IFI-C | 180 |
| IFI-U | 0 |
| IFI-S | 520 |
| IFI-B | 140 |
| IFI-K | 90 |
| IFI-A | 240 |

# Chapter 11 · The dark fruits — *pomegranate, blueberry, raspberry, sorghum.*

Some fruits are built on sugar and perfume. The dark fruits are built on tannin and color, and they are the drink-maker's secret source of astringency when grape is not the flavor you want. Pomegranate, blueberry, raspberry, and — unexpectedly — the grain sorghum all carry the astringent axis, and each stains a drink a different shade of red-to-purple while lending the structural grip that keeps sweetness honest. On the Index they cluster on IFI-A, but each grips through a different chemistry, and the differences matter at the bar.



Pomegranate in cross-section — the arils and the bitter pith membranes hold punicalagin, the deepest fruit tannin we grow.

**Pomegranate** (**120 constructs**) is the deepest of them, and its tannin is a different kind than grape's. Where grape makes *condensed* tannins (polymerized flavan-3-ols), pomegranate makes **hydrolyzable ellagitannins** — above all **punicalagin**, a large, water-soluble, intensely astringent molecule concentrated in the fruit's pale inner membranes. Ellagitannins grip hard and clean and finish with a slightly drying, almost mineral quality that reads as *serious*. A pomegranate cordial brings color, tart-sweet fruit, and a structural backbone all at once — the reason grenadine, properly made, is so much more than sugar syrup.

| DARK FRUIT | CONSTRUCTS | TANNIN TYPE | DRINK CHARACTER |
|---|---|---|---|
| Pomegranate | 120 | ellagitannin (punicalagin) | deep, clean, mineral grip; stains crimson |
| Blueberry | 120 | proanthocyanidin + anthocyanin | soft grip, round fruit, indigo color |
| Raspberry | 40 | ellagitannin + bright acid | tart, light grip, vivid red |
| Sorghum | 120 | condensed tannin (in a grain!) | dry, cereal, structural; a fermenting base |

**Blueberry** (**120 constructs**) grips more softly, through proanthocyanidins, and carries a cargo of anthocyanin color that shifts with pH — redder in acid, bluer toward neutral, a living dye a

careful bartender can play with. **Raspberry** (**40 constructs**) is the bright one, its ellagitannins lighter and wrapped in sharp acidity, perfect where you want a flash of grip and a vivid red without weight. And **sorghum** (**120 constructs**) is the quiet revelation: a cereal grain that, almost uniquely among grains, accumulates **condensed tannins** in its bran, giving it a dry, structural quality prized for millennia in fermented and non-fermented grain drinks across West Africa and beyond. A designed high-tannin sorghum is a base for a whole family of earthy, structured, grain-forward drinks the cocktail world has barely begun to explore — and a reminder that astringency is not only a fruit's gift.

The craft note that runs through all four: **anthocyanin color is pH-sensitive and astringency is pH-sharpened**, so when you brighten a dark-fruit drink with acid you are doing two things at once — tuning the color redder and tightening the grip. A splash of verjus or citrus does not merely balance a pomegranate cordial; it changes how it looks and how it feels. Design the acid in on purpose.

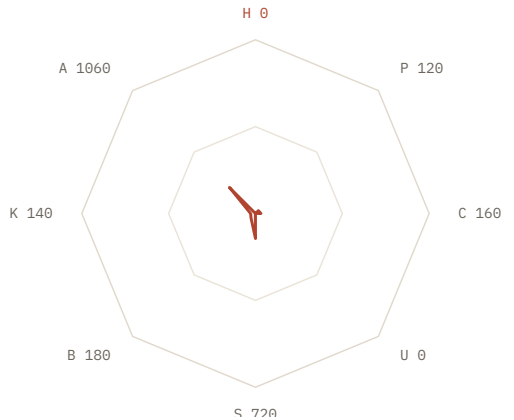
The color chemistry rewards a closer look, because in a dark-fruit drink color and structure are the same molecules wearing two hats. Anthocyanins live as a **flavylium cation** in acid — brilliant red, stable — and shift through colorless and blue-purple forms as the pH climbs, which is why a pomegranate or blueberry cordial flares crimson when you add verjus and dulls toward slate if a drink drifts toward neutral. Tannins then stabilize that color through **copigmentation**: a tannin and an anthocyanin stack face to face, shielding the pigment from the water that would otherwise bleach it, so a drink carrying both holds its color far longer than one with pigment alone. This is the quiet reason a well-structured dark-fruit cordial looks alive for weeks while a plain fruit syrup browns in days — the very tannin that grips the tongue is guarding the color in the bottle. Design the two together and you get a drink that is structured to taste *and* structured to look at, which, across a night of a drink sitting pretty on a back bar, is no small thing.

A pomegranate-and-sorghum cordial that layers the clean ellagitannin grip of the fruit over the dry cereal structure of the grain — deep, red-black, and completely zero-proof:

```
CRIMSON STRUCTURE — a dark-fruit cordial (makes ~500 mL)
250 mL   fresh designed-pomegranate juice (IFI-A ≈ 900)
100 mL   cooled high-tannin sorghum tea (toasted, then steeped)
120 g    raw cane sugar
0.5 oz   verjus (grape) · 1 strip orange peel
```

1. Warm the pomegranate juice gently with the sugar until dissolved — do not boil; heat dulls the fresh tannin.
2. Toast 40 g sorghum grain until fragrant, steep in 150 mL hot water 15 minutes, strain, and add 100 mL of that liquor to the cordial for its dry structural backbone.
3. Stir in verjus and orange peel; cool and bottle. To serve: 1.5 oz cordial, 4 oz soda, over ice, orange half-wheel. Readout is the serve.

## IFI PROFILE




| | | |
|---|---|---|
| IFI-H | | 0 |
| IFI-P | | 120 |
| IFI-C | | 160 |
| IFI-U | | 0 |
| IFI-S | | 720 |
| IFI-B | | 180 |
| IFI-K | | 140 |
| IFI-A | | 1,060 |

# Chapter 12 · The bitter larder — *hops, coffee, orange, and the art of attenuation.*

The last stop on the botanical shelf is the bitter larder, where the engineering runs in reverse. Everywhere else in this book we build an axis *up*; here, most often, we build one *down*, because the bitter world is already loud enough and the skill the bar needs is subtraction. Our three most-engineered bitter organisms — **hops (80 constructs), coffee (40), orange (120)** — are each a lesson in attenuating a bitterness to a signature without losing the ingredient's soul.




Coffee — chlorogenic acid and caffeine; a cold brew is a different bitterness than a hot one.

**Coffee** is the clearest case. Its bitterness is two things wearing one name: the bright, almost fruity bitterness of **chlorogenic acids**, and the flat, drilling bitterness of **caffeine** and the dark-roast degradation products. A cold brew already demonstrates the principle a bartender wants — steep coffee cold and you extract less of the harsh, fast-releasing bitter fraction and less acid, leaving a rounder, sweeter, lower-bitterness liquid. Our designed coffee does at the gene what cold brew does at the kettle: lower the harsh chlorogenic load and the bitter roast precursors while keeping the aromatic compounds that make coffee smell like coffee, landing a **20–65% attenuation** that leaves an espresso-martini base or a coffee-and-bitters drink with all of the flavor and none of the wince. Caffeine, separately, we can raise or lower as the drink demands.

The kinetics of extraction are themselves a bartender's lever, independent of the plant. Bitterness is largely carried by compounds that release *fast and hot* — which is why a shot pulled long or a tea steeped too far turns harsh, and why the cold-brew trick works at all: cold water over a long contact time preferentially pulls the sweeter, aromatic fraction and leaves much of the fast, harsh bitter behind. Roast adds its own layer through the **Maillard reaction**, the browning chemistry that builds coffee's and cacao's dark, drilling bitterness out of sugars and amino acids under heat; a light roast on

a designed low-chlorogenic bean gives a coffee that is bright and barely bitter, a dark roast on the same bean a depth without the usual sting. The point is that attenuation at the plant and technique at the bar *compound*: a cultivar bred 40% down, cold-brewed from a light roast, can land a coffee drink two-thirds gentler than a hot-pulled dark roast of a wild bean — all of it measured, none of it guessed, and every step of it still tasting unmistakably of coffee.

**Hops** (**80 constructs**) carries the resinous bitterness of **iso-alpha-acids** — isohumulone and its kin — the compounds that bitter every beer and, increasingly, a new wave of non-alcoholic aperitifs. Hops is also intensely aromatic, and the two qualities can be tuned apart: a hop bred for high aroma and attenuated bitterness gives a drink the whole perfume of a fresh-hopped ale with a gentle, friendly grip — a genuinely useful thing for a spirit-free bitter highball. **Orange**, met in Chapter 10, completes the trio with the pith bitterness of naringin and limonin, attenuated so the fruit can be used whole.

A word on the classical bitters a bar cannot do without — **gentian, cinchona, wormwood, quinine**. These are not organisms in our library; they are the traditional bitter principles of the amaro and the tonic, and we work with them as the craft always has, as intensely bitter botanicals dosed in drops. What the Index adds is measurement: we can read the bitterness of a house tincture, target a precise IFI-B for an aperitivo, and — where a drink wants the *shape* of gentian without its full sting — pair the traditional bitter with a measured attenuation so the finish stays long and clean rather than punishing. The amaro stays an amaro. It simply lands where we aimed it.

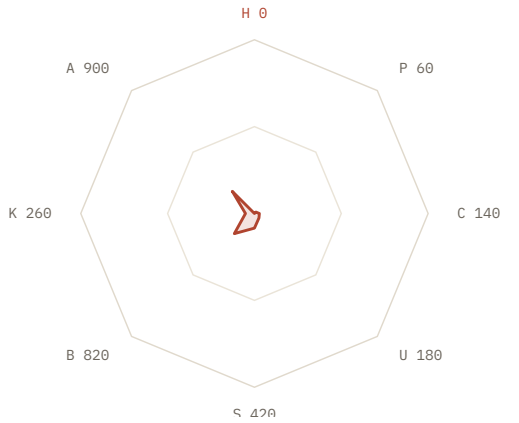
Here the regulatory note belongs, because bitters and aperitivi live in a lightly-regulated corner of the drinks world. In the United States, aromatic bitters sold as "non-beverage" products occupy their own category with the **TTB**, distinct from beverage spirits; a bittering agent used to flavor a cocktail is handled differently from the base spirit itself, and anyone bottling a house amaro for sale should know which side of that line they are on. Allergen and ingredient labeling applies to a packaged mixer as it does to any food. And across all of it, the framing we hold to without exception: a **"zero-bitter" attenuation is a measured sensory attribute** — a documented percentage reduction in perceived bitterness — and never a health claim of any kind. We tell you the number. We do not tell you what it will do for you. A drink is a pleasure; we keep it one.

A cold-brew coffee aperitivo — bitter, structured, barely sweet, and far gentler than its depth suggests:

```
THE SOFT BITTER — a coffee aperitivo      serve · rocks · one cube
1.5 oz   attenuated cold-brew coffee concentrate (IFI-B ≈ 820)
0.75 oz  designed grape vermouth (IFI-A ≈ 900)
0.25 oz  demerara syrup
2 dashes designed orange bitters (zero-bitter)
top      soda, 1.5 oz (optional)
         orange peel, expressed
```

1. Stir coffee concentrate, vermouth, syrup, and bitters over ice until cold.
2. Strain over a single large cube; add the soda if you want it longer and brighter.
3. Express an orange peel over the surface and drop it in. The bitterness should read deep and round — present on every sip, pleasant on every finish.

IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 60 |
| IFI-C | 140 |
| IFI-U | 180 |
| IFI-S | 420 |
| IFI-B | 820 |
| IFI-K | 260 |
| IFI-A | 900 |



PART III OF IV

# The Drinks

Stirred · sour · spicy · zero-proof · and the botanical pantry that builds them all

# Chapter 13 · Spirit-forward & stirred — *where ethanol softens the tannin you design.*

The stirred drink is the cocktail at its most architectural, and it is where this book's accent axis comes fully into its own. A Negroni, a Manhattan, a Boulevardier — these are drinks with almost nothing to hide behind: no citrus to brighten, no foam to soften, no bubbles to distract, just spirit and the structural botanicals, stirred cold and served naked. They live or die on balance between bitterness, astringency, sweetness, and the weight of the alcohol. And they carry a lovely secret, straight from Chapter 6's math: **ethanol softens astringency**, so a spirit-forward drink can hold more designed tannin than it reads, because the alcohol is quietly breaking up the tannin-protein aggregates even as you drink. You can build structure boldly here. The spirit will round it.



House tinctures and aromatized bases — the quiet library behind every stirred drink.

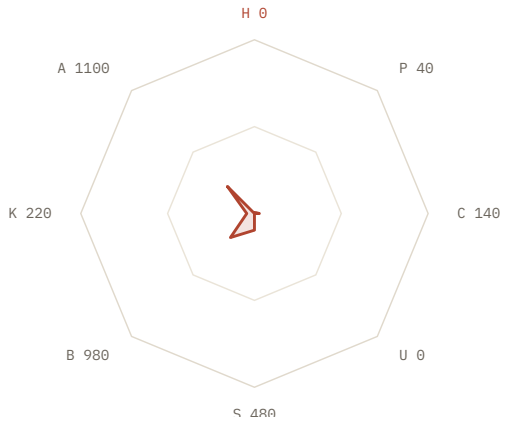
The craft of the stir is dilution control, and it is pure Chapter 6. You stir — rather than shake — a spirit-forward drink to chill it while adding a *measured* amount of water, typically landing around 20–25% dilution by the time it is cold enough to serve. That water is not a compromise; it is a term in the equation, opening the aromatics and softening the alcohol's bite and pulling every axis down from the loudness of the neat ingredient to the loudness of the drink. Under-stir and the drink is hot and closed; over-stir and it is slack and watery. The Index gives you a target to stir *toward*.

Three structural drinks, built on designed botanicals, laddered from bitter to fruit:

```
THE STRUCTURED NEGRONI                    serve · rocks · one large cube
1.0 oz   gin
1.0 oz   designed bitter aperitivo (gentian base, IFI-B ≈ 980)
1.0 oz   designed grape vermouth, firm (IFI-A ≈ 1,100)
         orange peel, expressed and dropped
```

1. Stir all over ice ~25 seconds, to roughly 24% dilution.
2. Strain over a large cube. Express the orange and drop it in.
3. The bitter and the tannin both come forward; the gin and the dilution hold them in frame. A drink built entirely on two of the eight axes, structured to last the whole evening.

IFI PROFILE



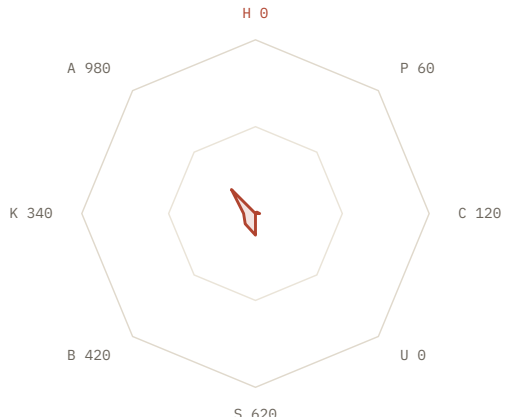

| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 40 |
| IFI-C | 140 |
| IFI-U | 0 |
| IFI-S | 480 |
| IFI-B | 980 |
| IFI-K | 220 |
| IFI-A | 1,100 |

```
TANNIN MANHATTAN                          serve · coupe · up
2.0 oz   rye whiskey
1.0 oz   designed grape vermouth, firm (IFI-A ≈ 1,100)
2 dashes designed aromatic bitters
1 dash   house grape-tannin shrub (Ch. 7), for grip
         brandied cherry
```

1. Stir rye, vermouth, bitters, and the dash of shrub over ice ~22 seconds.
2. Strain up into a chilled coupe. Garnish with a single cherry.

3. The shrub's tannin gives the drink a dry architectural spine the rye's sweetness leans against — a Manhattan with a backbone, the ethanol softening the grip into structure rather than austerity.

IFI PROFILE



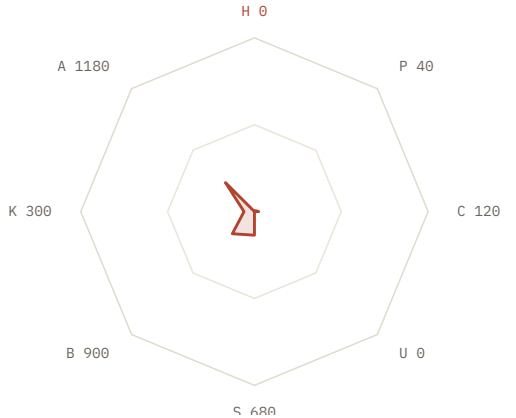

| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 60 |
| IFI-C | 120 |
| IFI-U | 0 |
| IFI-S | 620 |
| IFI-B | 420 |
| IFI-K | 340 |
| IFI-A | 980 |

POMEGRANATE BOULEVARDIER — serve · rocks · one cube

| | |
|---|---|
| 1.25 oz | bourbon |
| 1.0 oz | designed bitter aperitivo (IFI-B ≈ 980) |
| 0.75 oz | designed grape vermouth, firm |
| 0.25 oz | crimson structure cordial (Ch. 11) |
| | orange peel |

1. Stir all over ice ~24 seconds.
2. Strain over a cube. Express orange over the top.
3. The pomegranate cordial threads crimson fruit and a clean ellagitannin grip through the bitter spine — warmer and rounder than a Negroni, structured where a lesser sweet drink would sag.

IFI PROFILE



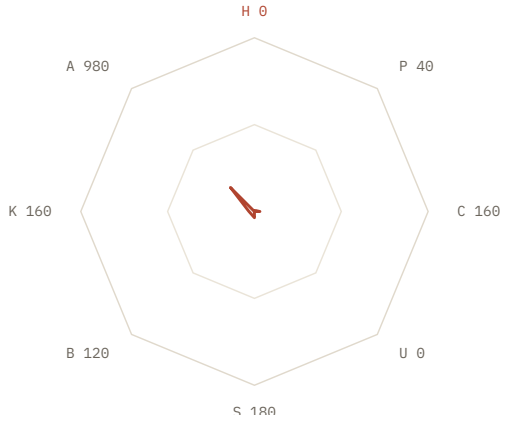

| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 40 |
| IFI-C | 120 |
| IFI-U | 0 |
| IFI-S | 680 |
| IFI-B | 900 |
| IFI-K | 300 |
| IFI-A | 1,180 |

One drink more, the driest in the book — a martini built not on dry vermouth but on designed verjus and a whisper of tannin, so that *dry* becomes a number you set rather than a style you hope for:

```
DRY AS THE INDEX — a verjus martini        serve · coupe · up
2.5 oz   gin (or a clean grain vodka)
0.5 oz   designed verjus (grape, IFI-A ≈ 1,350)
0.25 oz  designed grape vermouth, firm
1 dash   saline (20%)
         lemon twist or a single olive
```

1. Stir everything over ice ~20 seconds — short, because this drink wants to be bracingly cold and barely diluted.
2. Strain up into a frozen coupe.
3. Lemon twist for a bright version, an olive for a savory one. The verjus gives the drink a dry, structured spine where a classic martini has only the *absence* of sweetness — dryness as a presence you can measure, not a lack you hope for.

IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 40 |
| IFI-C | 160 |
| IFI-U | 0 |
| IFI-S | 180 |
| IFI-B | 120 |
| IFI-K | 160 |
| IFI-A | 980 |

# Chapter 14 · Sours, highballs & the balance math — *acid, sugar, and the architecture between.*

If the stirred drink is architecture, the sour is tension — a drink held in balance between acid and sugar, with structure and dilution tuning the whole. The sour template is the most generative form in all of mixology (spirit, sour, sweet, in rough proportion, shaken cold and often lengthened) and it is the clearest place to watch the balance math of Chapter 6 play out in the mouth, because here the cross-axis interactions are the whole point: **sweetness buffers the sour and the astringent; acid sharpens them; structure keeps the sweet from cloying.**



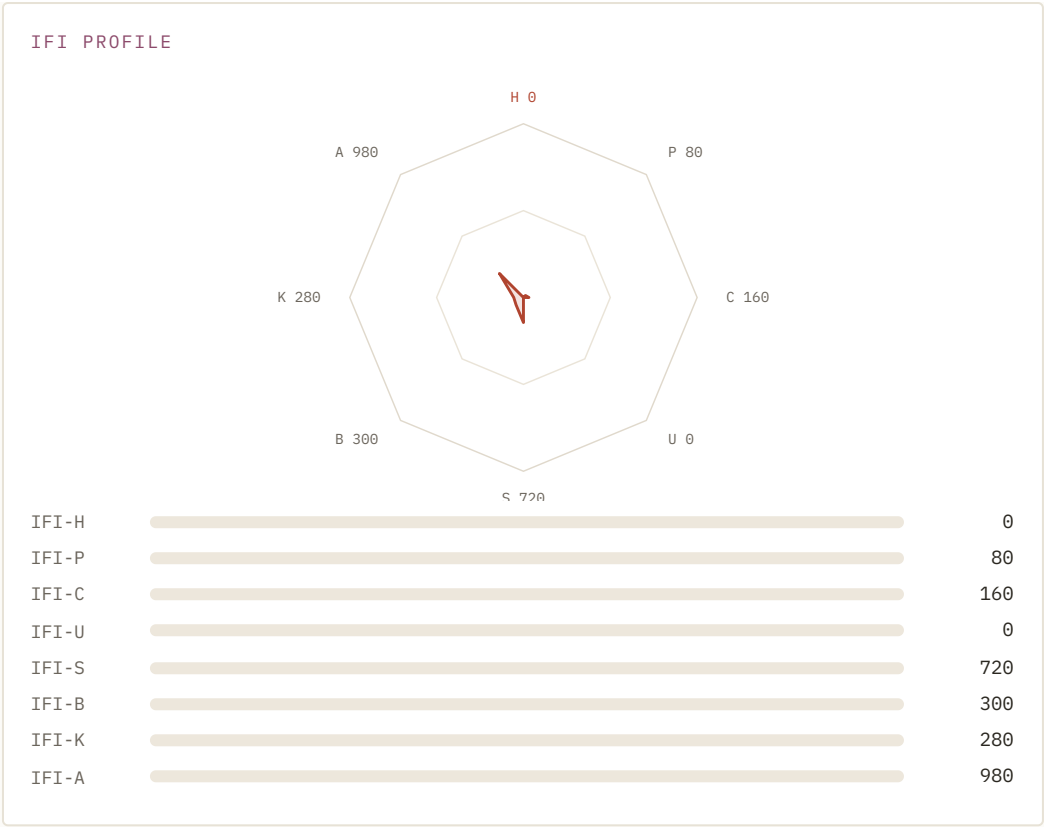

Cucumber — a cool, green, faintly astringent base that drinks far lighter than it reads.

The verjus sour is where this book's botany earns its keep. Replace the usual lemon with a designed verjus and you trade citrus's shouting brightness for grape's structured tartness — a sour with grip as well as acid, a drink that finishes dry instead of simply sweet-and-sour. The foam, traditionally egg white, we default to **aquafaba** — the viscous cooking liquid of chickpeas, whose plant proteins whip into a stable, silken foam — because this is a plant-forward kitchen and the vegetarian path is the one we reach for first. Egg white does the job beautifully too, with a slightly richer texture, and anyone who prefers it should use it without a second thought; we write the plant default plainly and the animal option with equal respect, never apology.

The balance target is worth stating as a number. A classic sour lands near a 2 : 0.75 : 0.75 ratio of spirit to sour to sweet, but the *felt* balance depends on the structure underneath: a tannic base reads drier, so it wants a touch more sweet to buffer the grip; a soft base reads rounder and wants more acid to sharpen it. The Index lets you aim. When a sour tastes flabby, you are short on acid or structure; when it tastes thin and harsh, you are short on sweet or kokumi weight. The fix is almost never the spirit.

```
VERJUS AQUAFABA SOUR                          serve · coupe · up
2.0 oz    base spirit (whiskey, pisco, or a clean blanco)
0.75 oz   designed verjus (grape, IFI-A ≈ 1,350)
0.5 oz    lemon
0.75 oz   light cane syrup
0.75 oz   aquafaba (or 1 egg white, with equal respect)
2 dashes  designed aromatic bitters, on the foam
```

1. Dry-shake spirit, verjus, lemon, syrup, and aquafaba hard, 15 seconds, no ice — this builds the foam.
2. Add ice and shake again until cold, ~12 seconds. Double-strain up into a chilled coupe.
3. Let the foam settle; dash the bitters across its surface and draw a pick through them for a pattern. The verjus gives the sour a dry, structured finish citrus cannot — tart and architectural at once.

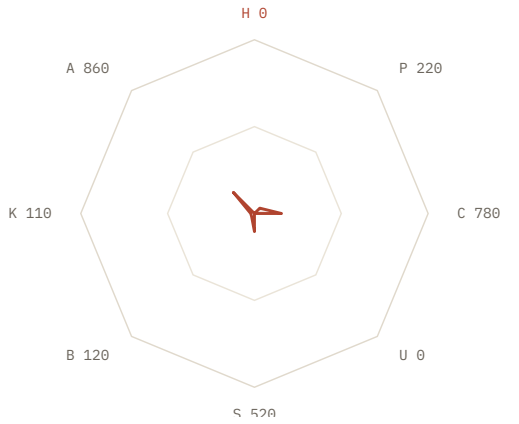



The **highball** is the sour's opposite temperament: long, cold, carbonated, built not shaken, a small amount of flavor stretched over a tall glass of sparkling water and ice. It is the most refreshing form there is and the one where carbonation's own chemistry matters most, because — as Chapter 6 showed — the dissolved $CO_2$ is itself a mild pungent agent, converted at the nerve ending into the acid-and-TRPA1 tingle that makes a highball feel *alive*. A highball is never only its ingredients; it is its ingredients plus the bite of the bubbles, a baseline pungency you build on top of.

```
CUCUMBER-LAVENDER COLLINS                    serve · highball · tall ice
1.5 oz   gin (or a zero-proof botanical base)
0.75 oz  designed verjus (grape)
0.5 oz   lavender cordial (IFI-C ≈ 700)
3        cucumber coins, lightly pressed
top      soda, 3 oz
         cucumber ribbon + lavender sprig
```

1. Gently press the cucumber coins in the shaker — press, don't pulverize; you want cool freshness, not vegetal bitterness.
2. Add gin, verjus, and lavender cordial with ice; short-shake to chill, then strain into a highball of fresh tall ice.
3. Top with soda. Garnish with a cucumber ribbon and a lavender sprig. Cool, floral, dry, and long — the carbonation lending a prickle the still version lacks.

IFI PROFILE



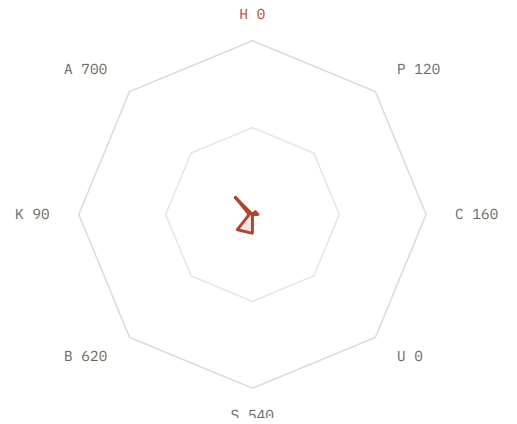

| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 220 |
| IFI-C | 780 |
| IFI-U | 0 |
| IFI-S | 520 |
| IFI-B | 120 |
| IFI-K | 110 |
| IFI-A | 860 |

One more long drink, because the highball is too generous a form to leave with a single example — a structured paloma, grapefruit's natural bitterness attenuated just enough to let the fruit through:

```
STRUCTURED PALOMA                          serve · highball · tall ice
1.5 oz   blanco tequila (or a zero-proof agave base)
2.0 oz   fresh designed grapefruit (naringin-attenuated)
0.5 oz   designed verjus (grape)
0.25 oz  agave syrup · pinch salt
top      soda, 2 oz
         grapefruit wedge · salt rim, half
```

1. Build tequila, grapefruit, verjus, agave, and salt over tall ice; stir.
2. Top with soda; garnish with a grapefruit wedge on a half salt rim.
3. The attenuated grapefruit keeps its bright bitterness and loses the harsh pith sting; the verjus lends a dry backbone citrus alone never has. Long, bittersweet, and clean.

IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 120 |
| IFI-C | 160 |
| IFI-U | 0 |
| IFI-S | 540 |
| IFI-B | 620 |
| IFI-K | 90 |
| IFI-A | 700 |

The stirred and the sour and the long are the grammar of the whole craft. What remains is the register this book was most eager to reach — the heat, the smoke, and then the drinks built with no alcohol at all.

# Chapter 15 · Spicy & smoky — *heat you can ladder, drink after drink.*

The spicy drink has a reputation it does not deserve. It is thought of as a novelty, a dare, a way to make a margarita interesting — and it is treated carelessly, built with whatever chili is on hand, so that one order scorches and the next is tame and nobody can order it twice with confidence. That carelessness is a failure of measurement, not of the idea. Heat in a glass can be as precise as the sweetness in a syrup, if it is carried by a tincture whose number holds. This chapter is about building heat you can *trust* — a laddered program a guest can climb one rung at a time, every rung the same every night.



Phoenix — the eight-axis flagship whose tincture, in drops, anchors the top of the heat ladder.

The source of the trust is the flagship library — ten proof-of-concept superhots, bred up gene by gene from a confident warmth to a number no plant had reached before, each one scored on the Index:

| CULTIVAR | SKU | PREDICTED SHU | IFI-H | AXES |
|---|---|---|---|---|
| Ember | SS-0087 | 866K | 1,570 | 2/8 |
| Cinder | SS-0088 | 1.05M | 2,290 | 3/8 |
| Kindle | SS-0089 | 1.25M | 2,000 | 3/8 |
| Flare | SS-0090 | 1.48M | — | 4/8 |
| Blaze | SS-0091 | 1.72M | 2,630 | 4/8 |
| Wildfire | SS-0092 | 1.96M | 2,930 | 5/8 |
| Scorch | SS-0093 | 2.21M | 3,220 | 5/8 |
| Firestorm | SS-0094 | 2.47M | 3,490 | 6/8 |
| Solara | SS-0095 | 2.72M | 3,980 | 6/8 |
| **Phoenix** | SS-0096 | 2.95M | **4,200** | **8/8** |

You do not put these fruits in a drink. You put *formulated tinctures* of them in a drink — high-proof extracts, standardized so that a fixed dose delivers a known in-glass heat after the dilution and chill of Chapter 6 have had their say. We standardize the whole bar to a five-band ladder, each band a tincture dosed so that **two drops in a four-ounce drink, served cold,** lands on its target IFI-H:

| BAND | NAME | ANCHOR CULTIVAR | IN-GLASS IFI-H (2 DROPS, COLD) | ON THE PALATE |
|---|---|---|---|---|
| I | Warmth | Ember · SS-0087 | ~250 | a glow at the finish |
| II | Glow | Blaze · SS-0091 | ~650 | a clean front bloom |
| III | Heat | Wildfire · SS-0092 | ~1,150 | eyes-open, lingering |
| IV | Fire | Solara · SS-0095 | ~1,800 | a sweat; a challenge |
| V | The Dare | Phoenix · SS-0096 | ~2,800 | drops only; a menu warning |

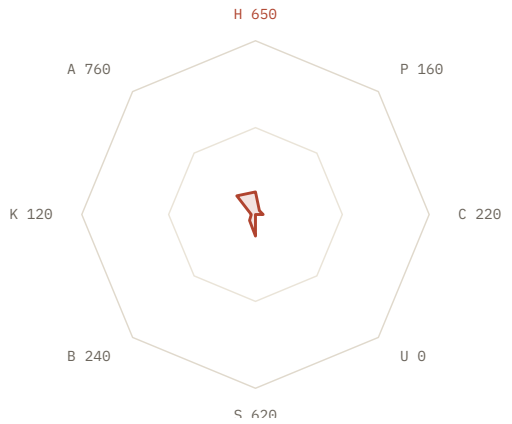
Because the tinctures are standardized and the cultivars hold their output at **CV ≤ 7%**, a guest who loved a Band II margarita can order a Band III next week and know *exactly* how much hotter it will be. That is the whole promise of designed heat, delivered in a glass: not the hottest possible drink, but the most *predictable* one.

Two more levers finish the spicy toolkit. **Temperature**, from Chapter 6: a warm drink reads hotter than a cold one at equal capsaicin, because warmth itself pushes TRPV1 toward threshold. A hot toddy built at Band II will drink like a Band III; an iced michelada at Band III will drink like a Band II. Build the band for the serving temperature. And **smoke**, which is not an axis at all — it is a retronasal aroma, a cargo of phenols perceived through the back of the nose — but which pairs with heat so naturally that the two are nearly inseparable in the mind. Smoke comes from a mezcal base, from a lapsang-souchong tea, from a smoked salt rim or a quick smoke over the glass; it adds no IFI reading but it changes how the heat is *framed*, lending it a savory, campfire depth. Heat says *danger*; smoke says *hearth*. Together they say *come closer*.

```
LADDERED MARGARITA · Band II                serve · rocks · salt rim, half
2.0 oz   blanco tequila
0.75 oz  designed verjus (grape) + 0.25 oz lime
0.5 oz   agave syrup (holds the capsaicin in suspension)
2 drops  Band II chili tincture (Blaze)
         smoked-salt rim, half the glass · grapefruit peel
```

1. Rim half the glass with smoked salt — half, always, so the guest chooses each sip's intensity.
2. Shake tequila, verjus, lime, agave, and the two measured drops with ice until cold.
3. Strain over fresh ice. Express grapefruit over the top. The heat blooms at the front and clears before the next sip; move a guest up or down the ladder by swapping only the tincture band.

IFI PROFILE

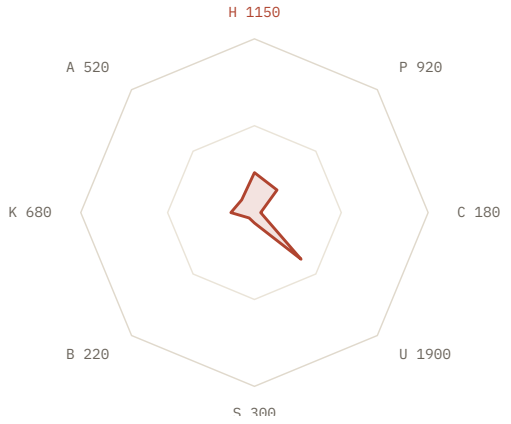



| | |
|---|---|
| IFI-H | 650 |
| IFI-P | 160 |
| IFI-C | 220 |
| IFI-U | 0 |
| IFI-S | 620 |
| IFI-B | 240 |
| IFI-K | 120 |
| IFI-A | 760 |

```
MICHELADA, MEASURED · Band III              serve · tall · spiced rim
4.0 oz   chilled light lager (or zero-proof pilsner)
2.0 oz   clarified designed-tomato water (IFI-U ≈ 1,900)
0.5 oz   lime · 2 dashes Worcestershire-style umami sauce
3 drops  Band III chili tincture (Wildfire)
2 drops  black-mustard pungency tincture
         chili-salt rim · cucumber spear
```

1. Build tomato water, lime, umami sauce, and both tinctures in a spiced-rim tall glass with ice.
2. Top gently with the cold lager to preserve its carbonation — the bubbles add their own pungent tingle on top of the mustard's.
3. The umami depth makes the heat read savory rather than sharp; the mustard flashes up the nose; the tomato carries it all. A spicy drink that eats like a meal.

IFI PROFILE

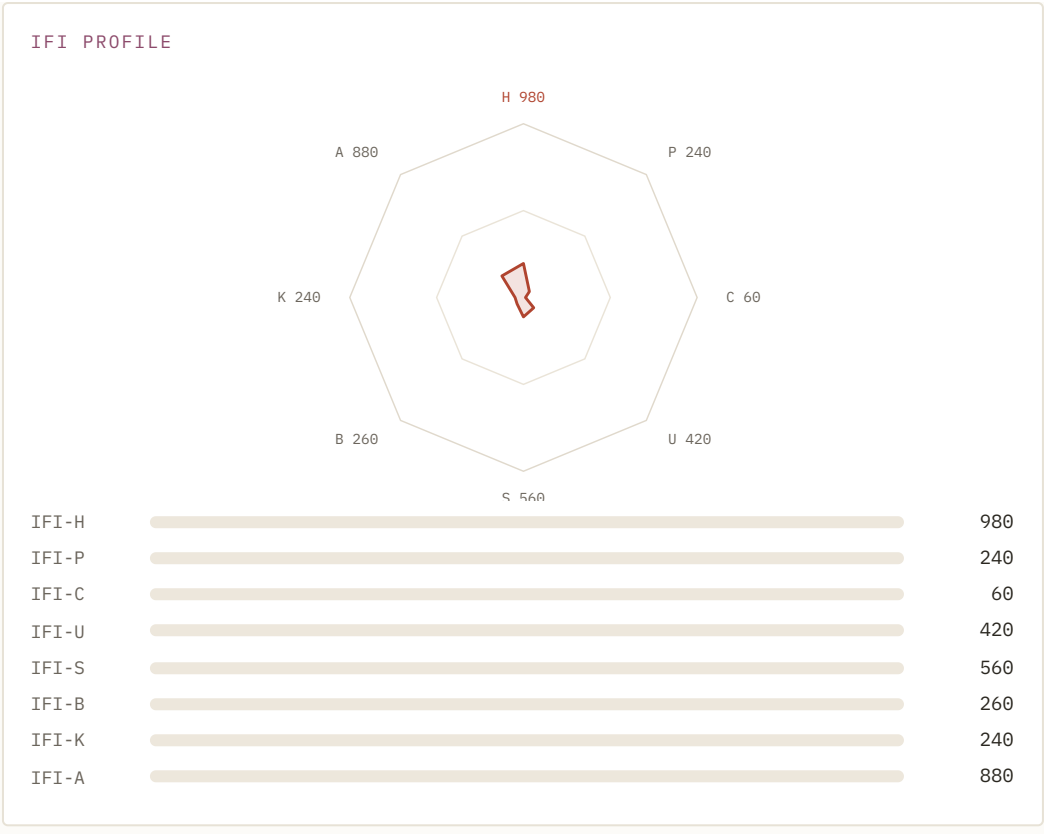



| | |
|---|---|
| IFI-H | 1,150 |
| IFI-P | 920 |
| IFI-C | 180 |
| IFI-U | 1,900 |
| IFI-S | 300 |
| IFI-B | 220 |
| IFI-K | 680 |
| IFI-A | 520 |

And the lever the cold drinks cannot pull — heat built *warm*, so the serving temperature itself amplifies the capsaicin. A toddy dosed at Band II drinks like a Band III, because warmth pushes TRPV1 toward threshold before the chili ever arrives:

```
WARM-POTENTIATED TODDY · Band II → III      serve · mug · hot
2.0 oz   bourbon (or a spiced zero-proof base)
4.0 oz   hot designed black tea (IFI-A ≈ 900)
0.75 oz  honey · 0.5 oz lemon
1 drop   Band II chili tincture (Blaze)
1        cinnamon stick · 2 cloves · lemon wheel
```

1. Warm the mug with hot water, then discard it. Combine tea, honey, lemon, bourbon, and the single drop of tincture; stir.
2. Add the cinnamon stick, cloves, and a lemon wheel. Serve steaming.
3. Sip and feel the warmth do the work: one drop, in a hot drink, reads where two would in a cold one. Comfort and a measured heat in the same mug — the temperature term from Chapter 6, made delicious.




That is the spicy register, laddered and warm and cold. The one that remains is its opposite — the drinks with no alcohol in them at all, where nothing is left to carry the flavor but the botany itself.

# Chapter 16 · The zero-proof program — *where the designed plant does all the work.*

This is the chapter the whole book was built toward. Everywhere else, alcohol has been quietly helping: dissolving the lipophilic flavors, carrying the aromatics on its volatility, softening the tannin's grip, lending the drink weight and length and warmth. Take the alcohol away and all of that help vanishes at once — and what is left standing is the botany. A great zero-proof drink is not a cocktail with a hole where the spirit was. It is a drink engineered so completely at the plant that it never needed the spirit at all. This is where designed flavor stops being a convenience and becomes the entire point.




Strawberry — bright, sweet, structured; the kind of fruit a zero-proof program is built to let speak.

Return to the math of Chapter 6, because it predicts exactly how a drink changes when the ethanol leaves:

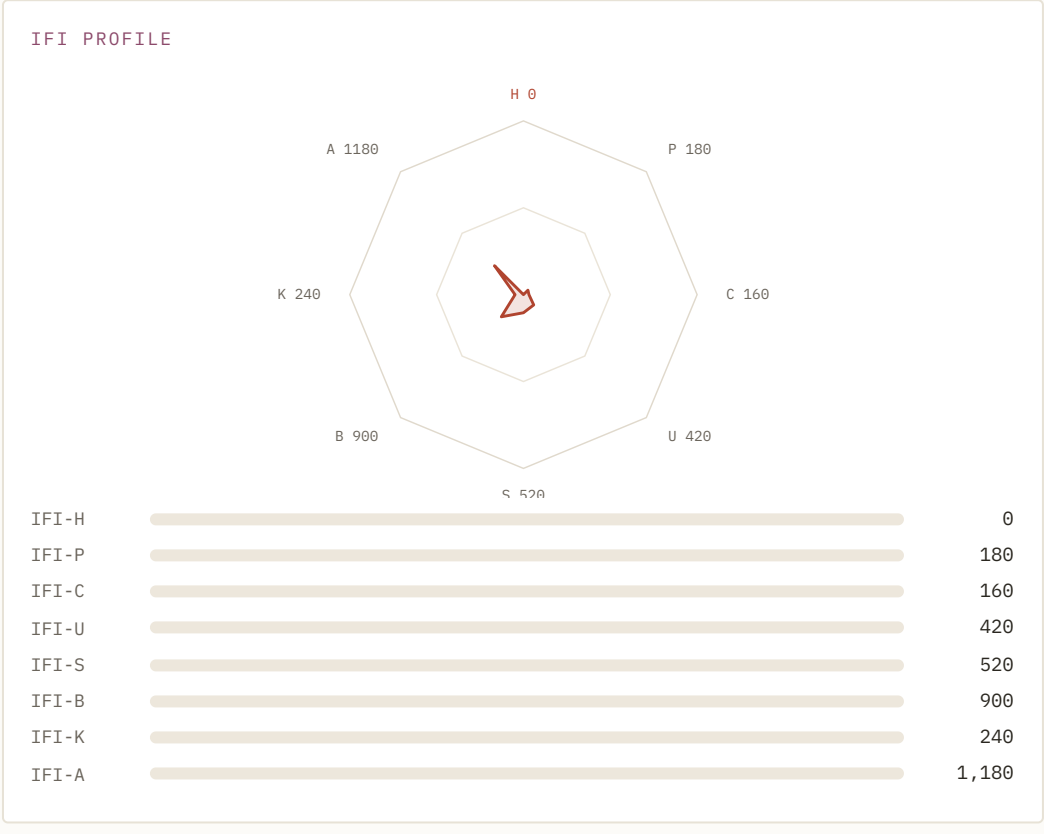
- **Astringency comes forward.** Ethanol was breaking up the tannin-protein aggregates; without it, the same tannin grips harder. A zero-proof drink can — and should — be built on *less* designed tannin than its alcoholic cousin, or the grip will turn austere. This is counter-intuitive and it is the single most common mistake in zero-proof bartending: people over-structure, chasing the "body" alcohol gave, and end up with something dry and hard.
- **Heat and pungency recede.** Ethanol was a co-agonist at TRPV1 and TRPA1 and a solvent for capsaicin; without it, a given dose reads cooler and the capsaicin risks precipitating. A zero-proof spicy drink needs a little more tincture, a little more syrup or glycerol to hold the capsaicin, and the heat will read cleaner and gentler for it.
- **Aroma needs a new carrier.** Ethanol's volatility lofted aromatics to the nose. Without it, aroma must be carried by what remains — the essential oils of an expressed peel, the volatiles of a fresh herb slapped over the glass, the retronasal lift of carbonation. Build the aroma in deliberately; do not assume it will arrive.

- **Sweetness and kokumi matter more.** With no alcoholic warmth to give the drink weight, the body has to come from somewhere — designed sugar-free sweetness for roundness, γ-glutamyl kokumi for length. A zero-proof drink lives or dies on its mid-palate, and the mid-palate is where kokumi lives.

The sweetness here deserves its careful word. Our stevia, monk fruit, and sugarcane organisms let a zero-proof drink carry real, rounded sweetness that is made by the plant as **glycoside rather than sucrose** — a documented attribute of the cultivar, selected for the clean rebaudioside-M profile and polished with a measured Zero-Bitter attenuation so none of the old stevia off-notes survive. We state that attribute plainly and we stop there. We do not call the drink healthy; we do not imply it will do anything for your body; the nourishment this family cares about is a reason we grow the way we grow, never a promise printed on a glass. A zero-proof drink is a pleasure you can hand to anyone at the table — the designated driver, the pregnant friend, the person simply not drinking tonight — and have it be as considered, as structured, as *complete* as anything with a spirit in it. That completeness is the respect. The rest is quiet.

```
ZERO-PROOF NEGRONI                              serve · rocks · one cube
1.5 oz    hard-brewed designed black tea (IFI-A ≈ 1,100, IFI-B ≈ 600)
0.75 oz   designed bitter aperitivo, non-alc (gentian base, IFI-B ≈ 900)
0.5 oz    crimson structure cordial (Ch. 11)
2 dashes  designed aromatic bitters
          orange peel, expressed generously
```

1. Stir tea, non-alcoholic aperitivo, cordial, and bitters over ice — a full 25 seconds, because without alcohol you want the dilution to do the softening the ethanol would have.
2. Strain over a large cube. Express the orange peel hard over the surface — this is now the drink's whole aromatic lift — and drop it in.
3. Bitter, structured, crimson, and long. The tea's tannin and the gentian's bite carry the architecture; the cordial gives the fruit; nothing here ever met a still.

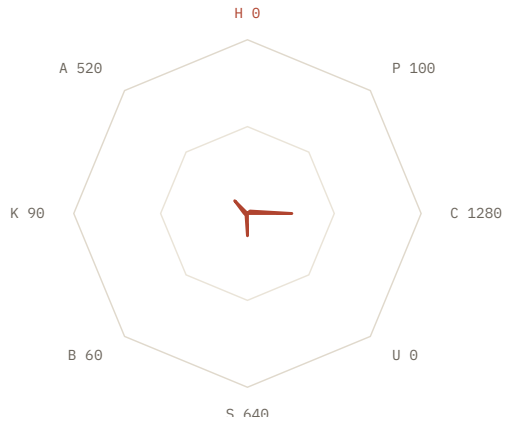


MINT-COOL NOJITO — serve · highball · crushed ice

| | |
|---|---|
| 10 | designed peppermint leaves (high-menthol) |
| 0.75 oz | lime · 0.5 oz light cane syrup |
| 0.5 oz | designed verjus (grape) |
| 2 drops | monk-fruit sweet concentrate (for round body, no sugar add) |
| top | soda, 3 oz |
| | mint crown, slapped |

1. Gently press the mint with lime and syrup — press to release oils, do not shred to bitterness.
2. Add verjus and the monk-fruit drops; fill with crushed ice; top with soda and churn once.
3. Crown with slapped mint. Serve frigid — cold is the free co-agonist that makes the menthol read loud. A cooler that finishes cold three breaths after the glass is down.

IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 100 |
| IFI-C | 1,280 |
| IFI-U | 0 |
| IFI-S | 640 |
| IFI-B | 60 |
| IFI-K | 90 |
| IFI-A | 520 |

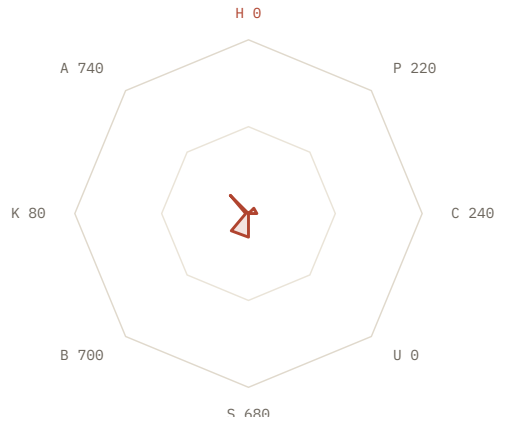
SUGAR-FREE GARDEN TONIC — serve · highball · tall ice

| | |
|---|---|
| 1.0 oz | cinchona-and-citrus tonic cordial, attenuated (IFI-B ≈ 700) |
| 0.5 oz | designed verjus (grape) |
| 3 drops | stevia concentrate (clean reb-M profile) |
| 4 | cucumber coins, pressed |
| top | soda, 4 oz |
| | lime wheel + rosemary tip |

1. Press cucumber with the tonic cordial and verjus; add the stevia drops.
2. Strain into a tall glass of fresh ice; top with soda.

3. Garnish with lime and a rosemary tip for aroma. Dry, bittersweet, and structured — a tonic's adult bitterness with the sweetness made by the plant, not spooned in.

IFI PROFILE



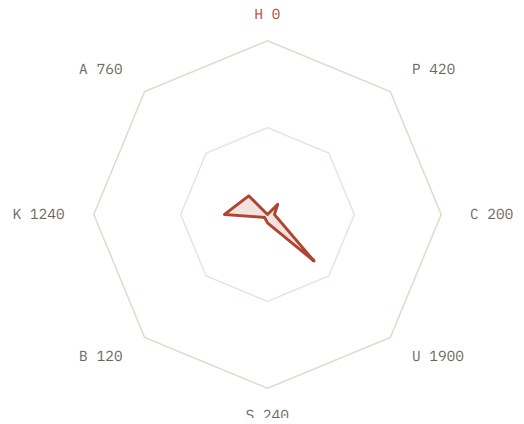

| | | |
|---|---|---|
| IFI-H | | 0 |
| IFI-P | | 220 |
| IFI-C | | 240 |
| IFI-U | | 0 |
| IFI-S | | 680 |
| IFI-B | | 700 |
| IFI-K | | 80 |
| IFI-A | | 740 |

Two more, to show the range a spirit-free program can hold — one savory, one dark and structural, neither of them a compromise:

```
GARDEN, NO PROOF — a savory zero-proof      serve · rocks · cubed ice
2.5 oz   clarified designed-tomato water (IFI-U ≈ 1,900)
0.5 oz   designed verjus (grape)
0.25 oz  celery-and-horseradish tincture
2 drops  γ-glutamyl kokumi tincture (garlic-derived)
2 dashes umami-forward bitters · pinch salt
         cherry tomato + basil
```

1. Stir tomato water, verjus, tinctures, bitters, and salt over ice until very cold.
2. Strain over fresh cubes. The kokumi gives it a savory length that reads, impossibly, like something aged.
3. Garnish with a cherry tomato and a basil leaf. A savory sipper with the depth of a consommé and the weight of a cocktail, and not a drop of alcohol in it.

IFI PROFILE

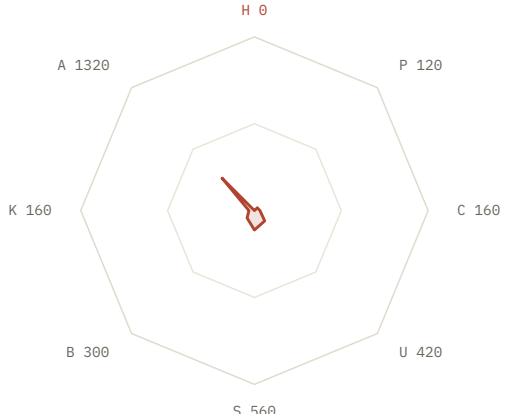



| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 420 |
| IFI-C | 200 |
| IFI-U | 1,900 |
| IFI-S | 240 |
| IFI-B | 120 |
| IFI-K | 1,240 |
| IFI-A | 760 |

```
SORGHUM SPRITZ — dark & structural          serve · wine glass · ice
1.5 oz   crimson structure cordial (Ch. 11, pomegranate-sorghum)
1.0 oz   hard-brewed designed black tea, chilled
0.5 oz   designed verjus (grape)
top      soda, 3 oz
         orange half-wheel + rosemary
```

1. Build cordial, tea, and verjus over ice in a wine glass.
2. Top with soda; stir once, gently.
3. Garnish with orange and a rosemary tip. Dry, dark, faintly cereal, structured by three different tannins at once — pomegranate's ellagitannin, sorghum's condensed tannin, tea's gallated catechin — a zero-proof drink with more architecture than most cocktails carry.

IFI PROFILE




| | |
|---|---|
| IFI-H | 0 |
| IFI-P | 120 |
| IFI-C | 160 |
| IFI-U | 420 |
| IFI-S | 560 |
| IFI-B | 300 |
| IFI-K | 160 |
| IFI-A | 1,320 |

# Chapter 17 · The botanical pantry — *the shrubs, cordials, bitters, and tinctures that build everything.*

Behind every drink in this book stands a pantry, and the pantry is where a bar's identity actually lives. The recipes in the preceding chapters all reach for the same handful of house-made bases — a designed verjus, a grape-tannin shrub, a laddered chili tincture, a cooling cordial, a kokumi tincture, a good saline. Make these well, standardize them, and the drinks assemble themselves. This chapter is the build kit: the formulas, the extraction math, and the few rules that keep a home or professional pantry honest.

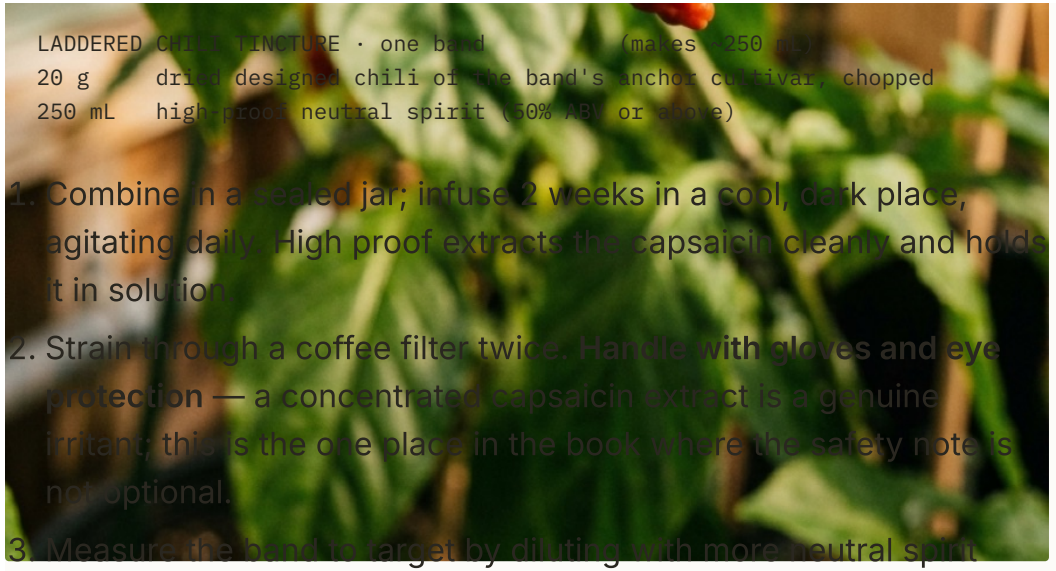



The quiet work of the pantry — extraction, measurement, the bases that outlast any single drink.

## The four preparations and what each is for:

| PREPARATION | METHOD | CARRIES | KEEPS |
|---|---|---|---|
| Shrub | fruit + sugar + vinegar, macerated | astringency, acid, fruit | ~1 month, refrigerated |
| Cordial | juice/infusion + sugar, gentle heat | sweetness, aroma, color | ~2 weeks, refrigerated |
| Bitters | botanicals in high-proof, long infusion | bitterness, aromatic depth | years, shelf-stable |
| Tincture | single botanical in high-proof, short | one axis, concentrated | years, shelf-stable |

The **tincture** is the pantry's precision instrument, and it runs on simple extraction logic. A lipophilic agonist — capsaicin, the menthol of a cooling tincture, the gingerol of a pungent one — extracts into high-proof neutral spirit far better than into water, because like dissolves like. The higher the proof, the more completely and quickly the extraction, and the more *stable* the result, because the agonist stays dissolved rather than precipitating over time. This is why the laddered chili tinctures of Chapter 15 are built in high-proof spirit and dosed in drops: a few drops carry a precisely known quantity of capsaicin because the extraction was complete and the solvent holds it. To standardize a band, you extract a known mass of a known cultivar — whose capsaicin content holds at CV ≤ 7% — for a fixed time at a fixed proof, then dilute the extract to the target concentration and bottle it. The predictability of the band is the predictability of the cultivar, carried through a predictable extraction.



```
LADDERED CHILI TINCTURE · one band          (makes ~250 mL)
20 g     dried designed chili of the band's anchor cultivar, chopped
250 mL   high-proof neutral spirit (50% ABV or above)
```

1. Combine in a sealed jar; infuse 2 weeks in a cool, dark place, agitating daily. High proof extracts the capsaicin cleanly and holds it in solution.
2. Strain through a coffee filter twice. **Handle with gloves and eye protection** — a concentrated capsaicin extract is a genuine irritant; this is the one place in the book where the safety note is not optional.
3. Measure the band to target by diluting with more neutral spirit until a two-drop dose in 120 mL of cold water reads at the band's intended IFI-H. Label with the band and the cultivar. Keeps for years.

```
HOUSE ZERO-BITTER AROMATIC BITTERS          (makes ~500 mL)
400 mL   high-proof neutral spirit
15 g     gentian root · 5 g wormwood · 10 g dried orange peel
5 g      designed hops (high-aroma, attenuated) · 3 g cardamom
3 g      cinnamon bark · 2 g dried cherry
```

1. Infuse all botanicals in the spirit 2 weeks, agitating daily, then strain.
2. Taste and measure: the gentian and wormwood bring the bitterness; the attenuated hops and the aromatics bring depth without adding to the sting. Target an IFI-B that reads structured, not harsh.
3. For a *zero-bitter* house style, blend the finished bitters with a measured masking fraction until the perceived bitterness drops to your target percentage — keeping the aromatic shape, lowering only the hurt. Bottle in dropper bottles; shelf-stable for years.

Two more bases the recipes lean on, specified here so the pantry is complete. First, the **cooling cordial** that appears in half the cold drinks:

```
COOLING CORDIAL — menthol-forward           (makes ~400 mL)
40 g     designed high-menthol peppermint leaves
300 mL   hot water (80 °C, not boiling)
160 g    cane sugar
0.5 oz   verjus (grape) · pinch salt
```

1. Steep the leaves in the 80 °C water 8 minutes — hotter scorches the leaf and turns the cool bitter; cooler under-extracts the menthol.
2. Strain, pressing gently; stir in the sugar while warm until dissolved, then the verjus and salt to brighten and preserve.
3. Cool quickly over an ice bath to lock the volatile menthol in. Bottle; keeps two weeks refrigerated. Standardize to IFI-C ≈ 1,600 by mouth against a reference serve.

And the three un-glamorous adjusters that make every other recipe land — the bartender's salt, acid, and sweet, kept in dropper and squeeze bottles and dosed to taste:

| ADJUSTER | FORMULA | WHAT IT DOES |
|---|---|---|
| Saline | 20 g salt : 80 g water | lifts sweetness and umami; tames bitterness |
| Rich syrup | 2 parts sugar : 1 part water | body and buffer without over-sweetening |
| Acid adjust | 5 g citric + 2 g malic : 100 mL water | tunes pH — and so astringency — without added flavor |
| Verjus | pressed designed green grapes | structured acid; the universal non-alcoholic backbone |

The acid adjuster earns its line, because it is the lever Chapter 6 kept pointing at: pH sets how hard a tannin grips, so a few drops of acid solution tighten a drink's astringency and brighten its color without changing one thing about its flavor. Keep it on the rail beside the saline and you can tune structure and sweetness independently — which is most of what balancing a drink actually is.

A compliance word belongs here as it did in Chapter 12, because the pantry is where a hobby becomes, sometimes, a product. **High-proof home extraction** carries real safety obligations — ventilation, flash-point awareness, and never near an open flame. A **house bitters or tincture bottled for sale** falls under the TTB's non-beverage framework in the United States and analogous regimes elsewhere, separate from the rules for beverage spirits, and any packaged mixer must carry honest ingredient and allergen labeling. None of this is a reason not to build a pantry. It is the reason to build one that could stand up to daylight.

The pantry is also where the plant-reverence of this whole project is most concretely felt. Every base in this kit begins as something grown — a grape pressed green, a chili dried whole, a mint cut at dawn — tuned at the gene so that the number it carries into your drink is the number you meant. Nineteen thousand constructs, a thousand of them live and growing now, resolve in the end to a row of dropper bottles on a shelf, each one a plant's voice held steady. That is the quiet machinery under every glass in this book.



PART IV OF IV

# The Frontier & The Table

What the bar will pour next — and what we pour for the people we love

# Chapter 18 · What the bar will pour — *the botanicals we have not built yet.*

Everything in this book so far is real: forty-two established organisms, a thousand cultivars live and growing, numbers that hold at CV ≤ 7%. This chapter is honest about being different. It is the frontier — the drinks the bar will pour when the roadmap of sixty-four concept organisms, today still largely designs and partial constructs, comes fully alive. We write it in the conditional because that is the truth of it, and because the frontier is where a drinks book gets to dream with its eyes open. The method that will build these plants is the method that built the ones we pour today; only the organisms are new.

The reason the frontier is credible and not fantasy is **method transfer**. The platform is seven modules — the models that score the edits, the flux-balance that finds the true bottleneck, the construct design, the delivery, and the rest — and **five of the seven carry unchanged** from a pepper to any plant with a sequenced genome, because the chemistry they act on is the general phenylpropanoid trunk that every vascular plant already runs. Only the terminal, pepper-specific enzymes must be ported, and only when heat is the goal. This is why the roadmap can be sixty-four organisms deep rather than one: the hard part was built once. A **Tomato *Volcanic*** — the T1 series whose cultivars climb *Ember · Magma · Pyroclast · Caldera · Krakatoa* up a laddered heat — is, from the platform's side, a nearer problem than it sounds, a four-to-five-gene edit on an easy, well-mapped host, and it would hand the savory bar its grail: a bloody-type drink built on a tomato that carries both the umami it always had and a designed, laddered heat it never did, a whole michelada reduced to a single pressed fruit. We say *would* because it is not yet poured. But the distance from here to there is engineering, not invention, and that distinction is the entire promise of this shelf.




Melon, on the frontier — *Solar*, a melon designed to carry structure and a whisper of heat.

The roadmap climbs through five tiers of increasing genetic difficulty, each adding genes and years, all drawing on the same transferable core — the phenylpropanoid trunk **PAL → C4H → 4CL → HCT → COMT** that runs in every vascular plant, plus the four terminal pepper enzymes **pAMT · Pun1/CS · KAS · BCAT** where heat is the goal. For the bar, a handful of these concepts are so clearly *drinks* that they almost mix themselves:

| CONCEPT ORGANISM | SERIES | TIER · GENES · HORIZON | WHY THE BAR WANTS IT |
|---|---|---|---|
| Tomatillo *Acid* | — | T2 · 5–7 · 24–36 mo | a designed sour base; tartness without citrus's shout |
| Petunia *Floral* | — | T2 · 5–7 · 24–36 mo | a true floral cordial organism; aroma as structure |
| Ground Cherry *Celestial* | — | T2 · 5–7 · 24–36 mo | husk-fruit sweetness with a bright, tropical lift |
| Cucumber *Contradiction* | — | T3 · 7–10 · 36–48 mo | cool and warm in one fruit; a drink that argues with itself |
| Melon *Solar* | — | T3 · 7–10 · 36–48 mo | structured melon with a sunlit whisper of heat |
| Strawberry *Sweet Heat* | Warm Kiss · Sugar Burn · Candied Fang · Devil's Dessert | T3 · 7–10 · 36–48 mo | the dessert cocktail; sweetness and heat on one axis-pair |
| Apple *Forbidden* | — | T3 · 7–10 · 36–48 mo | an orchard fruit with a serpent's warmth |



Cucumber *Contradiction* — the frontier fruit designed to cool and warm at once.

Two of these are worth dreaming on in detail. **Tomatillo *Acid*** is the base a zero-proof program has always wanted: a fruit engineered for clean, bright, structured tartness, so that a sour could be built on a single pressed juice with no citrus at all — the acidity designed in, held steady, shaped to finish dry rather than sharp. And **Cucumber *Contradiction*** is the frontier's most purely beautiful idea, a fruit that would carry both a cooling TRPM8 note and a warming TRPV1 one in the same flesh, so that a single slice could make a drink feel cold on the front of the tongue and warm at the back of the throat at once — a contradiction the mouth cannot resolve and keeps chasing. The **Strawberry *Sweet Heat*** series, with its cultivars named *Candied Fang* and *Devil's Dessert*, points at the dessert cocktail the heat-and-sweetness axis-pair was made for: a swizzle that is candy on the lips and a glow at the swallow.




Strawberry *Sweet Heat* — the series behind the dessert cocktail the frontier promises.

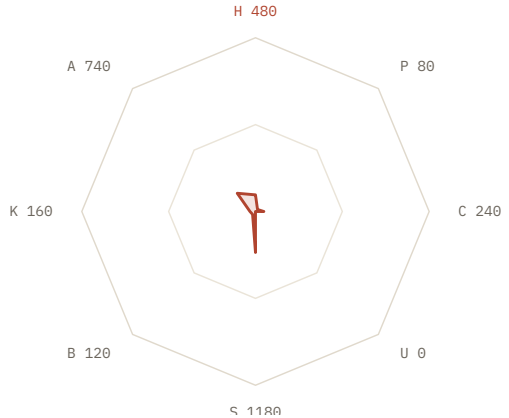
Here the regulatory horizon is real and worth naming plainly. Novel engineered food organisms move through genuine frameworks before they reach a glass — **GRAS** determination and FDA consultation in the United States, the **Novel Food** authorization regime in the European Union, and analogous review elsewhere — and a responsible program treats those not as obstacles but as the daylight its work should be built for. We say *what could be built* precisely because we will not say *what is poured* until it has earned the word. The frontier is a promise with a process attached.

A single speculative pour, offered in the conditional — the drink we would build the day Tomatillo *Acid* and Strawberry *Candied Fang* come fully alive. Its readout is a **projection**, not a measurement, and we mark it so:

```
DEVIL'S DESSERT SWIZZLE · a frontier pour   serve · tall · crushed ice
1.5 oz   pressed Tomatillo Acid juice (projected IFI-A ≈ 600)
0.75 oz  Candied Fang strawberry cordial (projected IFI-H ≈ 500, IFI-S ≈
900)
0.5 oz   designed verjus (grape)
2 drops  monk-fruit concentrate
top      soda
         strawberry fan + mint
```

1. Build tomatillo juice, strawberry cordial, verjus, and monk-fruit over crushed ice; swizzle with a bar spoon until the glass frosts.
2. Top with soda; crown with a strawberry fan and slapped mint.
3. *If it tastes the way the design predicts:* candy and bright acid on the front, a clean strawberry heat arriving only at the swallow — dessert and dare in one tall glass.

## IFI PROFILE




| | | |
|---|---|---|
| IFI-H | | 480 |
| IFI-P | | 80 |
| IFI-C | | 240 |
| IFI-U | | 0 |
| IFI-S | | 1,180 |
| IFI-B | | 120 |
| IFI-K | | 160 |
| IFI-A | | 740 |

# Chapter 19 · A glass, poured with intention — *what we hand across the table.*

We began at dusk, with a glass handed across a greenhouse gone the color of weak tea, and we have spent the chapters since taking that glass apart — the receptors it speaks to, the pathways that fill it, the arithmetic that balances it. It is worth, at the end, putting it back together, because a drink is never really the sum of eight numbers, however much the measuring helps. A drink is a thing you give to someone. The measuring is only in service of the giving.



The hour the work comes back to the table — dawn light through the research greenhouse, where it all began and ends.

Everything in this book was built on a single idea carried across from the rest of the Scoville Splice library: that you cannot design what you cannot measure, and that measuring a pleasure does not diminish it but lets you offer it more exactly. The Iyengar Flavor Index gave the cocktail its first real vocabulary for the things it had always done by feel — the structure of a tannin, the lie a menthol tells the cold receptor, the distance between a chili at the vine and a chili in a glass. Eight axes, eight receptors, and under them the same phenylpropanoid chemistry that runs in every green thing, tuned at the gene and held steady so that a drink tastes the same in January and July. That steadiness — CV ≤ 7%, a thousand cultivars live, a number you can trust — is not a technical boast. It is a form of respect for whoever is on the other side of the bar.

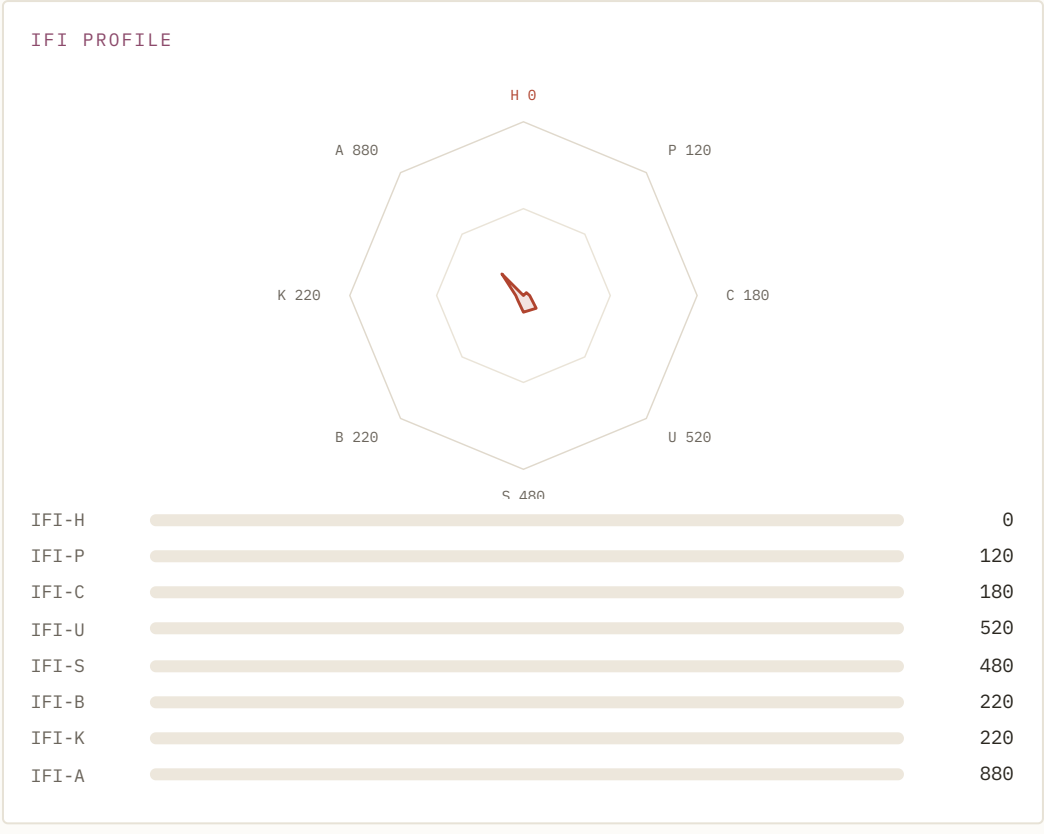
The ethos that hums under this book, as it hums under all of them, is the quietest thing we believe and the one we are most careful never to oversell. We grow plants to carry the most of what they should and the least of what they shouldn't, because that is how we think food ought to be grown. We make a sweetness the plant builds itself, a bitterness turned down to a signature rather than a sting, a zero-proof drink as considered as any with a spirit in it — and we do these things because they are how we would want to be fed, not because we are promising anyone anything. There are no claims in these

pages and there will be none. These are computational designs; Scoville Splice's cultivars and constructs have not been experimentally validated in a laboratory. A drink is a pleasure. We have only tried to make it a pleasure you can offer with intention: to the friend who is driving, to the one who is not drinking tonight, to the person you most want to hand something good across a table at dusk.

That is the whole of it. The science is real and shown; the plants are grown by our family and engineered from scratch; the numbers are a way of caring, made legible. When you build the last drink in this book, build it for someone. Measure it, because measuring is how you keep a promise. And then stop measuring, and hand it across.

```
THE HOUSE POUR — a benediction                serve · whatever glass is nearest
2.0 oz   cold-brewed designed tea (IFI-A ≈ 800, soft and savory)
0.75 oz  designed verjus (grape)
0.5 oz   pomegranate cordial (Ch. 11)
0.25 oz  light honey or cane syrup
top      soda, to taste
         a slapped herb from whatever is growing — mint, basil, thyme
```

1. Build over ice, gently, in no particular hurry.
2. Top with soda until it is as long as the evening wants.
3. Slap whatever herb is nearest and lay it on top. Hand it to someone. That is the recipe.




*— The family, at the greenhouse, at dusk.*