

THE SCOVILLE SPLICE LIBRARY · THE KITCHEN

The Vegetarian

No meat. *Nothing missing.*

Plant-forward cooking where engineered umami, kokumi, and sweetness do the heavy lifting — every plant grown back toward what it was always meant to taste like, and every dish scored on the same eight axes.

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

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Opening essay · A vegetarian's case for designing flavor

We have cooked without meat our whole lives, and not once did we think of it as cooking without something. It was simply cooking — a pan of onions going slow and sweet, a tomato grated down to its bright pulp, the particular hush of a kitchen when a pot of beans is almost ready. The plates we grew up on were not arguments. They were dinner. This is the book that finally explains, down to the receptor, why they were enough.

For a hundred years, breeding chose plants for everything except the way they taste. It chose for the truck and the warehouse, for a skin that would not bruise under a forklift, for a yield number on a seed-company spreadsheet, for the look of a thing under the cold light of a grocery aisle in January. Flavor was not on the form. And so what arrived in our kitchens was a plant quietly emptied of the very molecules that had made it worth growing — a tomato that could survive a thousand miles and tell you nothing when you bit it. We were handed the hollowed-out fruit and told, in a thousand recipes, to make up the difference with salt, with butter, with a hard Parmesan rind, with a piece of meat in the pot.



The family in the research greenhouse at dawn — where the question that became this book first came up at our own table.

We never believed the difference needed making up. It needed *restoring*. And that single word is the whole premise of designing flavor for a vegetarian kitchen. We are not imitating anything. We are not building a convincing counterfeit of a rib or a strip of bacon out of beans and smoke. We are growing a tomato back to the savory depth that a century of logistics bred out of it; growing a strawberry back to the sweetness of its one perfect ripe afternoon; growing a head of broccoli so that the bitterness it carries as a chemical warning is turned down to a hum, and the sweetness underneath finally gets to be heard.

Here is the mechanism, because in this library the wonder and the number are two halves of one sentence. Everything you taste is a chemical conversation between a molecule and a receptor — a

protein on the surface of a cell on your tongue, shaped to catch one kind of signal and report it to the brain. Sweetness is a sugar, or something sugar-shaped, settling into **TAS1R2/TAS1R3**. Savory depth is the amino acid glutamate finding **mGluR1** and the **TAS1R1/TAS1R3** pair. Heat is capsaicin prying open **TRPV1**, the same channel your nerves use to report a burn. Each of these conversations has a loudness, and loudness is a thing you can measure. We measure it with the Iyengar Flavor Index.

> $\mathrm{IFI(candidate)} = 1{,}000 \times \mathrm{EC_{50}(reference)} \div \mathrm{EC_{50}(candidate)}$

EC_{50} is the concentration of a stimulus at which its receptor reaches half of its full response — the point where the channel is open half the time, the point of maximum sensitivity. A compound with a *low* EC_{50} is potent: it drives the receptor hard at a small dose. Invert that against a fixed reference, scale by a thousand, and you have a single number that says not how much of a compound a food contains, but how *loudly* it speaks to the body. A supermarket tomato grown for the truck registers an umami loudness near **IFI-U 300**. The tomato we grew back toward itself registers **2,600** — not because we poured anything in, but because we restored the plant's own route to the glutamate it had lost. Roughly ninety-three percent of its savory voice had been bred away for shipping. We gave it back.

This is why a vegetarian, of all cooks, has the most to gain from designing flavor on purpose. The meat kitchen has long leaned on the fact that animal flesh arrives pre-loaded with free glutamate, with the inosine and guanosine ribonucleotides that multiply it, with fat that carries aroma and builds body. The plant kitchen was told it would always be working at a deficit, borrowing those qualities from butter and cheese and stock, or doing without. That was never a law of nature. It was a gap left by a breeding program that never thought flavor was its job. Close the gap at the source — in the living plant, through its own biochemistry — and the deficit disappears. Not hidden. Gone.

Every recipe in these pages rests on a plant we tuned toward what it was supposed to be, and every finished dish carries its IFI scorecard, so you can taste the intention and read it on the same page. We did not build the Index to replace the pleasure. We built it because you cannot design what you cannot measure, and we wanted, more than anything, to be able to grow dinner on purpose.

And underneath all of it, quietly, is the thing we actually care about: that food grown toward its fullest flavor is, not by coincidence, food grown toward its fullest nourishment — that the lycopene and the glutamate ride the same restored pathways, that taste and goodness were never two separate projects. We will not preach it at you. We will just keep setting the table.

A word on how to read this book, because it is built like the Index it uses. The eight axes are its skeleton, and we have ordered them the way a vegetarian kitchen actually leans on them. First the **savory floor** — umami (mGluR1, TAS1R1/R3) and kokumi (CaSR), the depth and body that meat was always invited into the pot to supply, and the two we can grow most completely. Then the **warnings we tune** — bitterness (TAS2R38), turned down so a vegetable can be

wanted, and sweetness (TAS1R2/R3), made loud without the cost of sugar. Then **heat and its cousins** — the warmth of capsaicin (TRPV1), the sharp pungency of allicin and mustard oil (TRPA1), the false cold of menthol (TRPM8) — the sensations that are not tastes at all but touches on the nerve, and the ones that give a plant plate its drama. Then **the sweet frontier** — fruit tuned to ripeness, and the astringency (salivary PRPs) that keeps sweetness and richness honest. And finally the **everyday table**, where all eight are composed into dinner. Each chapter moves the same way: a reverent look at the thing, then the mechanism exactly, then what it means when you eat it — and then, very often, a recipe, because this is a cookbook, and the proof of any axis is a plate.



PART I OF V

The Savory Floor

What meat was doing — and how a plant does it instead · mGluR1 · TAS1R1·R3 · CaSR

Chapter 1 · The Umami Axis — *the savory depth, grown back in.*

Begin with the taste a vegetarian kitchen is most often accused of lacking, because it is the one we can restore most completely. Umami is not a mood or a metaphor. It is the specific perception triggered when the amino acid **L-glutamate**, in its free (unbound) form, reaches two receptor systems on the tongue: the broadly-tuned metabotropic glutamate receptor **mGluR1**, a truncated taste variant of the same family your neurons use, and the heterodimer **TAS1R1/TAS1R3**, which shares its R3 subunit with the sweet receptor. When free glutamate settles into the large clamshell-shaped binding region of these receptors — the Venus flytrap domain, so named because it closes around its ligand like the plant — it reports a savory, mouth-filling, broth-like fullness that the brain reads as *food that will sustain me*.

That reading is not an illusion. Glutamate is the most abundant amino acid in most proteins; a tongue that lights up at free glutamate is a tongue tuned to find protein-dense nourishment. The meat kitchen has always traded on this quietly, because muscle tissue, as it ages and cooks, liberates free glutamate from its proteins. A long-braised stock is, in chemical terms, a slow extraction of glutamate and ribonucleotides into water. What we have done is give the plant the same cupboard, stocked from its own biochemistry, so the braise is unnecessary.



The tomato, restored — IFI-U 300 → 2,600, the savory voice shipping-first breeding bred out, grown back through the plant's native glutamate route.

The number, exactly

Put umami on the Index. The loudness of a savory stimulus is anchored by its EC_{50} at the glutamate receptors, inverted against a fixed reference and scaled by a thousand. A reading of **IFI-U 2,600** on our restored tomato means its effective free-glutamate signal is potent enough to half-activate the receptor at roughly 38 percent of the reference concentration — EC_{50}(candidate) ≈ EC_{50}(reference) × 1,000 ÷ 2,600. In plain kitchen terms: a little of it goes a long way, and a plate built on it tastes full at a lower dose of everything else, salt included.

SOURCE	FREE GLUTAMATE (MG/100 G)	IFI-U	WHAT IT DOES ON A PLATE
Supermarket tomato (shipping cultivar)	20–40	~300	thin; needs salt and fat to read as food
Vine tomato, peak season	140–250	~900	the brief August fullness
Restored tomato · 2,040 constructs	240–280 (stable)	2,600	August, in February, on purpose
Dried shiitake	1,000–1,500	~1,900	the vegetarian stock in one ingredient
Kombu (reference savory benchmark)	1,200–3,400	~2,000	the sea's glutamate, set as our north star

The right-hand column is the whole argument of this book compressed into a table. The supermarket tomato is not bad cooking waiting to happen; it is a plant that has been quietly defunded. Restore it, and the salt you add stops *creating* the savory depth and starts merely *uncovering* one that was grown in.

Two receptors, one savor

It matters, for a cook, that umami runs through two receptor systems rather than one, because they have different jobs and different manners. **mGluR1** — the taste-tissue variant of metabotropic glutamate receptor 1 — is a high-sensitivity, fast-reporting detector: it catches free glutamate at low concentration and gives umami its quick arrival, the savory *snap* of a ripe tomato at the front of the bite. The **TAS1R1/TAS1R3** heterodimer is the broader, slower channel, tuned by the ribonucleotide latch of the next chapter and responsible for the deep, mouth-filling, lingering savor of a long stock. A plant kitchen that understands this stops treating umami as one knob. The restored tomato, eaten raw, works mostly through the fast mGluR1 report; the same tomato cooked into a sauce with a pinch of dried mushroom recruits the slow TAS1R1/TAS1R3 channel and its multiplier, and the savor grows a tail. Same glutamate, two doors, two sensations — and a cook who knows which door a dish is knocking on can build the savor to arrive early, stay late, or both.

How we measure a loudness

The IFI-U number on every scorecard in this book is not a guess or a tasting-panel average dressed up as data. It is anchored to a measured EC_{50} — the half-maximal effective concentration of a sample's free glutamate equivalent at the receptor, read against a fixed kombu-glutamate reference. Work the restored tomato through the formula: IFI-U 2,600 = 1,000 × EC_{50}(reference) ÷ EC_{50}(candidate), so EC_{50}(candidate) = EC_{50}(reference) × 1,000 ÷ 2,600 ≈ 0.385 × EC_{50}(reference). The candidate half-activates the receptor at a little over a third of the reference dose. That is what *loud* means made exact: not more glutamate crammed in, but glutamate potent and available enough that a small amount drives the receptor hard. We hold that number to a batch-to-batch coefficient of variation at or below seven percent — which is the difference between a flavor you can cook *with* and one you can only hope for. A tomato that is savory in August and mute in February is not an ingredient; it is a gamble. The whole platform exists to turn the gamble into a specification.

How the voice was lost, and how we gave it back

The mechanism of the loss is almost tragic in its ordinariness. Glutamate in a tomato is produced and held through a small set of the plant's own enzymes — principally **glutamate decarboxylase (GAD)**, which in a living fruit converts glutamate to GABA and back as a pH and stress buffer, and **glutamate dehydrogenase (GDH1)**, which sits at the junction between carbon and nitrogen metabolism and governs how much free glutamate accumulates as the fruit ripens. Breeding for firmness, uniform ripening, and long shelf life repeatedly selected against exactly the metabolic states that let free glutamate pool. The truck did not steal the flavor in transit. The flavor was bred out before the seed ever went in the ground, as the unseen cost of a fruit that would not go soft.

Our restoration did not add a foreign gene to manufacture glutamate. We used a genome-scale metabolic model of the tomato — a flux-balance account of every reaction in the fruit — to find where the native pathway had been throttled, then tuned the plant's own **GAD/GDH1** balance so that free glutamate accumulates and holds through ripening and storage, at a batch-to-batch coefficient of variation at or below seven percent. Two thousand and forty constructs stand behind that single restored number. The result is not a tomato with umami bolted on. It is a tomato permitted, again, to be as savory as its biochemistry always could be.

> A plant grown back to its fullest flavor is a plant grown back toward its fullest nourishment. The same restored nitrogen metabolism that pools the glutamate pools the amino acids. Taste and goodness ride the same pathway home.

What it means when you eat it: a raw slice needs only salt. A sauce needs no stock. A soup tastes braised in twenty minutes. The savory floor of the entire vegetarian kitchen — the thing meat was always being asked into the pot to provide — is now something you can grow and keep on the counter.

Chapter 2 · The Tomato, Restored — *the vine as it was always meant to taste.*

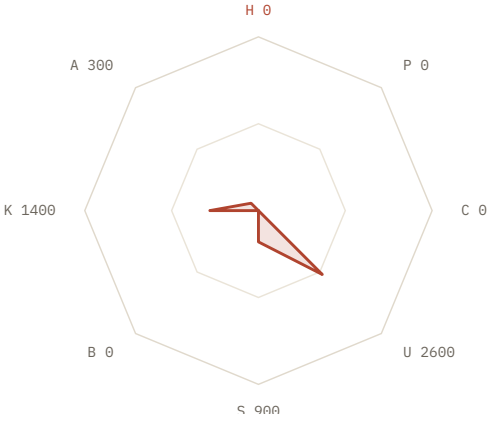
If the umami axis is the floor, the tomato is the room built on it. It is the single most important plant in a vegetarian kitchen and the one most completely betrayed by a century of breeding, which makes it the one where restoration feels the most like a homecoming. Two thousand and forty constructs stand behind our tomato work, tuned across the **S / U / F / M** axes — sweetness, umami, full-spectrum balance, and multi-axis composition — with umami as the hero.



Cross-section of the restored tomato — the gel and placental tissue where free glutamate pools; the part a shipping cultivar learned to keep empty.

Here is the tomato's full restored profile, the scorecard we measure every lot against before it earns the name:

IFI PROFILE



IFI-H	0
IFI-P	0
IFI-C	0
IFI-U	2,600
IFI-S	900
IFI-B	0
IFI-K	1,400
IFI-A	300

Read it like a sentence. The loud note is umami at 2,600 — the savory depth. Under it, sweetness at 900, the ripe-afternoon sugar that balances the acid. Kokumi at 1,400 is the quiet one that matters

most: a continuity and roundness, grown in through the fruit's own γ-glutamyl peptides, that makes the tomato taste *finished* rather than sharp. A faint astringency at 300 is the skin-and-seed bite we left on purpose, because a tomato with no grip at all tastes like juice. There is no heat and no bitterness, because this tomato was tuned to be the savory anchor of a plate, not the event.

What 2,040 constructs actually do

A number that large behind a single fruit deserves an accounting, because it is easy to read "2,040 constructs" as a boast rather than a method. It is a method. No single edit restores a tomato; flavor is a system property, emerging from dozens of pathways held in balance, and each construct is one tested hypothesis about one lever. The bulk of the work falls into four jobs. The first and largest is the **umami restoration** — tuning the GAD/GDH1 nitrogen balance so free glutamate pools and holds, the work of Chapter 1. The second is **sugar-acid balance**: a tomato that is all savor and no sweetness tastes like broth, so a parallel set of constructs lifts the fruit's Brix (its dissolved sugar) and holds its acidity in the range — a sugar-to-acid ratio near the ripe-vine ideal — that the tongue reads as *balanced* rather than flat or sour. The third is **kokumi**, raising the fruit's own γ-glutamyl peptides for the roundness that reads as finished. The fourth is **stability** — the constructs that do not change the peak flavor at all, but hold it steady through ripening, storage, and the cold chain, dragging the batch-to-batch CV down toward seven percent. The flavor is the headline; the stability is why it is an ingredient and not a lucky harvest.

Recipe · Shakshuka in Grown-In Tomato

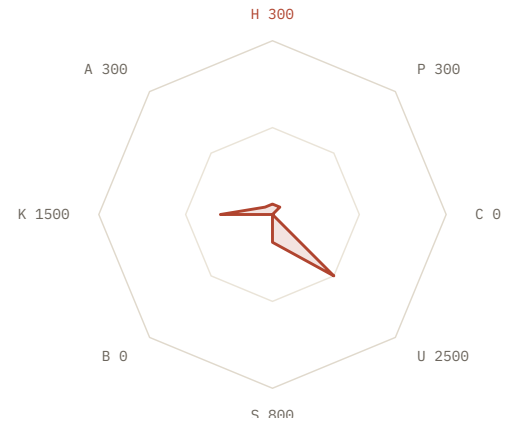
Serves 4 · 30 minutes · the one-pan dish that lives or dies on the tomato.

600 g	restored tomatoes, grated, or 1 large tin whole tomatoes, crushed
1	onion, diced · 1 red pepper, diced · 4 cloves garlic, sliced
2 tsp	cumin · 1 tsp smoked paprika · a pinch chili flake
4	eggs
4 tbsp	olive oil · flaky salt · a handful soft herbs · bread to serve

1. Soften the onion and pepper in the oil, then the garlic; bloom the cumin, paprika, and chili in the fat until fragrant.
2. Add the tomato and a long pinch of salt. Simmer twenty minutes until thick and jammy — the sauce should hold a spoon's trough.
3. Make four wells, crack in the eggs, cover, and cook gently until the whites set and the yolks stay loose, six minutes.
4. Herbs over the top; bread alongside to drag through the sauce.

Why it works — Shakshuka is tomato with nowhere to hide. A shipping tomato (IFI-U ~300) gives a thin, acidic sauce that the spices must rescue; the restored fruit (IFI-U 2,600) gives a sauce already deep and round, so the cumin and paprika decorate rather than resuscitate. The eggs add richness and a little more savor; the bread carries kokumi from the long-cooked alliums. A whole breakfast or supper from one honest fruit.

IFI PROFILE



IFI-H		300
IFI-P		300
IFI-C		0
IFI-U		2,500
IFI-S		800
IFI-B		0
IFI-K		1,500
IFI-A		300

Recipe · Tomatoes on Toast, the Way We Mean It

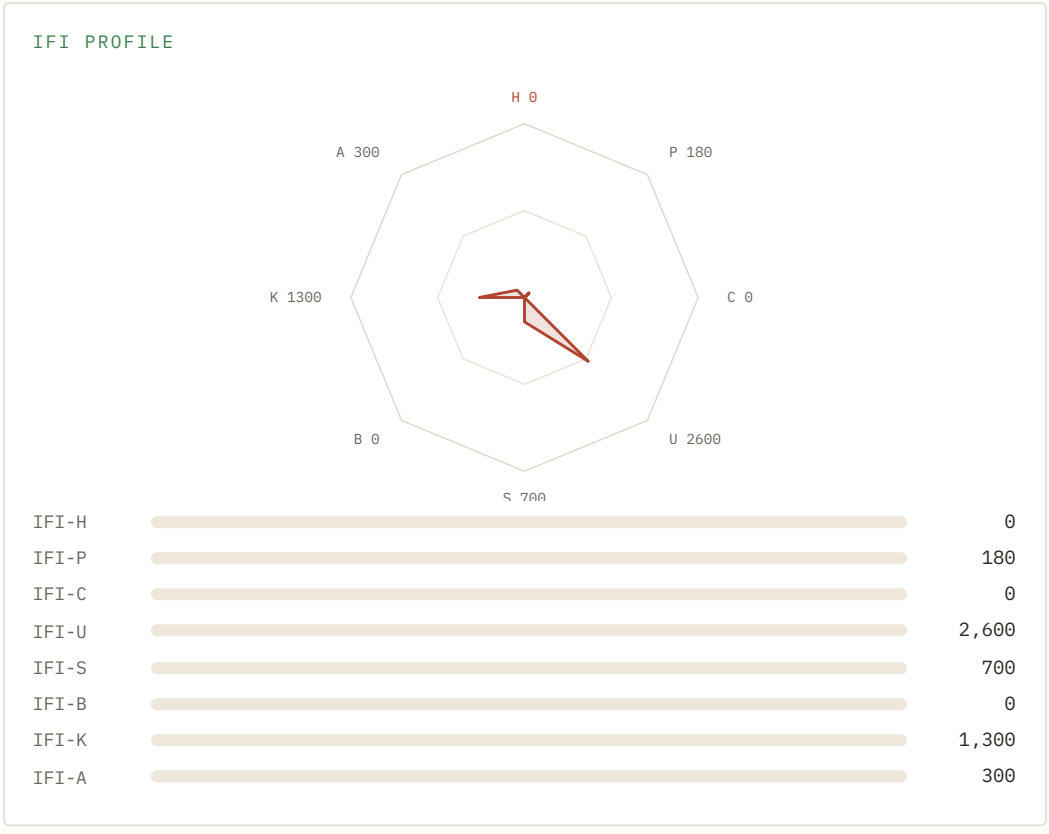
Serves 2 · 15 minutes · the dish we hand to anyone who assumes designed food must taste designed.

It is four ingredients, and the whole thing rests on the tomato. We eat this standing up at the counter in August, and again in February, grateful it still tastes like August. If you have ever been told a vegetarian plate is a plate missing something, this is the rebuttal, and it takes a quarter of an hour.

```
2            ripe restored tomatoes (or the best umami-restored tomato you
have)
2  thick     slices country bread
1  clove     garlic, halved
             good olive oil · flaky salt
```

1. Toast the bread hard — dark at the edges, almost too far. While it is still hot, rub the cut face of the garlic across the surface; the rough crust takes what it needs and leaves the rest. This is pungency used as a seasoning, not a subject.
2. Halve the tomatoes and grate the cut sides against the coarse holes of a box grater, down to the skin in your palm. You will have a loose, bright pulp that smells like a greenhouse at noon.
3. Spoon the tomato over the toast so it soaks just slightly in. Olive oil, generously. Flaky salt at the very end, so it stays loud on top.
4. Eat immediately, before the toast surrenders.

Why it works — The restored tomato carries IFI-U 2,600: roughly three times the free glutamate of a shipping tomato, pooled through the plant's own GAD/GDH1 route, not added. The salt does not *build* the savory depth here; it unmasks one that was grown in, because sodium ions lower the perceptual threshold at which the tongue registers glutamate. The garlic's single pass contributes a whisper of allicin on TRPA1 — present, never pungent. That is the entire thesis of this book on one piece of toast.



Recipe · Twenty-Minute Tomato Sugo That Tastes Braised

Serves 4 · 25 minutes · no stock, no sugar, no simmering it down for an afternoon.

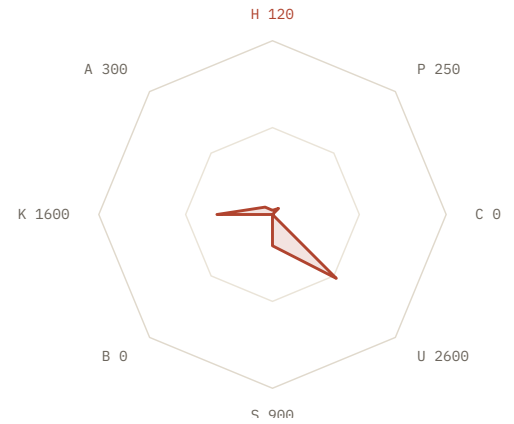
A long sugo is a technique invented to coax savor out of a tomato that did not have enough to give — hours of reduction to concentrate what little free glutamate the fruit held. Start with a tomato that already holds it, and the hours become minutes. This sauce tastes like it spent the afternoon on the stove. It spent twenty minutes.

800 g	restored tomatoes, grated, or 1 tin good whole tomatoes, crushed
4 cloves	garlic, sliced
1/2	onion, diced fine
5 tbsp	olive oil
	basil · flaky salt · a pinch of mild chili flake (optional)

1. Warm the oil gently and sweat the onion and garlic until soft and sweet, not coloured — eight minutes, patient. This is the kokumi base; rushing it is the only way to fail.
2. Add the tomato and a long pinch of salt. Raise the heat and let it bubble hard for twelve minutes, stirring, until it glosses and pulls away from the pan.
3. Off the heat, tear in basil and a last thread of raw oil. Taste. It will not need sugar, because the sweetness was grown in; it will not need stock, because the umami was.

Why it works — Reduction concentrates glutamate by driving off water, which is why ordinary sugo takes so long: you are chasing a target the fruit barely reaches. At IFI-U 2,600 the target is already met in the raw fruit, so twelve minutes of hard bubbling is about texture, not rescue. The slow alliums underneath add kokumi (CaSR) — the continuity that makes a quick sauce taste long.

IFI PROFILE



IFI-H		120
IFI-P		250
IFI-C		0
IFI-U		2,600
IFI-S		900
IFI-B		0
IFI-K		1,600
IFI-A		300

Recipe · Raw Tomato & Peach Salad, Basil, Salt

Serves 4 · 10 minutes · high summer, no cooking at all.

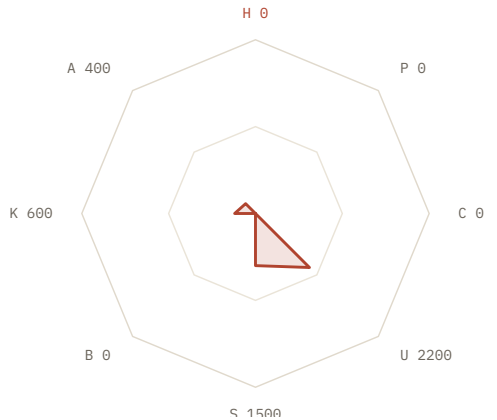
Umami and sweetness are not opponents; they are a chord. Here the restored tomato's savor meets a ripe peach's sugar, and basil's cooling top-note lifts both. Nothing is cooked. The only skill is choosing fruit at its peak and seasoning with nerve.

```
3           restored tomatoes, in thick wedges
2           ripe peaches, in wedges
            a handful basil, torn
            olive oil · flaky salt · a few drops of good vinegar
```

1. Lay tomato and peach together on a wide plate so their juices meet.
2. Salt from a height. Oil, vinegar sparingly, basil over the top.
3. Let it sit five minutes so the juices pool, then eat with bread to catch what is left.

Why it works — The tongue reads umami and sweet through receptors that share the TAS1R3 subunit; set side by side, each makes the other more legible. The salt does double duty — unmasking the tomato's glutamate and, by contrast, sharpening the peach's sugar. A ten-minute plate that eats like a composed course.

IFI PROFILE



IFI-H	0
IFI-P	0
IFI-C	0
IFI-U	2,200
IFI-S	1,500
IFI-B	0
IFI-K	600
IFI-A	400

Chapter 3 · Mushrooms & the Ribonucleotide Multiplier — *the stock that is one ingredient.*

If the tomato gives a vegetarian kitchen its glutamate, the mushroom gives it the multiplier. This is the most useful piece of savory chemistry a plant cook can own, and almost nobody is taught it: glutamate and the **5′-ribonucleotides** — inosine monophosphate (IMP) and guanosine monophosphate (GMP) — are not merely additive on the tongue. They are synergistic, and spectacularly so.



Shiitake — the dried cap is the single most concentrated vegetarian source of both glutamate and GMP, the two halves of the umami multiplier in one ingredient.

The multiplier, as an equation

The mechanism is structural and beautiful. Glutamate binds in the Venus flytrap domain of the TAS1R1/TAS1R3 receptor and begins to close it. The ribonucleotides bind at a separate site on the outer face of the same domain and act like a latch — they stabilise the closed, active conformation, so that any given amount of glutamate holds the receptor shut longer and harder. The receptor becomes dramatically more sensitive to glutamate in the ribonucleotides' presence. The classic Yamaguchi relationship captures it: perceived umami intensity scales not with the sum of the two compounds but with a term proportional to their *product*.

```
u = g + 1218 · g · r
```

where *g* is the glutamate fraction and *r* the ribonucleotide fraction of the total. The coefficient is large on purpose: a dish with glutamate alone and a dish with ribonucleotides alone can each taste mild, and the two combined can taste up to roughly **eight times** as savory as either part predicts. This is why a pinch of dried mushroom transforms a tomato sauce, and why dashi — kombu glutamate latched by bonito IMP — tastes like the sea distilled. The vegetarian version latches kombu's glutamate with shiitake's GMP, and needs nothing that swam.

PAIRING	GLUTAMATE SOURCE	RIBONUCLEOTIDE SOURCE	EFFECT
Classic dashi	kombu	bonito (IMP)	the benchmark — not vegetarian
Vegetarian dashi	kombu + restored tomato	dried shiitake (GMP)	matches the benchmark, from plants only
Quick weeknight	restored tomato	dried porcini / shiitake	sugo that tastes stocked
Koji-built	restored tomato	koji-cultured legume	fermented depth, no animal

Our engineered contributions here are precise. The restored tomato supplies stable, high free glutamate. Shiitake we have tuned along the **U** axis — 80 constructs, difficulty rated hard — to raise and stabilise its GMP yield, which in a wild mushroom swings wildly with drying and storage. **Koji mold** (80 constructs, U) and **baker's yeast** (240 constructs, U/K) round out the vegetarian ribonucleotide cupboard, each cultured to deliver the latch reliably. The point is never a single loud ingredient. It is the product term: two quiet things that multiply.

The latch, up close

It is worth sitting with the structural picture, because it explains every synergy in this book. The TAS1R1/TAS1R3 receptor's glutamate-binding lobe is a hinged clamshell — the Venus flytrap domain — that must close to signal. Glutamate lands inside and begins to pull the hinge shut, but the closure is reversible; at ordinary concentrations the clamshell flutters between open and closed, and the savory signal is modest. The 5′-ribonucleotides — IMP and GMP — bind not inside the pocket but at a cluster of positively-charged residues on the *outer* rim of the same lobe, near the hinge, where they act as a wedge that stabilises the closed state. With the wedge in place, each glutamate that enters holds the clamshell shut far longer. The receptor has not been given more glutamate; it has been made to hold what it has. This is why the effect is multiplicative rather than additive, and why the ribonucleotide alone — with no glutamate to hold — tastes of almost nothing: a latch on an empty door does nothing at all.

Koji, the enzyme kitchen

The third vegetarian route to deep savor is enzymatic, and it is ancient: **koji**, the mold *Aspergillus oryzae* that Japan has cultured for over a thousand years to make miso, tamari, sake, and shio koji. Koji's gift is a battery of **proteases** and **peptidases** — enzymes that cleave whole proteins into their constituent amino acids and short peptides, free glutamate chief among them. Spread koji on a legume or a grain and leave it warm, and it will, over hours to months, digest the bland storage proteins of the plant into a pooled, savory broth of free glutamate and kokumi-active peptides. It is, in effect, a cold braise run by a fungus — the same liberation of glutamate a long-simmered stock achieves, accomplished by enzymes at room temperature, from plants alone. Our koji strain (80 constructs, U) is tuned for protease yield and a clean glutamate profile, so shio koji rubbed on a mushroom or a cabbage steak lays down a layer of savor in fifteen minutes that no amount of searing could build on its own.

Concentration is a multiplier too

One more lever belongs to the cook, free of charge: water. Because umami scales with *concentration*, and because the ribonucleotide synergy scales with the *product* of two concentrations, driving off water concentrates savor faster than intuition suggests — halve the water and you more than double the perceived depth. This is the real reason a reduced sauce, a dried tomato, or a dried mushroom tastes so intense: drying is multiplication. A restored tomato that already starts high, slow-roasted until it has lost half its water, reaches a savory density that a fresh one cannot — the grown-in glutamate, concentrated by the oven, meeting the dried fruit's own rising ribonucleotides. Grown high, then concentrated, is the most savory a plant gets.

Recipe · Vegetarian Dashi, Two Ingredients, No Fish

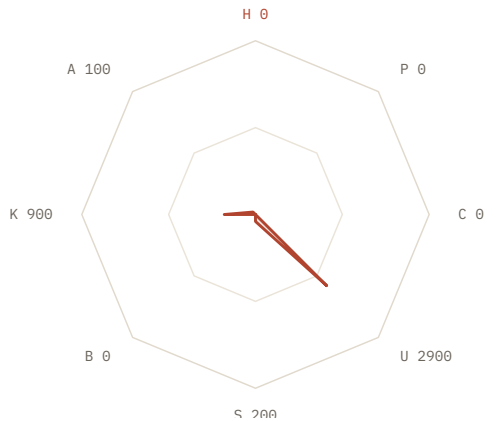
Makes 1 litre · 30 minutes, mostly waiting · the mother stock of this whole book.

```
1  litre     cold water
15 g         kombu (a palm-sized piece)
20 g         dried shiitake (about 6 caps)
```

1. Put the kombu and shiitake in the cold water and leave them one hour if you have it, or go straight to heat if you do not.
2. Warm slowly to just below a simmer — small bubbles at the edge, never a boil, which turns kombu bitter and cloudy. Hold there ten minutes.
3. Lift out the kombu. Let the shiitake steep another ten minutes off the heat, then strain. Keep the soft caps; they are dinner tomorrow.

Why it works — This is the multiplier in a pot. Kombu is almost pure glutamate; shiitake brings the GMP latch. Apart, each is a mild savory tea. Together, the product term u = g + 1218·g·r drives the perceived umami far past the sum, which is why a two-ingredient broth can carry a whole bowl of noodles. Hold it under a boil: above a simmer, kombu releases alginates and bitterness, lifting IFI-B where you want silence.

IFI PROFILE



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IFI-K		900
IFI-A		100

Recipe · Mushroom Ragù Over Soft Polenta

Serves 4 · 45 minutes · the Sunday dish that stands where a meat ragù used to.

This is the plate we cook for people who say they could never go without a slow-cooked meat sauce. It is not pretending to be that sauce. It is using the same chemistry — pooled glutamate, latched by ribonucleotides, bound by kokumi — to arrive at the same destination by the plant's own road.

```
500 g        mixed mushrooms (shiitake, cremini, king trumpet), torn
200 g        restored tomatoes, grated
1            onion, diced fine
4  cloves    garlic, sliced
200 ml       vegetarian dashi (above)
5  tbsp      olive oil · thyme · flaky salt · black pepper
for the polenta:
150 g        polenta · 700 ml water or dashi · olive oil · salt
```

1. Sear the mushrooms hard in batches in hot oil; crowd them and they steam, so give them room until they are deep brown and shrunken. This browning builds its own savory compounds on top of the grown-in ones.
2. Lower the heat, add onion and garlic, cook slow and sweet, eight minutes.
3. Return the mushrooms, add tomato, dashi, thyme, salt. Simmer twenty-five minutes until glossy and thick.
4. Meanwhile cook polenta in dashi or water, whisking, until soft and loose; finish with oil and salt. Spoon the ragù over, with no cheese unless you want it — the point is that you do not need it.

Why it works — Three savory mechanisms stack: the restored tomato's glutamate, the mushrooms' and dashi's GMP latch (the 1218·g·r product term), and the long-cooked alliums' γ-glutamyl peptides on CaSR for kokumi — the continuity a meat ragù gets from gelatin. The hard sear adds browning-reaction savor on top. No stock cube, no rind, no bone.

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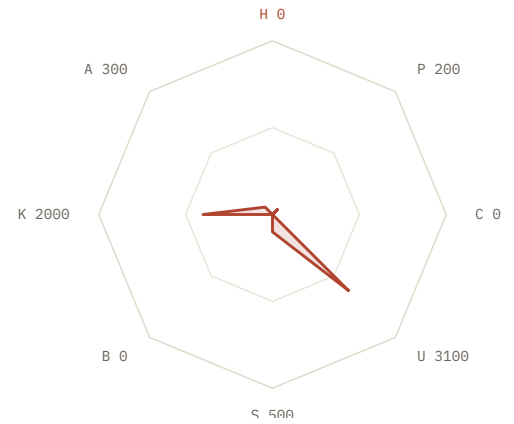

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IFI-A		300

Recipe · Roasted King Trumpets, Koji Butter

Serves 4 · 30 minutes · the mushroom treated like a steak, honestly, not as a costume.

4	large	king trumpet mushrooms, halved lengthwise, scored
2	tbsp	white koji paste (shio koji)
50	g	butter (or good olive oil for a vegan version)
		thyme · flaky salt

1. Score the cut faces in a crosshatch and rub lightly with shio koji. Rest fifteen minutes; the koji's enzymes begin liberating free glutamate and amino acids at the surface.
2. Sear cut-side down in a hot pan until deeply caramelised, then add butter and thyme and baste as it foams.
3. Salt, rest two minutes, slice thick.

Why it works — Koji (*Aspergillus oryzae*, here on our U-tuned strain) carries proteases and peptidases that pre-digest surface protein into free glutamate and savory peptides — an enzymatic head start on the browning reaction. The mushroom's own GMP latches that glutamate. We are not dressing a mushroom as meat; we are using an animal-free enzymatic route to the same savory, mouth-filling result.

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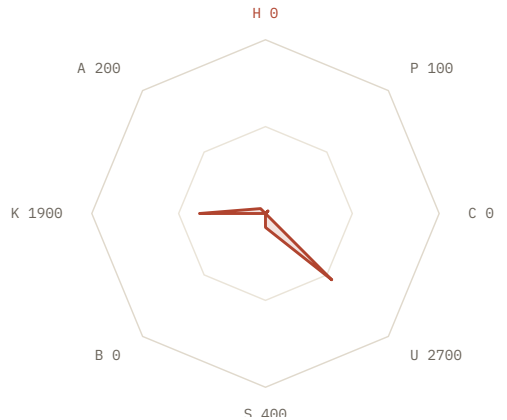

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IFI-K	1,900
IFI-A	200

Chapter 4 · Kokumi, the Invisible Axis — *body without a bone.*

There is a taste you have never named and never cooked toward on purpose, and it may be the most important one in this book. We call it kokumi, from the Japanese for *rich taste*, and it is the quality that makes a slow-cooked thing taste slow-cooked: a continuity, a mouth-filling body, a sense that the flavor arrives, lasts, and finishes rather than flashing and vanishing. For a vegetarian kitchen it is the holy grail, because it is exactly what a long bone broth or a knob of good butter has always been smuggled in to provide.



Garlic in cross-section — the γ-glutamyl peptides that drive kokumi concentrate here; our K/P work raises them without raising the raw bite.

The receptor nobody mentions

Kokumi has a receptor, and it is not a taste receptor in the usual sense. It is the **calcium-sensing receptor (CaSR)**, a protein your body uses throughout to monitor calcium, and which on the tongue responds to a family of small peptides called **γ-glutamyl peptides** — glutathione (γ-Glu-Cys-Gly), and most potently **γ-Glu-Val-Gly**. Here is the strange and wonderful part: these peptides are, on their own, nearly tasteless. You cannot point to kokumi the way you can point to sweet. What they do instead is *modulate* — binding CaSR and amplifying and lengthening the perception of sweet, salty, and umami that are already present, adding the continuity and mouth-coating body we read as richness.

Their potency is the headline. γ-Glu-Val-Gly registers at sub-micromolar EC_{50} — among the most potent flavor-active compounds known, so that vanishingly small quantities transform a dish. On the Index this translates to high IFI-K at concentrations you would never detect by any single taste. It is the definition of an invisible axis: you do not notice it is there; you notice, acutely, when it is gone.

The receptor the tongue borrowed

The strangest fact about kokumi is that its receptor was never meant to taste anything. **CaSR** — the calcium-sensing receptor — evolved as a sentinel of blood calcium, sitting on the parathyroid gland and the kidney to keep the body's mineral balance within its narrow safe band. That it also appears on the tongue, and that γ-glutamyl

peptides activate it there, was discovered only when researchers chasing the "rich taste" of aged cheeses, long-cooked stocks, and matured ferments traced the sensation past the known taste receptors to this unlikely modulator. The implication is quietly profound: kokumi is not a sixth basic taste competing with the others. It is a *gain control* — a dial that turns up the volume on sweet, salty, and umami signals already arriving, and lengthens their stay. This is why a kokumi-rich dish does not taste of any new thing; it tastes *more*, and *longer*, and *rounder* — the difference between a chord played once and the same chord allowed to ring.

Why a vegetarian kitchen feels it most

Every kitchen uses kokumi; the meat kitchen simply gets it for free. Dissolved collagen from a long-braised joint, the matured proteins of a hard cheese, the slow breakdown of fish in a fermented sauce — these are all γ-glutamyl peptide factories, and a cook leaning on them builds continuity without naming it. A vegetarian kitchen that does not grow or culture its kokumi deliberately is the one that tastes, to the unkind critic, "like something is missing" — and the missing thing is precisely this: not a flavor, but the body and continuity that let a flavor last. Grow it into the garlic and onion, culture it into the yeast, and the gap closes completely. The peptides do not know or care that no animal was involved. CaSR reads γ-Glu-Val-Gly the same whether it came from a bone or a bulb.

A note on measuring the invisible

Because kokumi peptides are nearly tasteless alone, they cannot be scored by a tasting panel sampling them in water — there is nothing to rate. We anchor IFI-K instead to their measured EC_{50} at CaSR and to their *potentiation* of a reference umami-salt solution: how much a fixed dose of the peptide raises the perceived intensity and duration of that reference. A kokumi score, then, is a measurement of amplification, not of a taste — the honest way to put a number on a thing the tongue cannot point to.

Γ-GLUTAMYL PEPTIDE	FOUND IN	RELATIVE KOKUMI POTENCY
Glutathione (γ-Glu-Cys-Gly)	yeast, garlic, onion	baseline
γ-Glu-Val-Gly	engineered yeast, fermented legume	~12× glutathione
γ-Glu-Cys	alliums, Brassica	moderate
γ-Glu-Val	matured cheese, ferments	moderate

Our kokumi work lives mostly in three organisms. **Garlic** (560 constructs, K/P) and **onion** (40 constructs, K) we tuned to raise γ-glutamyl peptide content while holding the raw pungency in check, so you can build body without building bite. **Baker's yeast** (240 constructs, U/K) we engineered as a dedicated kokumi and umami factory — a spoonful of our nutritional yeast delivers the continuity a vegetarian stew has always had to fake. **Vanilla** (40 constructs, K) carries kokumi into the sweet kitchen, where it rounds a custard the way long cooking rounds a sauce.

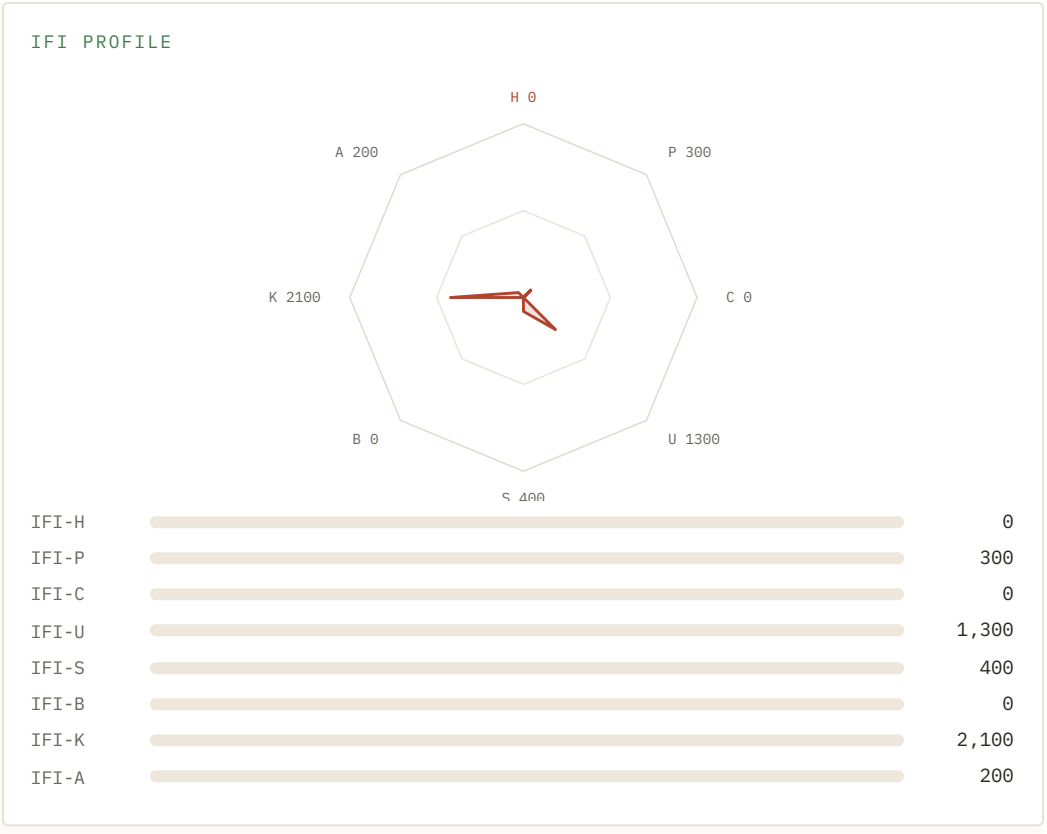
Recipe · White Beans, Many Alliums, Good Oil

Serves 4 · 35 minutes · no stock, no meat, no apology — the dish that taught us kokumi has a name.

2	tins	white beans (cannellini or butter), with their liquid
6	cloves	garlic, sliced
1	large	onion, sliced thin
4	tbsp	olive oil
1	sprig	rosemary
		flaky salt · lemon

1. Cook the onion and garlic slowly in the oil until sweet and gold — fifteen minutes, no browning, no rush. This is the whole dish; everything after is assembly.
2. Add the beans and all their starchy liquid, the rosemary, and a long pinch of salt. Simmer gently until the liquid turns silky and thick, fifteen minutes.
3. Crush a handful of beans against the side of the pan to release their starch and body. Finish with raw oil and a squeeze of lemon to cut the richness.

Why it works — The silkiness is not fat and it is not a bone; it is kokumi. Slow-cooked alliums release γ-glutamyl peptides that bind CaSR and lengthen the perception of the beans' own gentle umami and the salt, giving the dish the continuous, mouth-filling body a long meat braise gets from dissolved collagen. The bean starch adds literal viscosity; the peptides add perceived richness. Two routes to the same full bowl.



Recipe · Caramelised Onion & Yeast Toast

Serves 2 · 40 minutes, mostly unattended · the snack that proves the axis.

2	large	onions, sliced thin
3	tbsp	olive oil or butter
2	tbsp	engineered nutritional yeast
2	thick	slices sourdough, toasted
		flaky salt · black pepper · thyme

1. Cook the onions in the fat over low heat, stirring now and then, for thirty to forty minutes, until collapsed, jammy, and mahogany. Do not hurry this; the sweetness and the peptides both come from patience.
2. Stir in the nutritional yeast off the heat so it dissolves into the jam.
3. Pile onto hot toast, salt, pepper, a few thyme leaves.

Why it works — Caramelised onions are a kokumi and umami concentrate: long heat liberates both glutamate and γ-glutamyl peptides while the sugars brown. Our engineered yeast adds a second, concentrated dose of both — glutathione-family peptides on CaSR for body, nucleotides and glutamate for savor. The result tastes profoundly of *more*, from two ingredients that cost almost nothing and never saw an animal.

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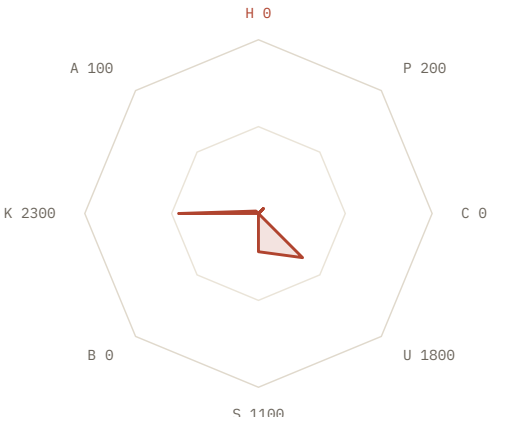

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IFI-P	200
IFI-C	0
IFI-U	1,800
IFI-S	1,100
IFI-B	0
IFI-K	2,300
IFI-A	100

Recipe · Onion Soup, No Bone

Serves 4 · 1 hour · the classic, rebuilt from the receptor up.

6	large	onions, sliced thin
4	tbsp	butter or olive oil
1	litre	vegetarian dashi (Chapter 3)
2	tbsp	engineered nutritional yeast
		thyme · bay · flaky salt · a splash of dry sherry
		bread · grated cheese (optional)

1. Caramelise the onions in the fat, slow and low, for forty-five minutes, until deep brown and sweet — the single step the whole soup depends on.
2. Deglaze with sherry, scraping up the fond. Add dashi, yeast, thyme, bay, salt. Simmer twenty minutes.
3. Ladle over toasted bread; grill with cheese if you keep it, or leave it bare — it holds without.

Why it works — Traditional onion soup leans on beef stock for its savory continuity. We rebuild that continuity from its parts: the dashi supplies the glutamate-GMP multiplier, the caramelised onions and engineered yeast supply the γ-glutamyl kokumi peptides that bind CaSR and give the broth its long, round, coating finish. The bone was never doing anything the receptor could not be reached without.

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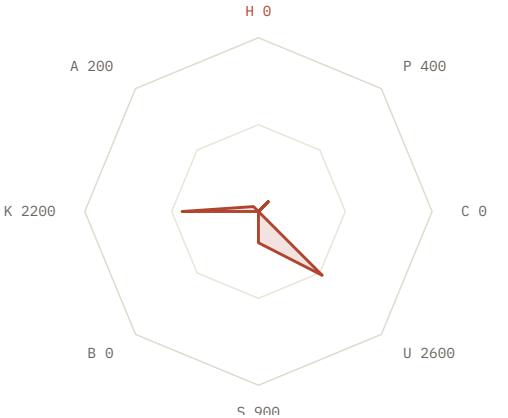

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IFI-U	2,600
IFI-S	900
IFI-B	0
IFI-K	2,200
IFI-A	200



PART II OF V

Turning Down the Warning

Bitterness, sweetness, and making a vegetable wanted · TAS2R38 · TAS1R2·R3

Chapter 5 · The Bitter Axis — *the warning, turned to a hum.*

The vegetables children are told to finish are, very often, the ones evolution built to taste like a warning. Bitterness is the body's oldest alarm — a broad, suspicious sense tuned to flag the alkaloids and glucosinolates that a plant makes to keep from being eaten. A tongue that recoils from bitter is a tongue doing its job. The trouble is that the same chemistry a plant uses to defend itself overlaps with the chemistry we now know to be nourishing, and so the alarm fires on foods we would, on reflection, very much like to eat. The Zero-Bitter axis is how we turn the alarm down to a hum without turning off what it was guarding.



Broccoli in cross-section — the glucosinolates that drive its bitter warning concentrate in the stalk and floret skin; our B-axis work tunes the perception, not the protective chemistry.

One receptor, and the genetics of who tastes it

Most of the bitterness that matters in the vegetable kitchen runs through a single, famous receptor: **TAS2R38**. It is the one you may have met in a biology class, where strips of paper treated with **PTC** (phenylthiocarbamide) or **PROP** (propylthiouracil) taste of nothing to some people and of searing bitterness to others. The difference is genetic: a common haplotype called **PAV** builds a sensitive, taster receptor; the **AVI** haplotype builds one that barely responds. The compounds TAS2R38 detects share a chemical signature — the **thiourea** group, N–C=S — and that signature appears, not by accident, in the breakdown products of the **glucosinolates** that defend broccoli, kale, cabbage, and their whole Brassica family.

This is why a vegetable can be loved and loathed at the same table in good faith: the two diners are running different receptors. Designing against bitterness, then, is not a matter of taste or willpower. It is molecular, and it is the most quietly transformative thing we do for the people who were simply built to taste the warning loudest.

Attenuation, not removal — and why that line matters

Our bitterness work attenuates perceived bitterness by **20 to 65 percent**, measured against the wild-type parent, and the span of that range is deliberate. We do not aim for zero, and we could not

responsibly want to. Here is the care, stated plainly: the glucosinolates that break down into bitter, TAS2R38-active isothiocyanates are the *same* molecules that yield **sulforaphane** and the other compounds that make a Brassica worth eating in the first place. Strip the chemistry to kill the bitterness and you strip the nourishment with it. So we do not strip it.

Instead, we shift the glucosinolate *profile* and tune the enzymatic context — principally the balance at **myrosinase**, the enzyme that cleaves glucosinolates when a plant cell is crushed — so that the plant produces fewer of the specific breakdown products the receptor reads as *warning* while preserving the precursors the body reads as *good*. The alarm quiets; the guard stays at its post. This is an attribute, measured and modest, not a claim: we say the broccoli is less bitter, and we mean exactly and only that.

BRASSICA	CONSTRUCTS	IFI-B (ATTENUATION)	NOTE
Broccoli	380	up to 2,400	the flagship; florets read sweet after a char
Broccoli-Kale	280	up to 2,200	the hybrid, bred for leaf and stalk alike
Kale	40	up to 1,900	the back-of-throat bite, lifted
Cabbage	40	up to 1,800	sweetens dramatically when roasted
Radish	40	up to 1,600	keeps a clean pungency, loses the acrid edge

A note on the Index direction: IFI-B scores *attenuation* — a higher number means a quieter warning, the one axis where more means less. It is the mirror of heat, and the two together are the whole range of the tongue's alarms, one we raise on purpose and one we lower.

The chemistry of the warning

To tune a signal you must know exactly what it is made of, so here is the Brassica alarm, molecule by molecule. The defense compounds are **glucosinolates** — sulfur-and-nitrogen-rich molecules the plant stores intact and harmless in its cells. The flagship in broccoli is **glucoraphanin**. On its own it tastes of almost nothing. The warning is manufactured only on damage: when you chew, cut, or crush the tissue, the stored glucosinolate meets a physically separate enzyme, **myrosinase**, and the two react within seconds to release an **isothiocyanate** — in broccoli's case, **sulforaphane**, carrying the thiourea-like N–C=S signature that TAS2R38 reads as bitter alarm. The same split-second reaction, with a different glucosinolate, gives mustard its AITC and horseradish its sting; it is the Brassica family's shared chemical trigger, and it is the reason raw, chopped, or lightly cooked Brassica tastes sharpest while a long-roasted head tastes sweet — heat denatures myrosinase before much isothiocyanate can form.

Now the care, in full. Sulforaphane is also, famously, the compound that has made broccoli a byword for a vegetable worth eating. The bitter warning and the prized phytochemistry are, at the molecular level, *the same reaction*. This is why we refuse the brute-force route

of simply knocking out the pathway: a broccoli with no glucosinolates would be sweeter and emptier, a vegetable that had surrendered the very thing that justified it. Instead our 380 constructs shift the glucosinolate *profile* — the ratio among the dozen or so glucosinolates a plant makes — and tune the enzymatic context (the balance at myrosinase and at the epithiospecifier protein that steers the reaction's products) so the plant yields proportionally fewer of the specific, loudest-to-TAS2R38 breakdown products while preserving the glucoraphanin-to-sulforaphane route. The alarm quiets by twenty to sixty-five percent; the guard stays at its post.

Who tastes it, and why a range

The twenty-to-sixty-five-percent span is not imprecision. It is us designing for a tongue that varies. TAS2R38 is only one of roughly twenty-five bitter receptors in the human genome, but it is the one that governs the Brassica experience, and its two common haplotypes — the sensitive **PAV** taster and the near-silent **AVI** non-taster — are distributed differently across any real table. A PAV taster, chewing wild-type kale, meets a wall; the AVI diner beside them barely registers it. Attenuating by sixty-five percent brings the vegetable within reach of the most sensitive taster at the table; attenuating by twenty keeps a pleasant adult bitterness for the diner who has learned to love it. We tune to the dish and the eater, not to a single flat target, because the point was never to abolish bitterness. It was to make sure no one at the table is served a warning they cannot hear past.

> We are not making vegetables that lie about what they are. We are making vegetables honest enough to be wanted — where the first thing you taste is the sweetness underneath, not the alarm on top.

Chapter 6 · Greens & Brassicas — *the thing eaten because it is wanted.*

With the warning turned down, a different vegetable walks into the kitchen. Char it, and the char reads as sweetness rather than acridity, because the bitter signal that used to fight the browning has been lowered at the source. The sugars step forward into the space the bitterness used to hold. These are the recipes for the vegetables most people learned to tolerate, cooked so they can be loved.



Kale, tuned — the back-of-throat bitterness lifted so the leaf reads green and sweet, not punishing.

Recipe · Charred Broccoli, Lemon, a Little Heat

Serves 4 · 20 minutes · the dish that converts the broccoli-skeptic.

1	large	head low-bitter broccoli, in long spears through the stalk
2	tbsp	olive oil
1		lemon
		flaky salt · a pinch of mild chili flake

1. Heat a dry, heavy pan until it just begins to smoke. Toss the broccoli in the oil, lay it flat in one layer, and leave it alone until it blackens at the edges — do not stir, do not fuss.
2. Turn once, char the second side, then pull it while the stalks still have snap.
3. Salt, a hard squeeze of lemon, the chili.

Why it works — In an ordinary head, a hard char deepens the acrid, sulfurous bitterness as the glucosinolate breakdown products concentrate — which is why so many people believe they hate broccoli. At IFI-B up to 2,400, that warning is attenuated by well over half, so the Maillard sweetness of the char arrives unopposed. The lemon's acid brightens; the chili's trace of capsaicin on TRPV1 wakes the whole thing up. Same vegetable, different receptor experience.

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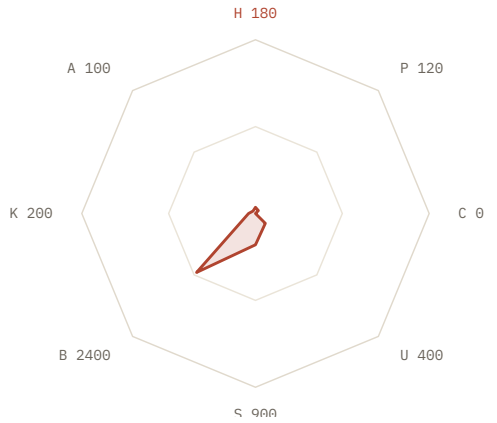

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IFI-U		400
IFI-S		900
IFI-B		2,400
IFI-K		200
IFI-A		100

Recipe · Massaged Kale, Pomegranate, Toasted Seeds

Serves 4 · 15 minutes · raw kale that is a pleasure, not a penance.

1	bunch	low-bitter kale, stalks stripped, leaves torn
1/2		lemon · 2 tbsp olive oil · flaky salt
		seeds of 1/2 pomegranate
2	tbsp	toasted pumpkin seeds

1. Put the kale in a wide bowl with the lemon, oil, and salt. Massage with your hands for two full minutes, until the leaves darken, soften, and halve in volume.
2. Fold through the pomegranate seeds and toasted seeds.

Why it works — Raw kale is where the TAS2R38 warning is loudest, with nothing cooked off. Our kale (IFI-B up to 1,900) lets the massage — which bruises the leaf and softens its texture — proceed without unlocking a wall of bitterness. The pomegranate adds a bright, astringent snap (salivary PRPs, the subject of Chapter 12); the seeds add kokumi and crunch. A salad people ask for again.

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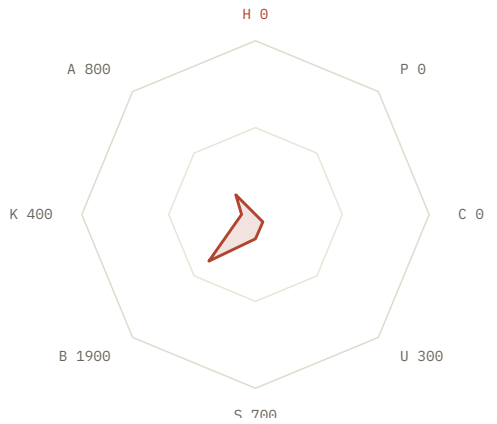

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IFI-C	0
IFI-U	300
IFI-S	700
IFI-B	1,900
IFI-K	400
IFI-A	800

Recipe · Cabbage Steaks, Koji, Charred Edges

Serves 4 · 40 minutes · the cheapest vegetable in the shop, treated like the best.

1		head low-bitter cabbage, in thick wedges through the core
2	tbsp	shio koji
3	tbsp	olive oil
		flaky salt · black pepper · lemon

1. Brush the cut faces of the wedges with shio koji and a little oil; rest fifteen minutes.
2. Sear in a hot ovenproof pan until the cut faces are deeply charred, then transfer to a 220°C oven for twenty minutes, until the core is tender.
3. Salt, pepper, a squeeze of lemon.

Why it works — Cabbage carries the same Brassica glucosinolates; tuned down (IFI-B up to 1,800), it caramelises into something astonishingly sweet. The koji's proteases add a layer of free glutamate at the surface — umami meeting the attenuated bitter — so a vegetable that cost almost nothing eats with the depth of a main course.

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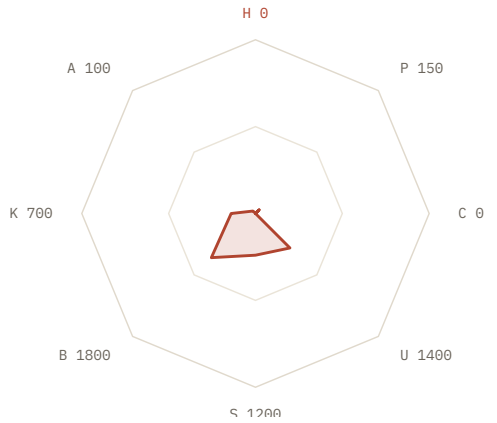

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IFI-C	0
IFI-U	1,400
IFI-S	1,200
IFI-B	1,800
IFI-K	700
IFI-A	100

Recipe · Blistered Brussels Sprouts, Maple & Chili

Serves 4 · 25 minutes · the vegetable that taught a generation to hate it, grown to be loved.

500 g	low-bitter Brussels sprouts, halved
3 tbsp	olive oil
1 tbsp	maple syrup (or warmed agave)
	chili flake · flaky salt · lemon · toasted walnuts

1. Toss the halved sprouts in oil and salt, lay them cut-side down on a hot tray, and roast at 220°C until deeply browned and crisp at the edges, twenty minutes, undisturbed.
2. Toss the hot sprouts with a little maple, chili flake, a squeeze of lemon, and the walnuts.

Why it works — No vegetable is more slandered than the sprout, and the slander is pure TAS2R38: boiled, a wild-type sprout floods the taster with its glucosinolate warning. Our low-bitter sprout (IFI-B in the Brassica range) lets a hard roast drive Maillard sweetness with no acrid wall to fight, so the caramelised cut face reads candy-sweet. The maple leans into it, the chili and lemon cut it, the walnuts add kokumi and crunch. Served to a sprout-hater, this is a small act of persuasion.

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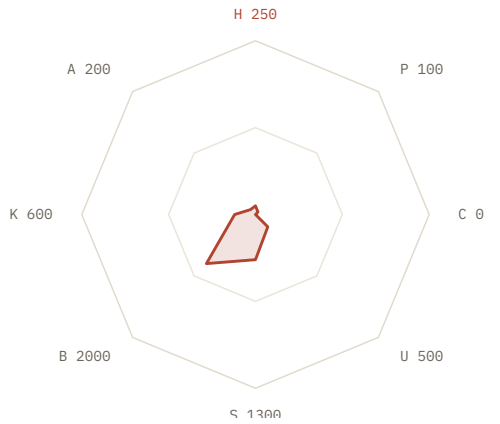

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IFI-P	100
IFI-C	0
IFI-U	500
IFI-S	1,300
IFI-B	2,000
IFI-K	600
IFI-A	200

Recipe · Crunchy Cabbage & Kale Slaw, Sesame

Serves 6 · 15 minutes · raw Brassica as a bright, crisp pleasure.

```
1/2          head low-bitter cabbage, shredded fine
1  bunch     low-bitter kale, stalks stripped, sliced thin
2            carrots, grated
for the dressing:
3  tbsp      rice vinegar · 2 tbsp tamari · 1 tbsp sesame oil
1  tbsp      grated ginger · 1 tsp maple or Reb-M syrup
             toasted sesame seeds · scallions
```

1. Toss the shredded cabbage, kale, and carrot in a big bowl.
2. Whisk the dressing and pour over; massage briefly so the kale softens and everything slicks.
3. Rest ten minutes; finish with sesame and scallions.

Why it works — Raw, finely shredded Brassica is the hardest test of bitterness attenuation — nothing is cooked off, and the cut surfaces keep generating isothiocyanate. Tuned down across both cabbage and kale, the slaw stays crisp and sweet where a wild-type version would turn sharp and sulfurous within the hour. The ginger adds TRPA1 lift; the tamari a savory floor; the vinegar a brightness that keeps it awake. A slaw you make a bowl of and finish without noticing.

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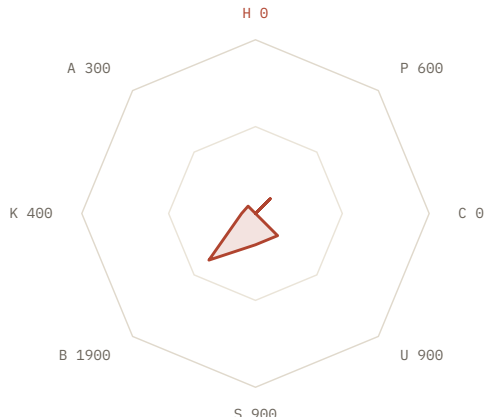

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IFI-S	900
IFI-B	1,900
IFI-K	400
IFI-A	300

Chapter 7 · Sweetness Without Sugar — *the axis that carries this book's green accent.*

Sweetness is the taste we trust first and most completely — the infant's first preference, the signal of safe calories, the easiest pleasure on the tongue. It is also the one modern eating most needs a gentler route through, which is why the sweet axis carries this book's accent color and a particular care. We do not add sugar to make a plant sweet. We make the plant speak more loudly to the sweet receptor, which is a different thing entirely, and a quietly revolutionary one.



Stevia — the leaf whose steviol glycosides reach TAS1R2/TAS1R3 at a potency hundreds of times that of sucrose; 910 constructs tune which glycosides it makes.

One receptor, many keys

Sweetness runs through a single receptor, the heterodimer **TAS1R2/TAS1R3**, and the remarkable fact about it is how many differently-shaped molecules can turn it. Sucrose is the familiar key, but it is a weak one — it takes a lot of sugar to fill the receptor's large binding pocket. Nature and our platform offer far more potent keys, molecules that bind the same receptor (often at additional sites beyond the sugar pocket) and hold it open at a fraction of the dose:

SWEETENER	SOURCE ORGANISM	POTENCY VS SUCROSE	RECEPTOR NOTE
Sucrose	sugarcane (reference)	1×	fills the orthosteric pocket weakly
Steviol glycosides (Reb M)	stevia · 910 constructs	~200–300×	binds transmembrane + VFT sites
Mogroside V	monk fruit · 80 constructs	~250×	triterpene glycoside; clean finish
Brazzein	engineered sugarcane · 200	~500–2,000×	sweet *protein*; heat-stable

The potency column is the whole opportunity. On the Index, a compound's IFI-S is anchored to its EC_{50} at TAS1R2/TAS1R3: a steviol glycoside with an EC_{50} a few hundred times lower than sucrose's reaches a high sweet loudness at a dose small enough to carry

almost no calories. The old problem with these potent sweeteners was never potency; it was *shape of the sweetness* — a lingering edge, a slow onset, a whisper of bitterness as a second receptor (yes, TAS2R, from Chapter 5) caught the molecule on its way past.

Designing the shape, not just the strength

This is where 910 constructs behind stevia earn their keep. A stevia leaf makes a mixture of steviol glycosides — stevioside, rebaudioside A, D, M, and others — and the *ratio* among them sets the quality of the sweetness. Rebaudioside M and D are clean, sugar-like, fast, and free of the licorice-bitter edge; stevioside and Reb A carry more of it. We tuned the plant's glycosyltransferase pathway to shift production toward the Reb D/M end, so the leaf itself makes a sweetness shaped like sugar rather than a sweetness that needs apologising for. Monk fruit (mogroside V) and brazzein-expressing sugarcane extend the palette — the first for a clean triterpene sweetness, the second for a sweet *protein* that survives baking heat where small-molecule sweeteners falter.

> We are not in the business of making food that is sweet and empty. We are in the business of letting a plant reach the sweet receptor on its own terms, so a dessert can taste generous without asking the body for as much in return. An attribute, measured — never a claim.

The shape of a sweetness in time

Potency is only half of what the tongue judges. The other half is *temporal profile* — the onset, peak, and decay of the sweet signal across a few seconds. Sucrose has a clean profile: it arrives fast, peaks, and leaves. The old failing of high-potency sweeteners was a mismatched shape — a slow onset (the sugar that seems to arrive late), a lingering tail (the sweetness that overstays), or a bitter-metallic cross-signal as the large molecule brushed a TAS2R receptor on its way past. Because these compounds bind TAS1R2/TAS1R3 at additional sites beyond the small sucrose pocket — steviol glycosides engage both the transmembrane domain and the Venus flytrap — they hold the receptor differently, and that difference is felt as a shape. Our stevia work targets the shape as directly as the strength: shifting production toward rebaudioside M and D narrows the onset and clips the tail, so the sweetness rises and falls on sucrose's schedule rather than lingering like a memory of licorice.

The reformulation arithmetic

For anyone building a dish or a product, the practical math is a substitution ratio. A sweetener at roughly 250× sucrose means that, by sweetening power, one gram does the work of about 250 grams of sugar — so a recipe calling for 100 grams of sugar needs on the order of 0.4 grams of a Reb-M-grade extract to reach the same loudness on the sweet axis. The calories fall almost to nothing; the volume and body that sugar also provided do not, which is why a straight swap fails in a cake and succeeds in a glaze, a drink, or a fruit macerate. The honest rule: use the potent sweeteners where

sugar was doing sweetening, and keep a little real carbohydrate where sugar was doing *structure* — the browning of a crust, the chew of a cookie, the syrup that clings. We score the sweetness, not the gram. The gram is a cook's problem, and this is a cookbook.

Recipe · Macerated Berries, Reb M, Lemon, Mint

Serves 4 · 10 minutes plus 20 to sit · sweetness with almost no sugar, no cooking.

400 g	mixed berries (strawberries halved, the rest whole)
1/4 tsp	Reb-M stevia extract (or to taste)
1/2	lemon, juiced · a strip of zest
	a few torn mint leaves · a pinch of salt

1. Toss the berries with the Reb M, lemon juice and zest, and a bare pinch of salt.
2. Leave twenty minutes; the fruit will release a bright, light syrup — sweet, but without the heavy sugar load of a classic macerate.
3. Mint at the end; spoon over yogurt, or eat as is.

Why it works — Maceration usually relies on sugar both to sweeten and to draw out juice by osmosis. Here the lemon's acid and the salt draw the juice, while a pinch of Reb M supplies the sweetness at TAS1R2/TAS1R3 — clean, because it is the M glycoside with its clipped tail, not stevioside. A dessert that tastes generous and sits light.

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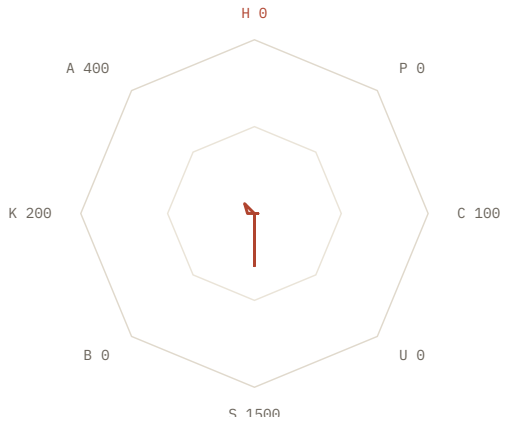

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IFI-C		100
IFI-U		0
IFI-S		1,500
IFI-B		0
IFI-K		200
IFI-A		400

Recipe · Glazed Carrots, Stevia, Thyme

Serves 4 · 25 minutes · a sweet, glossy side with almost no added sugar.

500 g	carrots, in thick diagonal coins
2 tbsp	butter or olive oil
1/4 tsp	Reb-M stevia extract (or to taste)
	thyme · flaky salt · a squeeze of lemon

1. Cook the carrots in a wide pan with the fat and a splash of water, covered, until nearly tender, eight minutes.
2. Uncover, raise the heat, add the stevia and thyme, and let the carrots glaze and catch, two minutes.
3. Salt, lemon, serve glossy.

Why it works — A classic glaze uses sugar both to sweeten and to make the glossy, clinging syrup. Here the carrot's own sugars, concentrated by the browning, do most of the sweetening; a pinch of high-purity Reb M lifts it over the top at TAS1R2/TAS1R3 without the calorie load of a spoonful of sugar, and because it is Reb M rather than stevioside, there is no licorice tail. The thyme keeps it savory enough for the center of a plate.

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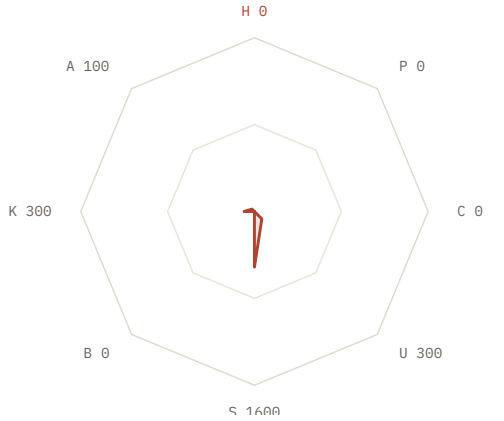

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IFI-B	0
IFI-K	300
IFI-A	100



PART III OF V

Heat, With a Shape

Warmth at a vegetarian table · TRPV1 · TRPA1 · TRPM8

Chapter 8 · The Heat Axis — *warmth with a shape, laddered for the table.*

Heat is the axis everyone knows, and the one a vegetarian table can use with the most freedom, because it belongs to no diet. Capsaicin does not care what else is on the plate. It binds **TRPV1**, a non-selective cation channel on the trigeminal nerve endings of the tongue — the same receptor gated by temperatures above 43°C and by acidity. The molecule does not warm the tissue. It lowers the channel's thermal threshold, so the body reports a fire that is not there. That is the deep strangeness of chili heat: it is a true sensation of a false event, and once you know it, you can design it.



The controlled chamber — where we grow heat to a specification, so warmth arrives with a shape and a schedule rather than as an assault.

The molecule, and the three mutations

Capsaicin is built where the plant's universal **phenylpropanoid branch** — PAL → C4H → 4CL → HCT → COMT, present in every vascular plant — meets a short run of pepper-specific terminal enzymes. Vanillylamine condenses with an 8-methyl branched-chain fatty acid at the **Pun1/AT3** acyltransferase to form capsaicin; the length and saturation of that acyl chain set the balance between capsaicin and dihydrocapsaicin, and with it the *shape* of the burn — where it lands, how fast it rises, how long it stays.

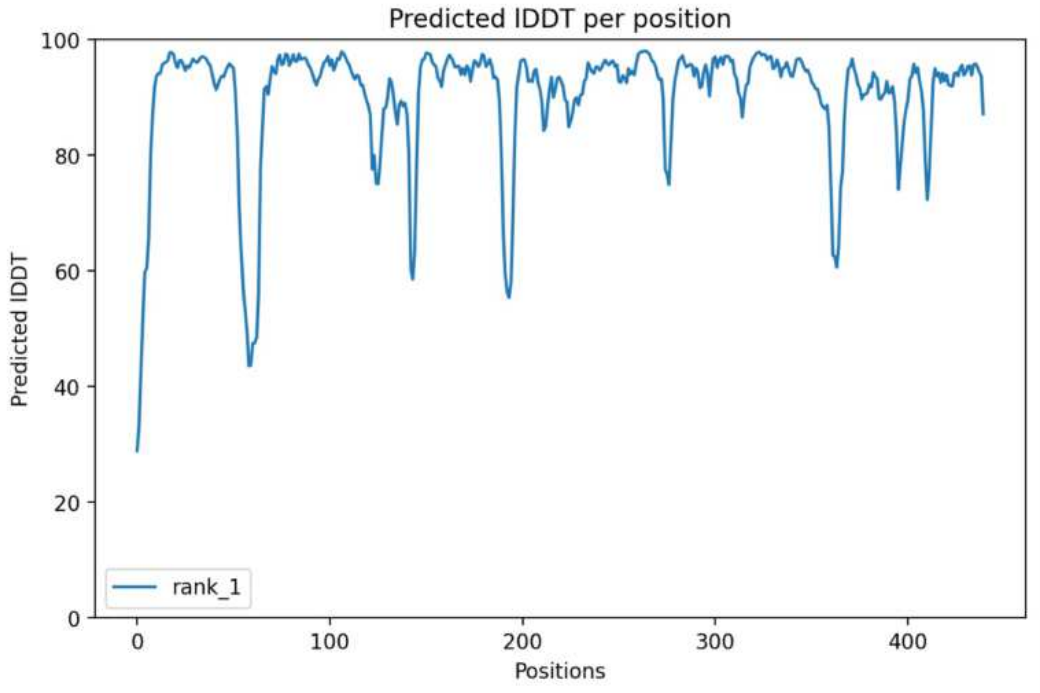

FIG. — the Pun1/AT3 acyltransferase model coloured by pLDDT confidence; the active-site cleft, where two designed substitutions are predicted to reshape the burn, sits in the high-confidence core.

Our heat platform did not chase Scoville units by selecting hot phenotypes and hoping the genotype followed. We inverted the method. A protein language model scored every possible single-residue substitution in Pun1 for predicted effect on catalytic efficiency and fold stability; our flux model predicts that pathway control sits upstream in the phenylpropanoid trunk — at 4CL and HCT/CCoAOMT — not at the terminal Pun1 step, which labels the product but does not govern the rate. Working from that model, two substitutions emerged that our design predicts will reshape capsaicin output:

EDIT	EFFECT	ΔΔG (KCAL/MOL)
S39L	binding affinity ↑ at the N-terminus	−2.1
L345G	steric relief in the active-site cleft	−1.8

(C175S, ΔΔG −0.9, prevents a disulfide misfold — a structural annotation from our modelling, not part of the shipped construct.)

In our computational design, these two substitutions are predicted to lift peak output to approximately **2.95 million SHU** at a designed batch-to-batch coefficient of variation at or below seven percent, against roughly forty-two percent in the wild type. A vegetarian cook rarely wants three million Scovilles. But the *consistency* — the CV ≤ 7% design target — is the gift: heat you can dose like an ingredient, the same from one jar to the next, so a dish is warm exactly as you meant it rather than warm by accident.

The shape of a burn

Heat is not a single sensation but a trajectory — where it lands, how fast it rises, how long it stays — and that trajectory is set by *which* capsaicinoids a pepper makes. The two principal molecules, **capsaicin** and **dihydrocapsaicin**, differ only in a single double bond in the fatty-acid tail, but the tongue reads the difference as geography. Capsaicin rises fast and lands high and forward — the tip and front of the mouth, a quick bright sting that fades. Dihydrocapsaicin rises slower, sits lower and further back — the throat and mid-palate, a creeping warmth that lingers long after capsaicin has gone. A pepper's capsaicin-to-dihydrocapsaicin ratio is therefore its *burn signature*, and because that ratio is set by the

acyl chain the Pun1 enzyme selects, it is something we can design. For a vegetarian table this is the real luxury: not raw Scovilles, but a warmth shaped to a dish — a front-of-mouth brightness for a fresh salsa, a slow back-palate glow for a braise — grown to specification rather than left to the lottery of a wild pepper.

A word on translating Scoville to the Index, since both appear on these pages. The Scoville scale measures *how much* capsaicinoid is present (parts per million, by the old dilution assay or modern HPLC); IFI-H measures how *loudly* it speaks at TRPV1. The two track closely at the top of the range — a three-million-SHU fruit is unambiguously loud — but diverge in the subtleties a cook cares about, because a lower-SHU pepper with a forward, fast capsaicin profile can read *hotter on arrival* than a higher-SHU one weighted toward slow dihydrocapsaicin. SHU is the quantity; IFI-H, anchored to the EC_{50} at TRPV1, is the experience. We cook by the second.

Laddering heat for a real table

The practical art of heat in a shared vegetarian kitchen is the ladder — building a dish so one base serves a table of different tolerances, warmth added in rungs rather than baked in. Here is the flagship ladder we cook from — ordered by increasing computational design scope and axis activation, not by certified measurement — and the scorecard of its summit, the eight-axis cultivar that proves heat need not come alone:

CULTIVAR	SKU	PREDICTED SHU	IFI-H	AXES
Ember	SS-0087	~866K	1,570	2/8
Blaze	SS-0091	~1.72M	2,630	4/8
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

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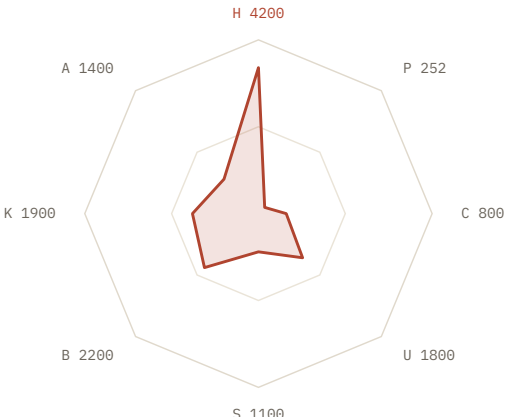
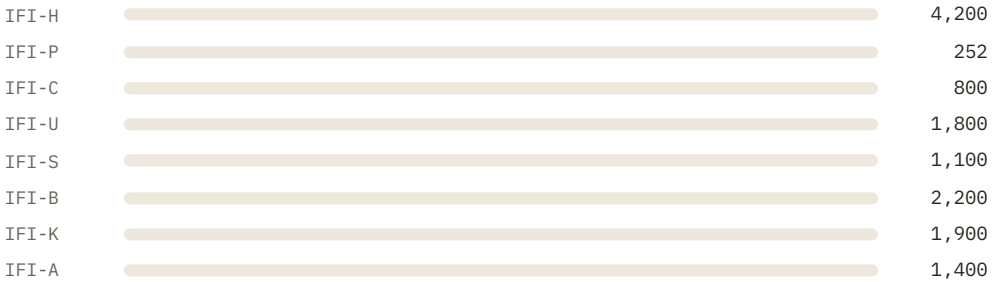




That scorecard — Phoenix, the first cultivar engineered to register on all eight axes at once — is not a vegetarian weeknight ingredient. We show it because it is the proof of the whole platform: that heat can be grown with umami, kokumi, sweetness, and the rest riding alongside it, a single fruit speaking every language the tongue knows. For dinner, you will use a rung much lower down. But you will use it on purpose.

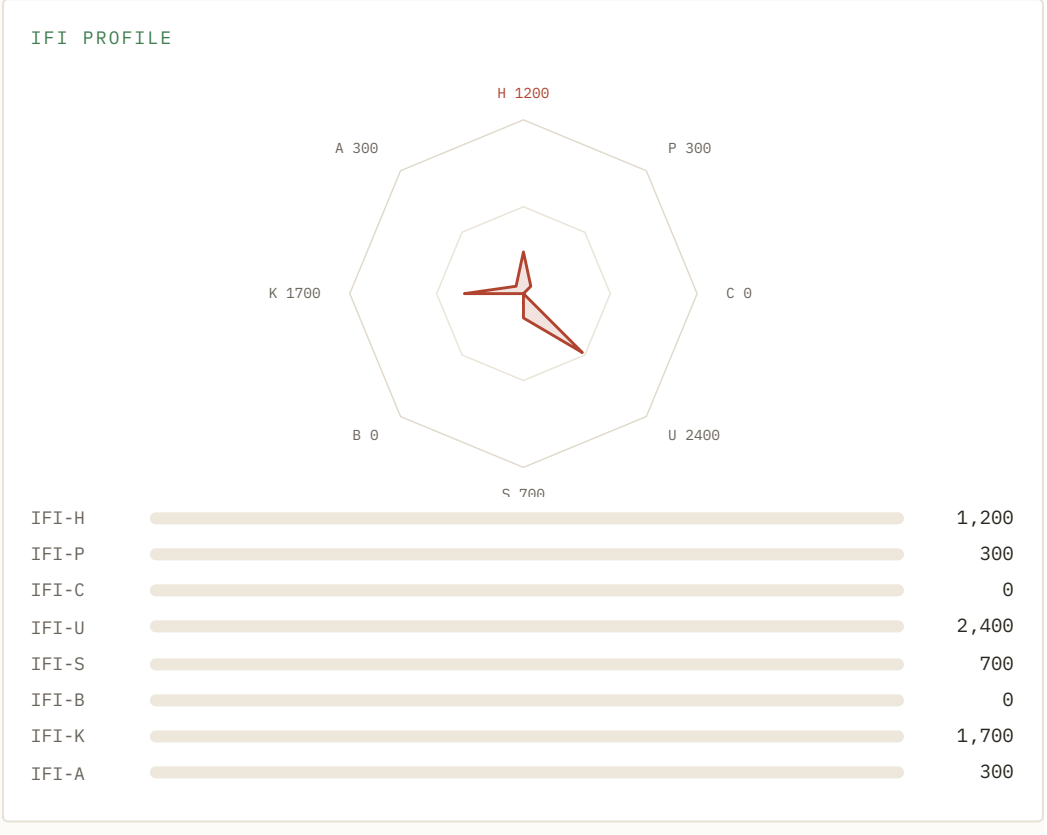
Recipe · Three-Alarm Tomato Braise, Laddered

Serves 4–6, at three heat levels · 40 minutes · one pot, every tolerance at the table.

```
800 g        restored tomatoes, grated
1            onion, diced · 4 cloves garlic, sliced
400 g        cooked chickpeas
4  tbsp      olive oil · smoked paprika · cumin · salt
to ladder:   mild chili flake · a hotter fresh chili · a few drops of
extract-grade hot sauce
```

1. Build the base: sweat onion and garlic in oil, bloom the paprika and cumin, add tomato and chickpeas, simmer twenty-five minutes into a thick, savory braise. Salt well. This is the mild rung — warm, not hot.
2. Serve the base as is for the gentlest palate. For the middle rung, stir a spoon of mild chili flake into a portion. For the top rung, add a few drops of consistent, extract-grade heat to a bowl at the table.
3. Because the heat is dosed at the end from a CV ≤ 7% source, each rung is exactly as hot as intended — not a guess.

Why it works — Capsaicin is fat-soluble and binds TRPV1 whether you add it early or late, so laddering at the table loses nothing. The savory base (restored tomato's glutamate, long alliums' kokumi) stands on its own at zero heat; the ladder lets one pot feed a child and a chilihead from the same spoon. This is heat as hospitality.



Recipe · Blistered Peppers, Flaky Salt

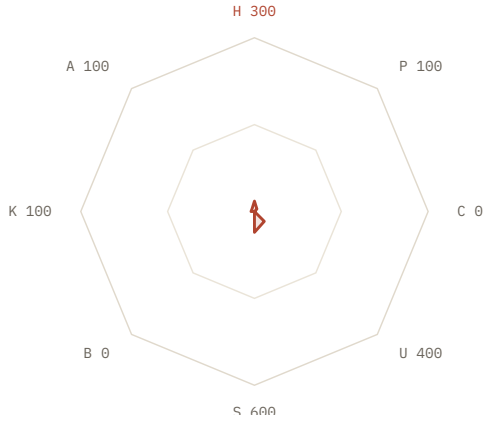
Serves 4 · 10 minutes · the simplest possible argument for a pepper grown with a shape.

250 g	shishito or Padrón-type peppers
2 tbsp	olive oil
	flaky salt · lemon

1. Get a pan smoking hot. Add the peppers dry-ish with just a film of oil and blister them hard, tossing, until black-spotted and slumped, three minutes.
2. Salt heavily, squeeze lemon, eat with your fingers while hot.

Why it works — Shishitos sit near IFI-H 40 — the sunlit low end of the heat axis, where perhaps one pepper in ten surprises you. The blistering caramelises the skin's sugars; the capsaicin that is present lands as warmth, not fire. It is heat used as seasoning, the gentlest rung of the whole ladder, and proof that the bottom of the TRPV1 scale is as worth designing as the top.

IFI PROFILE



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IFI-C	0
IFI-U	400
IFI-S	600
IFI-B	0
IFI-K	100
IFI-A	100

Chapter 9 · Pungency & the Sharp High Notes — *the other burn, and the cold one.*

There is a second heat, and a vegetarian kitchen leans on it constantly: the sharp, nose-filling, tear-pulling pungency of garlic, mustard, horseradish, wasabi, and ginger. It feels related to chili heat, but it is a different channel entirely, and knowing the difference is the difference between a dish that bites and one that merely burns.



Garlic specimen — crush the clove and alliinase converts alliin to allicin in seconds; the sharp high note that opens a thousand vegetarian dishes.

The electrophile channel

Pungency runs through **TRPA1**, a cousin of the heat channel TRPV1, and it is activated by a fundamentally different trick. Where capsaicin settles into a binding pocket and holds TRPV1 open by shape, the pungent molecules of the mustard and allium families are **electrophiles** — reactive compounds that form covalent bonds with specific cysteine residues on TRPA1's inner face, chemically latching the channel open. This is why pungency feels so immediate and volatile: it is a chemical reaction happening on the nerve, and the compounds are often volatile enough to climb into the nose and hit the channel there too, which is the wasabi tears and the raw-onion sting.

The compounds, and where our platform makes them:

COMPOUND	PRECURSOR → ENZYME	SOURCE · CONSTRUCTS	CHARACTER
Allicin	alliin → alliinase	garlic · 560 (K/P)	the warm, round allium sharp
Allyl isothiocyanate (AITC)	sinigrin → myrosinase	black mustard · 2,790 (P/M)	the cold, nasal wasabi hit
[6]-gingerol / [6]-shogaol	—	ginger · 120 (P)	warm, slow, lingering pungency
Sinalbin-derived ITC	—	white mustard · 200 (P)	milder, broader table-mustard heat

The craft is that these are made *on crushing*. In an intact clove, alliin and the enzyme alliinase sit in separate compartments; cut or crush the cell and they meet, and allicin forms within seconds. The same is true of mustard and wasabi — sinigrin meets myrosinase only when the cell wall breaks. This is why *how* you cut matters as much as *what*: a crushed garlic clove is a different ingredient from a whole roasted one, because in one the pungency reaction has run and in the other it never started. Our black mustard work (2,790 constructs — one of the largest construct counts in the whole library) tunes the sinigrin-myrosinase system for a clean, reliable AITC yield, so wasabi-grade pungency can be grown rather than imported.

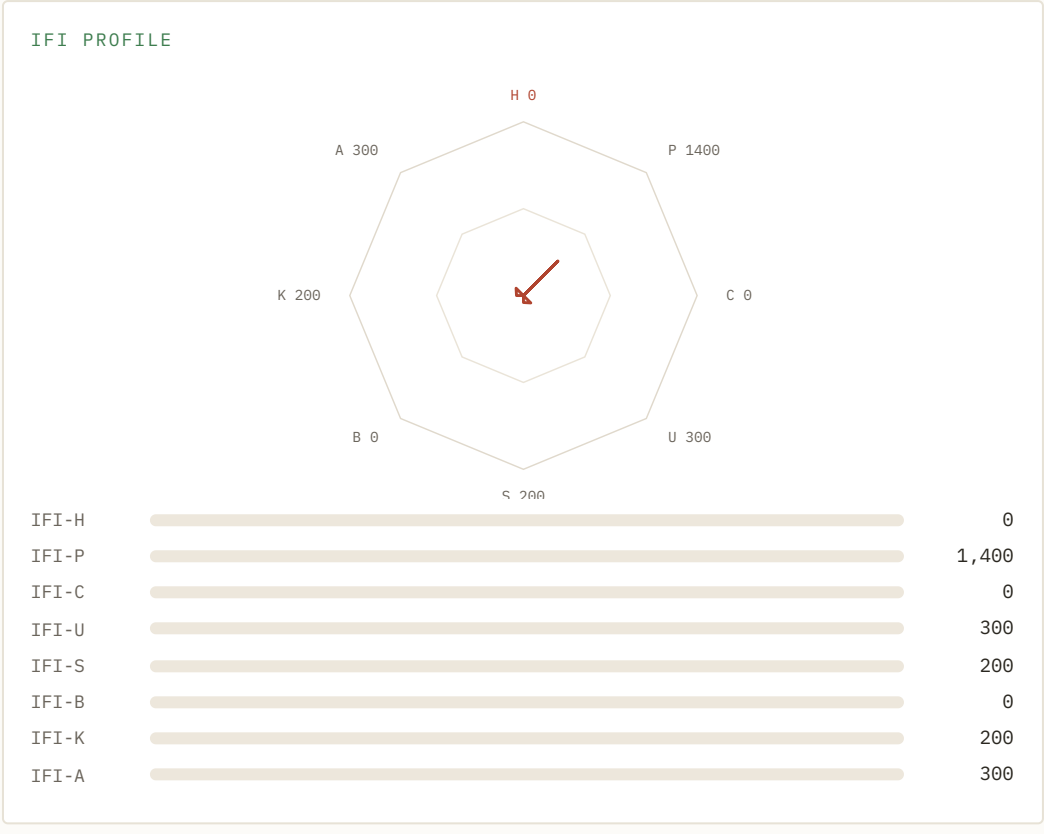
Recipe · Garlic-Scape Salsa Verde

Serves 6 as a sauce · 10 minutes · raw pungency, used as a bright green jolt.

8	garlic scapes (or 3 raw cloves + extra herbs), chopped
1 bunch	parsley · a handful mint
2 tbsp	capers · 1 tbsp mustard
120 ml	olive oil · lemon · salt

1. Chop everything together fine, by hand for texture or pulse in a processor.
2. Stir in the oil, mustard, lemon, and salt. Let it sit ten minutes for the flavors to marry and the raw edge to round.

Why it works — Chopping the scapes and whisking in mustard sets two TRPA1 reactions running at once — allicin from the alliums, AITC from the mustard — for a layered pungency that is sharp but not hot in the chili sense (no TRPV1). Spooned over beans, grains, roasted vegetables, or eggs, it is the high green note that makes a plain plate sing.



Recipe · Ginger-Scallion Oil

Makes 1 jar · 15 minutes · the condiment we keep on the counter at all times.

60 g	ginger, minced fine
6	scallions, sliced thin
1 tsp	salt
120 ml	neutral oil, heated until shimmering
	a few drops toasted sesame oil

1. Pile the ginger, scallions, and salt in a heatproof bowl.
2. Heat the oil until it shimmers and pour it over; it will seethe and smell extraordinary. Stir, cool, add sesame oil.

Why it works — Ginger's [6]-gingerol gives a warm, slow TRPA1 pungency; the hot oil blooms it and softens the scallions' raw allium sharp into something mellow and sweet. Spoon over rice, tofu, noodles, or roasted squash. It is the dish that proves pungency is not aggression — it is the aromatic lift that wakes the savory floor up.

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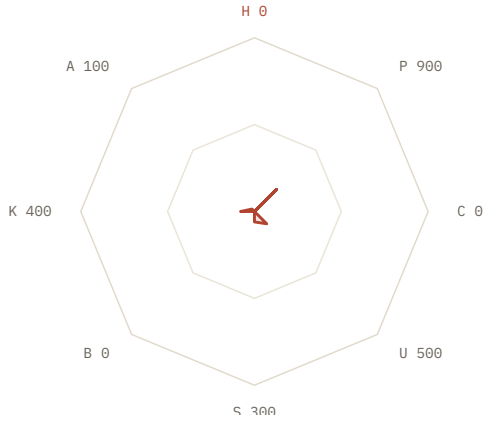


IFI-H	0
IFI-P	900
IFI-C	0
IFI-U	500
IFI-S	300
IFI-B	0
IFI-K	400
IFI-A	100

Recipe · Mustard Greens, Fast, Garlic & Chili

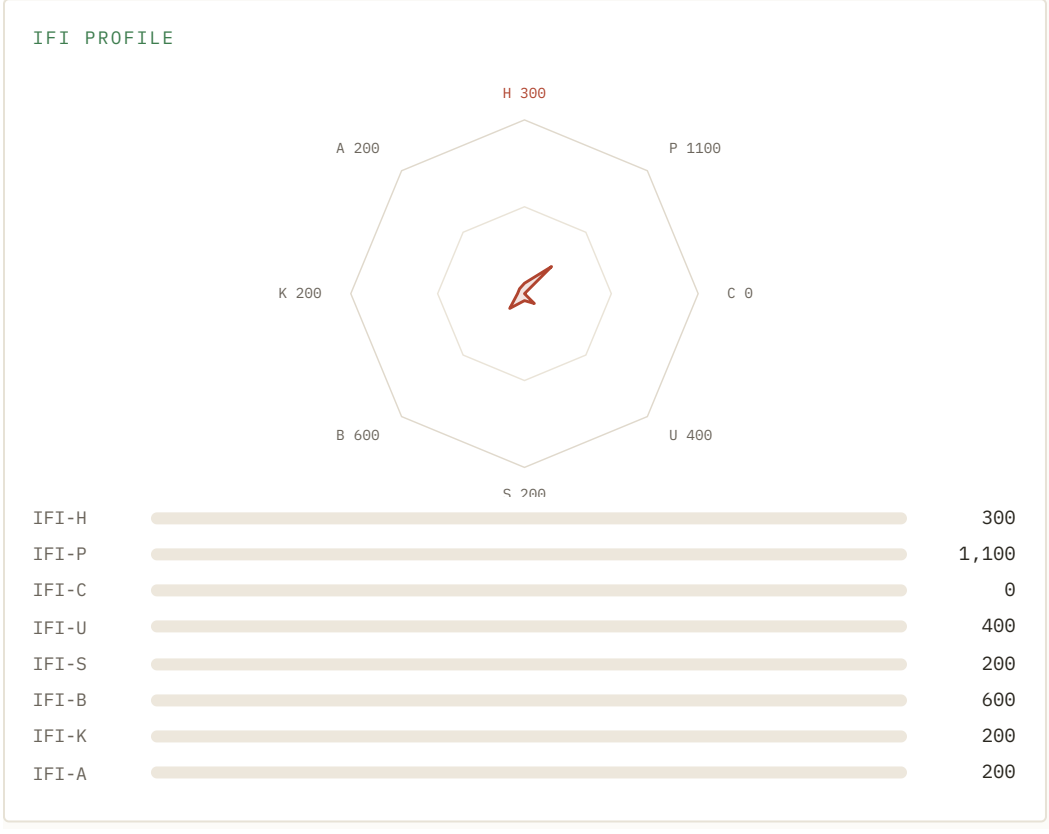
Serves 4 · 12 minutes · the green with its own built-in pungency.

400 g	mustard greens, washed, torn
3 cloves	garlic, sliced
2 tbsp	olive oil
	chili flake · salt · a splash of soy or tamari

1. Heat the oil and garlic until fragrant, add chili flake.

2. Add the greens in handfuls, tossing, until just wilted but still bright, three minutes.
3. Season with soy and salt; serve at once.

Why it works — Mustard greens carry their own glucosinolate-derived pungency (AITC family) in the leaf, so they season themselves on the TRPA1 channel. Cooked fast and hot, they keep that sharp edge where long cooking would blow it off. Garlic layers a second pungency; a little chili adds a TRPV1 warmth underneath. Three channels, one fast pan of greens.



The channel that latches shut

It is worth understanding exactly why pungency feels so different from chili heat, because the difference is mechanical. Capsaicin binds TRPV1 reversibly, settling into a pocket and lifting back out — which is why chili heat, for all its intensity, has an end. The pungent electrophiles do something more violent and more fleeting at once: allicin, AITC, and cinnamaldehyde carry reactive groups that form **covalent bonds** with specific cysteine residues on the inner face of TRPA1, chemically latching the channel open. The sensation is immediate and sharp because it is a reaction, not a fit — and it fades fast because the volatile compounds dissipate and the cell repairs the modified cysteine. This is also why pungency climbs into the nose: the compounds are volatile enough to reach TRPA1 on the nerves of the nasal passage directly, which is the wasabi rush and the raw-onion tear that chili heat never produces. Front-of-nose and fleeting (pungency) versus deep-in-mouth and lasting (heat): two channels, two mechanisms, two tools.

Recipe · Wasabi Pea Smash on Toast

Serves 4 · 15 minutes · cold, nasal pungency used as a bright jolt.

```
300 g       peas (fresh or frozen, blanched)
1–2 tsp     fresh grated wasabi or strong horseradish (to taste)
2  tbsp     olive oil · 1/2 lemon · flaky salt
            a handful mint · 4 slices toasted sourdough
```

1. Crush the warm peas roughly with a fork, keeping plenty of texture.

2. Fold in the wasabi, oil, lemon, salt, and torn mint. Taste — the wasabi should lift, not level.
3. Pile onto toast and eat at once, before the wasabi's volatility fades.

Why it works — Wasabi and horseradish carry the same AITC-family pungency as mustard, generated on grating when the cell breaks and myrosinase meets the glucosinolate. On TRPA1 it gives a cold, nasal, instantly-rising sharp — the opposite geography of chili heat — that cuts the peas' sweetness and wakes the whole bite. Because AITC is so volatile, this is a dish to make and eat immediately: the pungency is a candle, not a coal.

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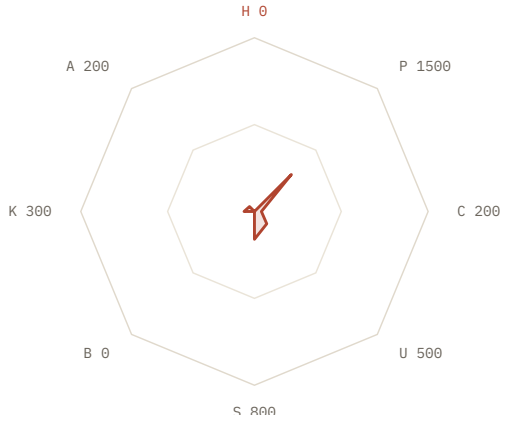

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IFI-K	300
IFI-A	200

Chapter 10 · Cool-Burn — *the sensation that runs the fire backward.*

If heat reports a warmth that is not there, cooling reports a chill that is equally imaginary, and through an almost perfectly mirrored mechanism. Menthol binds **TRPM8**, the channel your nerves use to detect temperatures below about 26°C, and lowers its activation threshold — so the body reports cold on tissue that has not changed temperature at all. It is the twin of capsaicin's trick, run backward, and in a vegetarian kitchen it is the high, clean finish that lifts a heavy plate and cools a hot one.



Peppermint — 2,360 constructs tune the five-gene menthol pathway; one of the largest construct counts in the library sits behind a single cooling note.

A five-gene pathway, tuned

Menthol is the end of a short, elegant biosynthetic road that begins with limonene and runs through a five-enzyme sequence — limonene-3-hydroxylase, then a cascade of reductases and dehydrogenases — to (−)-menthol, the specific stereoisomer that reads as clean, sweet cold. Get the stereochemistry wrong and you get the medicinal, camphorous off-notes of a lesser mint. Our peppermint work — **2,360 constructs**, difficulty rated hard, one of the deepest in the whole library — tunes that pathway for high (−)-menthol yield and the right isomer balance, so the cooling is sweet and clean rather than sharp and pharmacy-like. Spearmint, camphor, eucalyptus, and lavender extend the cool axis into their own characters, each a different ligand on the same TRPM8 channel.

The craft note for the cook: menthol, like the pungent electrophiles, is volatile and heat-fugitive. It is a *finishing* flavor. Add mint at the end, off the heat, or raw — cook it hard and the cooling climbs out of the pot and is lost.

The channel, and why cold has no temperature

TRPM8 is a cation channel on the same sensory nerves that carry heat and pungency, and it is the body's genuine cold detector — it opens as tissue cools below about 26°C, letting ions flow and the nerve fire *cold*. Menthol's trick is to shift the channel's voltage-and-temperature sensitivity so that it opens at warmer temperatures than it should, reporting cold on tissue sitting at a comfortable room-

warm 20-something. The sensation is real; the cold is not. It is the exact mirror of capsaicin lowering TRPV1's heat threshold — two molecules, two channels, two imaginary temperatures, run in opposite directions. This symmetry is why heat and cool cancel so cleanly when served together, and why a cuisine that loves chili so often loves mint beside it: the body is being told two contradictory thermal stories at once, and the contradiction reads as balance.

A palette of cold

Menthol is the archetype, but the cool axis is a family, each member a different ligand on TRPM8 with its own character and its own organism behind it:

COOLING SOURCE	KEY COMPOUND	CONSTRUCTS · AXIS	CHARACTER
Peppermint	(−)-menthol	2,360 · C/M	sweet, clean, the reference cool
Spearmint	carvone + low menthol	— · C	gentle, herbaceous, barely cold
Eucalyptus	eucalyptol (1,8-cineole)	— · C	sharp, camphoraceous, medicinal lift
Camphor	camphor	— · C	dry, penetrating, a trace goes far
Lavender	linalool	— · C	floral, soft, cool at the edges

The (−)-menthol stereochemistry is the whole game for the kitchen member of this family. Of menthol's eight possible stereoisomers, only (−)-menthol delivers the clean, sweet, strongly-cooling sensation; the others range from weakly cooling to frankly medicinal. A mint bred or grown for the wrong isomer balance tastes of cough drops. Our 2,360 constructs — among the deepest counts in the entire library, sitting behind what a diner experiences as a single simple note — exist largely to pin that stereochemistry, so the cool is dessert-clean rather than pharmacy-sharp.

Recipe · Cucumber-Mint Raita

Serves 4 · 10 minutes · the cooling counterweight to every hot dish in this book.

```
400 g       thick yogurt (or coconut yogurt for vegan)
1/2         cucumber, grated and squeezed dry
            a handful mint, chopped fine
1/2 tsp     toasted cumin, ground · salt · a squeeze of lime
```

1. Stir everything together. Taste for salt and lime.
2. Chill until needed; it only improves in half an hour.

Why it works — This is cool-burn as architecture: served alongside the Three-Alarm Braise or the mustard greens, the mint's menthol hits TRPM8 while the chili's capsaicin hits TRPV1, and the two opposite sensations on neighbouring nerve endings cancel the fire's edge and reset the palate for the next bite. The cucumber adds literal coolness and water; the yogurt's fat carries both away. It is how a spicy table stays comfortable.

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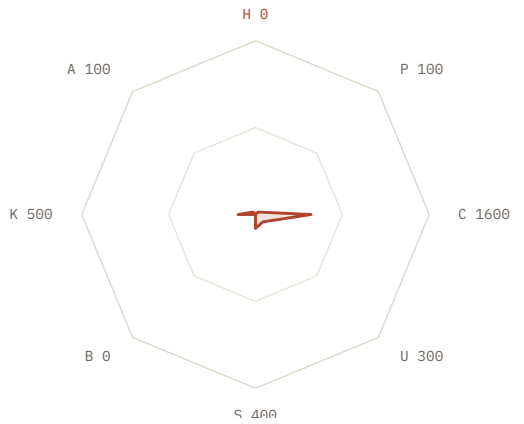

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IFI-B	0
IFI-K	500
IFI-A	100

Recipe · Minted Pea Soup, Hot or Cold

Serves 4 · 20 minutes · the cooling axis as the whole point of a dish.

```
500 g       peas (fresh or frozen)
1           onion, diced · 2 tbsp olive oil
700 ml      vegetarian dashi or water
            a big handful mint · salt · lemon · yogurt to finish
```

1. Sweat the onion soft in the oil. Add dashi and peas, simmer just five minutes — no longer, to keep the peas green and sweet.
2. Off the heat, add most of the mint and blend until smooth. Season with salt and lemon.
3. Serve hot with a swirl of yogurt and the last of the mint, or chill and serve cold.

Why it works — Peas are naturally high in sugar and glutamate, so the base reads sweet-savory with no help. The mint, blended in at the end, carries (−)-menthol onto TRPM8 for a cooling lift that makes the whole bowl taste fresher and lighter than its richness suggests. Added at the end, not boiled, the cool survives. A soup that eats like a breath of cold air.

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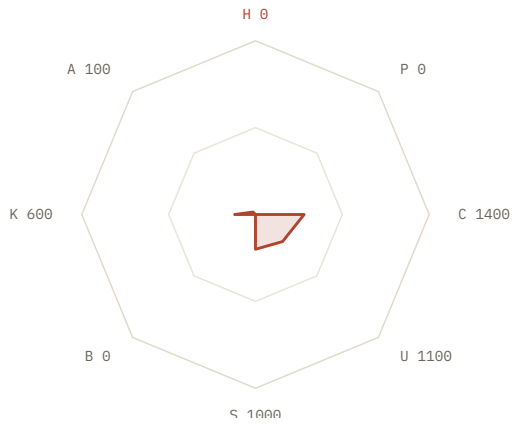

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IFI-B	0
IFI-K	600
IFI-A	100

Recipe · Cucumber, Mint & Lime, Smashed

Serves 4 · 10 minutes · the coolest thing on a hot table, and almost not a recipe at all.

1 large	cucumber
	a handful mint, torn
1	lime, juiced · 1 tsp rice vinegar
1 tsp	maple or Reb-M syrup · flaky salt
	a pinch chili flake · toasted sesame

1. Smash the cucumber with the flat of a knife until it splits, then tear it into rough, craggy pieces — the broken surfaces hold dressing where neat slices shed it.
2. Toss with lime, vinegar, sweetener, salt, and most of the mint. Rest five minutes.
3. Finish with chili flake, sesame, and the last of the mint.

Why it works — Cucumber is almost entirely cool water, and smashing it opens that water to the dressing. The mint lays (–)-menthol over the top on TRPM8, so the salad reads cold twice over — once in temperature, once in sensation. A whisper of chili on TRPV1 and a little sweetness keep it from being merely refreshing; the heat-and-cool contrast makes both edges sharper. This is the plate that sits beside the spiciest dish in the book and keeps the whole table comfortable.

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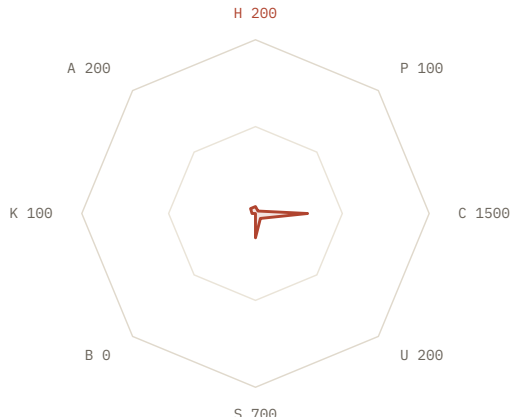

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IFI-B	0
IFI-K	100
IFI-A	200



PART IV OF V

The Sweet Frontier

Fruit, dessert, and the grip that holds them · TAS1R2·R3 · Salivary PRPs

Chapter 11 · Fruit, Tuned to Ripeness — *the one perfect afternoon, kept.*

Every fruit has a single perfect afternoon — the hours when its sugars have climbed, its acid has settled into balance, and its aromatics are at their peak — and the entire apparatus of modern produce is arranged to miss it. Fruit is picked hard and green so it can travel, then gassed or simply surrendered to a slow, flavorless ripening on a shelf. The afternoon happens in a warehouse, to no one. The sweet frontier of our work is, more than anything, an attempt to keep that afternoon — to let a fruit reach and hold the ripeness it was built for, measured on the sweet axis and grown in on purpose.



Strawberry in cross-section — where the sugars and aromatics of the perfect afternoon concentrate; the Sweet Heat roadmap tunes them toward ripeness that holds.

The sweet-heat frontier

The most imaginative corner of the fruit work is the cross-family **Sweet Heat** roadmap — the concept series that puts a shape of warmth into a sweet fruit, so a strawberry can carry both sugar and a whisper of heat. The named cultivars of that frontier read like a menu written by someone who loves both dessert and danger:

SERIES	CULTIVARS	AXES	TIER
Strawberry *Sweet Heat*	Warm Kiss · Sugar Burn · Candied Fang · Devil's Dessert	S × H	T3 (cross-family)
Melon *Solar*	—	S × H	T3
Apple *Forbidden*	—	S × H	T3

These are the frontier — what the method could build on the 36-to-48-month horizon, cross-family engineering that moves the capsaicinoid logic into a berry. We hold them here as what is coming. For tonight's dessert, the point is gentler and already real: heat, used below the threshold of *hot*, makes sweetness taste like more of itself, because a trace of TRPV1 warmth heightens the contrast that lets the sweet receptor's signal stand out.

The chemistry of ripe

What, exactly, is the perfect afternoon made of? Ripeness is a measurable chemical event, and naming its parts is how we learned to keep it. Three numbers define it. The first is **Brix** — the concentration of dissolved sugar — which climbs as the fruit converts stored starch and imports sugar from the plant. The second is **titratable acidity** — the malic and citric acids that give fruit its brightness — which falls as the fruit ripens and respires its acids away. The perception of *ripe* is governed less by either alone than by their **ratio**: a strawberry at high Brix and low acid tastes flat and cloying; at low Brix and high acid, green and sour; the perfect afternoon is a specific sugar-to-acid ratio, held for a window of hours. The third is the bloom of **volatile aromatics** — the esters and furanones that give a ripe strawberry its smell, built only in the final stage of on-plant ripening and never afterward, which is why a fruit picked green can soften and sweeten on a shelf but never gain its aroma.

This is the real theft of shipping-first produce, and it is not quite the same theft as the tomato's. The fruit is picked before the aromatic bloom and before the sugar-acid ratio settles, so that it can travel firm; it then ripens *texturally* on the shelf — softening, losing acid — while never building the aromatics it needed the plant for. The result is a fruit that is soft and sweet-ish and smells of almost nothing. Our fruit work targets all three numbers at once: holding the Brix-to-acid ratio in its ideal window through storage, and extending the on-plant aromatic bloom so the fruit can be picked riper and still arrive intact. The perfect afternoon, measured in three numbers, and grown to last past its one day.

Recipe · Strawberries, Warm Honey, a Whisper of Heat

Serves 4 · 10 minutes · the dessert that taught us heat could be tender.

```
500 g      ripe strawberries, halved
2  tbsp    honey, gently warmed (or warmed agave for vegan)
           a very small pinch of chili flake · flaky salt
           black pepper · a few torn mint leaves
```

1. Halve the strawberries into a bowl.

2. Warm the honey with the smallest pinch of chili until it loosens and the chili blooms. Pour over; add a bare pinch of salt and a grind of pepper.
3. Wait five minutes. The fruit will weep a little, and the whole bowl will smell like summer with its sleeves rolled up. Mint at the end.

Why it works — The heat sits below the threshold of *hot* — just enough capsaicin on TRPV1 to register as warmth, not fire — and that faint warmth sharpens the perceived sweetness by contrast, the same way a pinch of salt does. The pepper adds a dry aromatic bite; the mint's cool lifts the top. A dessert that is almost nothing and tastes like everything.

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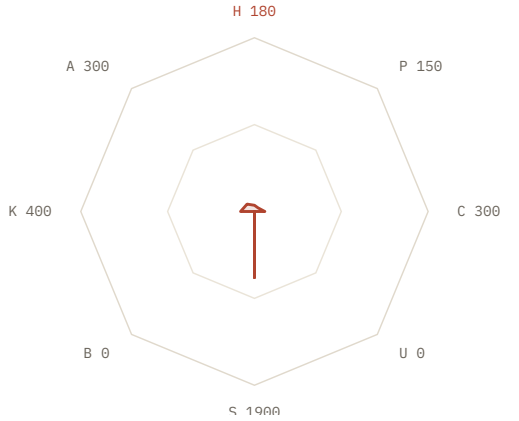

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IFI-B	0
IFI-K	400
IFI-A	300

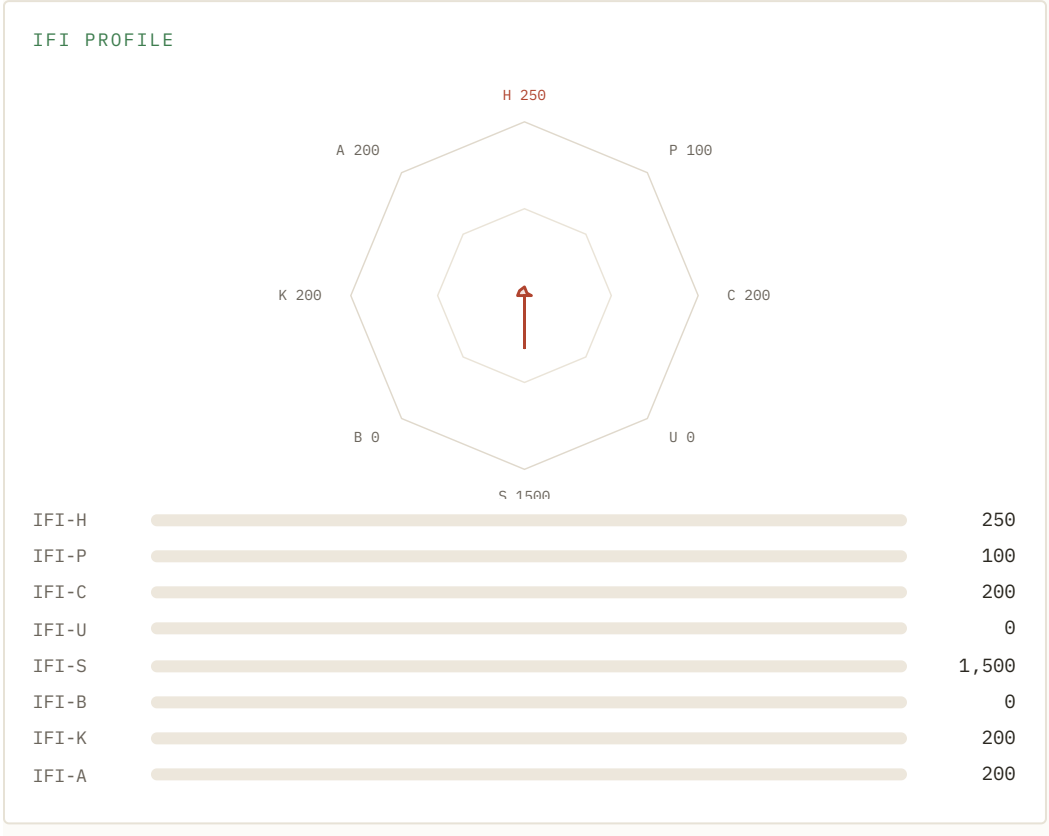
Recipe · Melon, Chili, Lime, Salt

Serves 4 · 5 minutes · the fruit plate as a four-axis composition.

1	ripe melon (cantaloupe or honeydew), in wedges
	chili-lime salt (or flaky salt + chili + lime zest)
1	lime, in wedges

1. Lay the melon on a plate.
2. Dust with chili-lime salt, squeeze lime over, serve cold.

Why it works — This street-fruit classic is a tiny IFI composition: the melon's sugar (TAS1R2/TAS1R3), the chili's warmth (TRPV1), the lime's acid, and the salt that unmasks them all. The heat and salt together make the melon taste sweeter and more intensely of itself than it does plain — four inputs, one bright, cold, addictive plate.



Recipe · Grilled Apricots, Vanilla, Flaky Salt

Serves 4 · 12 minutes · the fruit dessert that leans on kokumi.

8		apricots, halved and stoned
1	tbsp	olive oil or melted butter
		seeds of 1/2 vanilla pod (or 1/2 tsp paste)
		flaky salt · a drizzle of honey or warmed agave

1. Brush the cut faces with oil and grill or sear cut-side down until caramelised and soft, four minutes.
2. Off the heat, scatter with vanilla seeds, a little salt, and a thread of honey.

Why it works — Grilling concentrates the apricot's sugar and adds Maillard depth; the vanilla does something subtler. Beyond its aroma, vanilla (40 constructs, K) carries kokumi — a CaSR-active roundness that lengthens and fills the fruit's sweetness, giving a simple grilled apricot the long, custardy finish usually built from cream. The salt sharpens it all. Sweetness, grown a little longer on the tongue.

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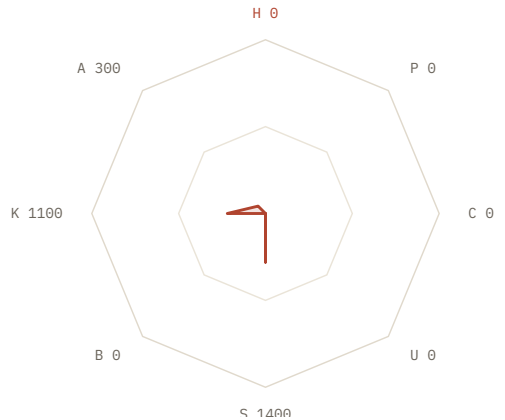

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IFI-K	1,100
IFI-A	300

Chapter 12 · Astringency & Structure — *the grip that keeps sweetness honest.*

The last of the eight axes is the one least discussed and most structural: astringency, the dry, puckering grip of strong tea, young red wine, pomegranate, and the skin of a grape. It is, uniquely, not a taste at all. There is no astringency receptor on the tongue. It is a *tactile* sensation, and understanding that is the key to using it — because in a vegetarian kitchen, astringency is the architecture that keeps a sweet or rich plate from going slack.



Tea — the galloylated catechins that drive astringency; 280 constructs tune the U/B/A balance of a single leaf.

A mouthfeel, not a taste

Astringency happens when **tannins** — large polyphenols, the condensed proanthocyanidins of grape skin and the galloylated catechins of tea — bind and precipitate the **proline-rich proteins (PRPs)** that lubricate your saliva. Those proteins exist precisely to be sacrificed: they bind astringent plant defense compounds before the compounds can do harm, and in doing so they clump and fall out of solution, stripping the mouth of its slipperiness. The sensation you read as *dry* is your own saliva, momentarily deprived of its lubricating proteins. This is why astringency builds across sips, why it feels textural rather than flavorful, and why a splash of fat or cream erases it instantly — the fat re-coats what the tannins stripped.

Our astringency work tunes this grip to a specification. **Tea** (280 constructs, U/B/A) balances astringency against umami and bitterness within a single leaf, so a green tea can be savory and bright without turning harsh. **Grape** (1,610 constructs, B/A/M) tunes tannin structure through the anthocyanidin reductase pathway for winemaking and the table. **Pomegranate** (120 constructs, A) and **blueberry** (120 constructs, A) carry a cleaner, fruit-forward astringency for the plate.

SOURCE	TANNIN TYPE	CONSTRUCTS · IFI-A	KITCHEN USE
Tea	galloylated catechins	280 · U/B/A	poaching liquid, dressings, drinks
Grape	condensed proanthocyanidins	1,610 · B/A/M	the table grape with structure
Pomegranate	ellagitannins	120 · A	the bright, dry jewel on a rich plate
Blueberry	anthocyanin-linked	120 · A	a gentle grip in sweet dishes

> Astringency is the grip a plate needs to keep its balance. Without it, richness turns cloying and sweetness turns flat. It is the frame, not the picture — and a vegetarian kitchen that ignores it is cooking with one dimension missing.

Two families of grip

Not all astringency is the same, and a cook who can tell the two apart can place it precisely. **Condensed tannins** — the proanthocyanidins of grape skin and seed, and the galloylated catechins of tea — are large, flexible polymers that bind PRPs broadly and build a slow, spreading, coating dryness that grows across sips; this is the grip of a young red wine or an over-steeped tea, the kind that accumulates. **Hydrolyzable tannins** — the ellagitannins of pomegranate and the gallotannins of some nuts and skins — are smaller and sharper, giving a brighter, more immediate, more localized pucker that arrives and clears. The first is architecture, a structural dryness you build a rich dish around; the second is punctuation, a bright dry jewel you place on top. Our grape work (1,610 constructs) tunes the condensed-tannin structure for the spreading, wine-like grip; our pomegranate (120 constructs) and blueberry (120 constructs) carry the brighter hydrolyzable snap. Knowing which you want is knowing whether you are framing the plate or lighting one corner of it.

The reset, and how to undo it

The most practical fact about astringency is its off switch: **fat**. Because the sensation is literally the stripping of lubricating proteins from your saliva, anything that re-coats the mouth erases it instantly — a spoon of yogurt, a thread of olive oil, a slice of avocado. This is the lever a cook holds. Want the grip to stay and keep cutting a rich dish? Keep the fat separate, a bright astringent garnish against a creamy base, so each bite re-triggers the cut. Want the grip to vanish into roundness? Emulsify the tannin into fat — the pomegranate molasses whisked into a tahini dressing — and the astringency softens to a whisper. The same tannin, two opposite jobs, decided entirely by where the fat is. Astringency is the one axis you conduct as much by physics as by chemistry.

Recipe · Pomegranate-Glazed Eggplant

Serves 4 · 40 minutes · the dry bright grip against a soft rich flesh.

2		eggplants, halved and scored deep
3	tbsp	olive oil
3	tbsp	pomegranate molasses
1	tbsp	shio koji or soy
		pomegranate seeds · mint · flaky salt

1. Score the eggplant faces deeply, brush with oil, and roast cut-side up at 220°C until completely soft and collapsed, thirty minutes.
2. Brush with pomegranate molasses mixed with koji and roast ten minutes more until glazed and dark.
3. Scatter with fresh pomegranate seeds, mint, and salt.

Why it works — Roasted eggplant is all soft, rich, umami-adjacent flesh — and left alone it can read heavy and one-note. The pomegranate's ellagitannins add astringency (the PRP grip) that cuts straight through the richness, resetting the mouth so each bite tastes as good as the first. The koji adds a savory glutamate base underneath. Richness and grip, held in balance, with nothing from an animal doing the cutting.

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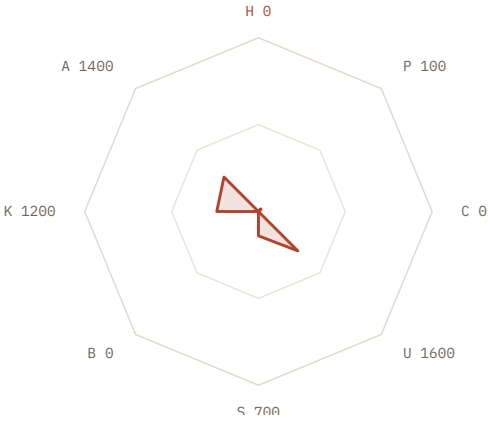

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IFI-U	1,600
IFI-S	700
IFI-B	0
IFI-K	1,200
IFI-A	1,400

Recipe · Tea-Poached Pears

Serves 4 · 30 minutes · astringency and sweetness, built to meet.

4		firm pears, peeled
750	ml	brewed green or black tea, strong
2	tbsp	honey or Reb-M stevia to taste
1		strip lemon peel · a few cardamom pods

1. Simmer the tea with the sweetener, lemon peel, and cardamom.

2. Lower in the pears and poach gently until just tender, twenty minutes, turning so they colour evenly.
3. Cool in the liquid; serve with a little of the reduced poaching syrup.

Why it works — Tea's catechins lend the poaching liquid a structured astringency that the pear absorbs, so the finished fruit has grip as well as sweetness — the dry edge that keeps a poached pear from being merely sugary. Sweetening with Reb M rather than a cup of sugar keeps the dish's sweetness clean and light on TAS1R2/TAS1R3 while the tannins on the PRPs provide the frame. The two axes, sweet and astringent, meeting in one spoonful.

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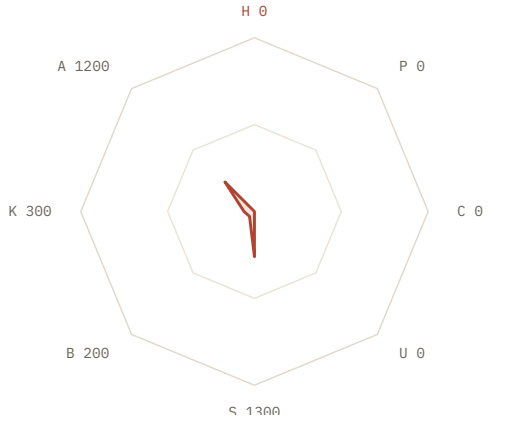

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IFI-B	200
IFI-K	300
IFI-A	1,200



PART V OF V

The Everyday Table

Putting eight axes on a weeknight plate · composition · nourishment · grace

Chapter 13 · Beans, Grains & the Center of the Plate — *where meat used to be asked to stand.*

Every cuisine has a center-of-the-plate problem, and for a vegetarian it is the most honest one to solve: what holds the middle, carries the protein, and gives the meal its weight when there is no roast at the center? The answer this book has been building toward is that the center does not need to be a single heroic object at all. It needs umami to anchor it, kokumi to give it body, and enough protein to satisfy — and all three can be grown, cultured, and composed from plants.



Soybean — 360 constructs across the U/K axes; the legume that carries both savory depth and body, and the protein that lets a plate stand on its own.

The protein-and-savor organisms

The soybean is the quiet workhorse here — **360 constructs** across the **U/K** axes, difficulty rated frontier — tuned to carry both umami and kokumi, which is why soy in its thousand forms (tofu, tempeh, miso, tamari) has anchored vegetarian plates across Asia for millennia. Our work raises and stabilises the glutamate and γ-glutamyl peptide content so a block of tofu, braised, delivers savory body rather than blankness. Alongside it, **koji mold** (80 constructs, U) pre-digests legume and grain proteins into free glutamate through fermentation — the engine of miso, tamari, and shio koji — and the grains themselves, **corn** (Storm, a frontier concept) and **rice** (Dynasty, frontier), carry the starch and the structure.

> A plate stands when three things are true: it is savory enough to satisfy the glutamate-seeking tongue, it has the continuous body that kokumi provides, and it carries enough protein to leave you full. None of the three requires an animal. All three can be grown toward.

The protein question, answered plainly

The oldest objection to a vegetarian plate is the protein one, and it deserves a plain, honest answer rather than a defensive one. Protein is built from twenty amino acids, nine of which the human body

cannot make and must eat — the *essential* amino acids. Animal flesh carries all nine in roughly the proportions the body uses, which is the entire basis of the "complete protein" idea. No single plant does — most grains run low on lysine, most legumes run low on the sulfur amino acid methionine — and for a century this was read as a deficiency of plant eating. It is nothing of the kind. The grain's shortfall is the legume's surplus and the reverse: **beans and rice, lentils and wheat, tofu and sesame** — the pairings that nearly every traditional vegetarian cuisine arrived at independently, long before anyone could name an amino acid — combine to cover all nine essential acids completely. The body, moreover, pools amino acids across a day; the pairing need not even share a plate. The center of a vegetarian meal was solved by grandmothers before it was solved by biochemists, and the biochemistry only confirms the plate.

Where our work enters is not the protein count — a cup of cooked soybeans carries as much protein as an egg, and we do not need to engineer that — but the *flavor* that makes a high-protein plant worth eating often enough to matter. A nutritionally perfect bowl of beans that tastes of nothing gets cooked once. The soybean's engineered umami and kokumi (U/K), the koji's liberated glutamate, the long alliums' peptides — these are what turn the protein source from a duty into a dinner you reach for. Nourishment that is not eaten nourishes no one; flavor is how the protein gets to the table.

The fermentation shortcut

Fermentation deserves its own line here, because it solves savor and protein at once. When koji, or the bacteria of a miso, or the cultures of a tempeh work on a legume, they do two things simultaneously: their proteases liberate free glutamate and kokumi peptides for savor, *and* their metabolism pre-digests the bean's proteins and neutralizes its anti-nutrients, making the protein more available to the body. A block of tempeh is more savory *and* more digestible than the soybeans it came from — the same microbial work serving taste and nourishment in one step. It is the oldest version of this book's whole thesis: that done right, making a plant taste better and making it feed you better are not two projects but one.

Recipe · Soy-Braised Tofu, Koji, Scallion

Serves 4 · 30 minutes · the center of the plate, built from the legume up.

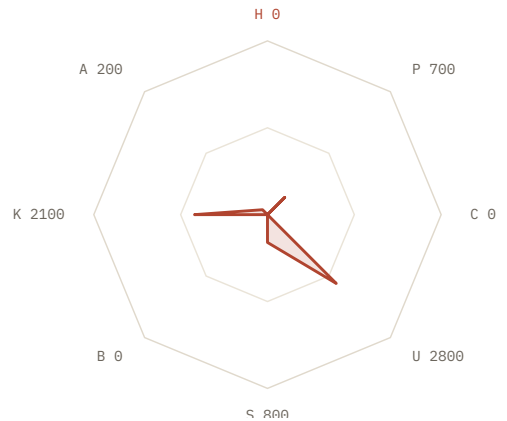
```
400 g       firm tofu, in thick slabs, pressed
2  tbsp     tamari · 1 tbsp shio koji · 1 tbsp maple or Reb-M syrup
3  cloves   garlic, grated · 20 g ginger, grated
200 ml      vegetarian dashi
            scallions · sesame oil · rice to serve
```

1. Sear the pressed tofu slabs in oil until golden and crisp on both faces.
2. Add garlic, ginger, tamari, koji, sweetener, and dashi. Simmer until the braise reduces to a glossy glaze that coats the tofu, ten minutes, spooning it over.

3. Finish with scallions and a few drops of sesame oil; serve over rice.

Why it works — This is the whole book in one bowl. The tofu brings soy's engineered umami and kokumi (U/K); the koji's enzymes liberate still more free glutamate at the surface; the dashi adds the glutamate-GMP multiplier; the ginger lays a warm TRPA1 pungency over the top. The result is a center-of-plate dish with savory depth, body, and protein — standing entirely on plants, imitating nothing.

IFI PROFILE



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IFI-C	0
IFI-U	2,800
IFI-S	800
IFI-B	0
IFI-K	2,100
IFI-A	200

Recipe · A Big Pot of Beans, the Foundation Dish

Serves 6, and better the next day · 2 hours mostly unattended · the dish to build a week on.

500 g	dried beans (borlotti, cannellini, or chickpeas), soaked overnight
1	onion, halved · 1 head garlic, halved crosswise
2 tbsp	olive oil · 1 strip kombu · bay · thyme
	flaky salt

1. Drain the beans and cover with fresh water by two inches. Add the onion, garlic, kombu, herbs, and oil. Do not salt yet.
2. Bring to a bare simmer and cook gently until the beans are completely tender and the broth has turned silky, 1½ to 2 hours. Salt generously only in the last twenty minutes.
3. Fish out the kombu (or chop it back in). Keep the beans in their broth; it is liquid gold.

Why it works — The kombu is doing quiet, essential work: its glutamate joins the beans' own gentle savor, and across the long cook the garlic and onion release γ-glutamyl peptides that build kokumi into the broth. Salting late keeps the bean skins tender. What you get is not a pot of plain beans but a savory, bodied foundation — the base of soups, the filling of a bowl, the thing you crush onto toast all week. No bone, grown and built in.

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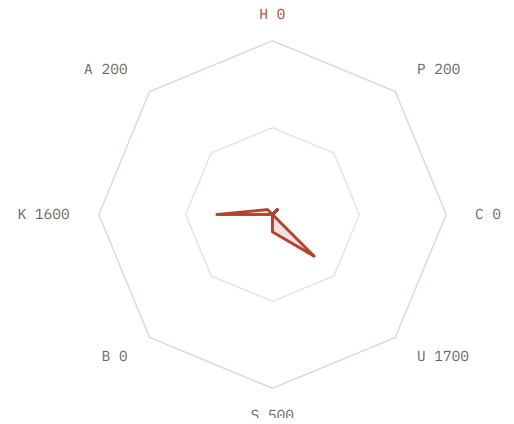

IFI-H	0
IFI-P	200
IFI-C	0
IFI-U	1,700
IFI-S	500
IFI-B	0
IFI-K	1,600
IFI-A	200

Recipe · Charred Corn, Lime, Yeast

Serves 4 · 15 minutes · sweetness and savor off a single cob.

4		ears corn, husked
2	tbsp	olive oil or butter
2	tbsp	engineered nutritional yeast
		chili-lime salt · 1 lime · chopped coriander

1. Char the corn directly over a flame or in a dry hot pan until blackened in spots and the kernels pop.
2. Roll in butter or oil, dust with nutritional yeast and chili-lime salt, squeeze lime, scatter coriander.

Why it works — Corn is high in natural sugar and, when charred, develops deep Maillard savor; the engineered yeast adds a concentrated umami-kokumi dusting (U/K) that stands in for the usual cheese, while the lime and chili bring acid and a warm TRPV1 edge. Sweet, savory, bright, and warm off one cheap cob — the four-axis street-food trick, made vegetarian and whole.

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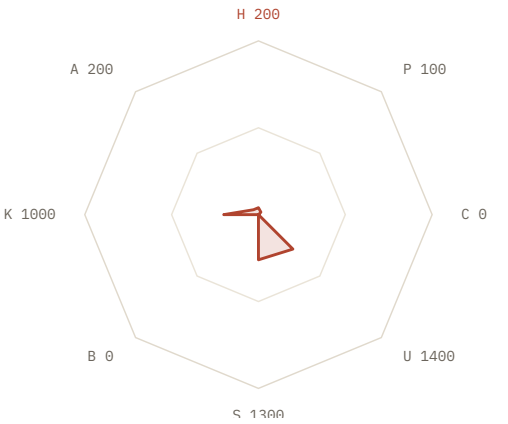


IFI-H	200
IFI-P	100
IFI-C	0
IFI-U	1,400
IFI-S	1,300
IFI-B	0
IFI-K	1,000
IFI-A	200

Chapter 14 · Composing a Plate on Eight Axes — *the mathematics of balance.*

By now you have met all eight axes one at a time. The art of this kitchen — the thing that turns a set of good ingredients into a plate that feels complete — is composition: holding several axes at once, in a balance that the tongue reads as *whole*. This is not a mystical skill. It is close to arithmetic, and the Index makes it legible.

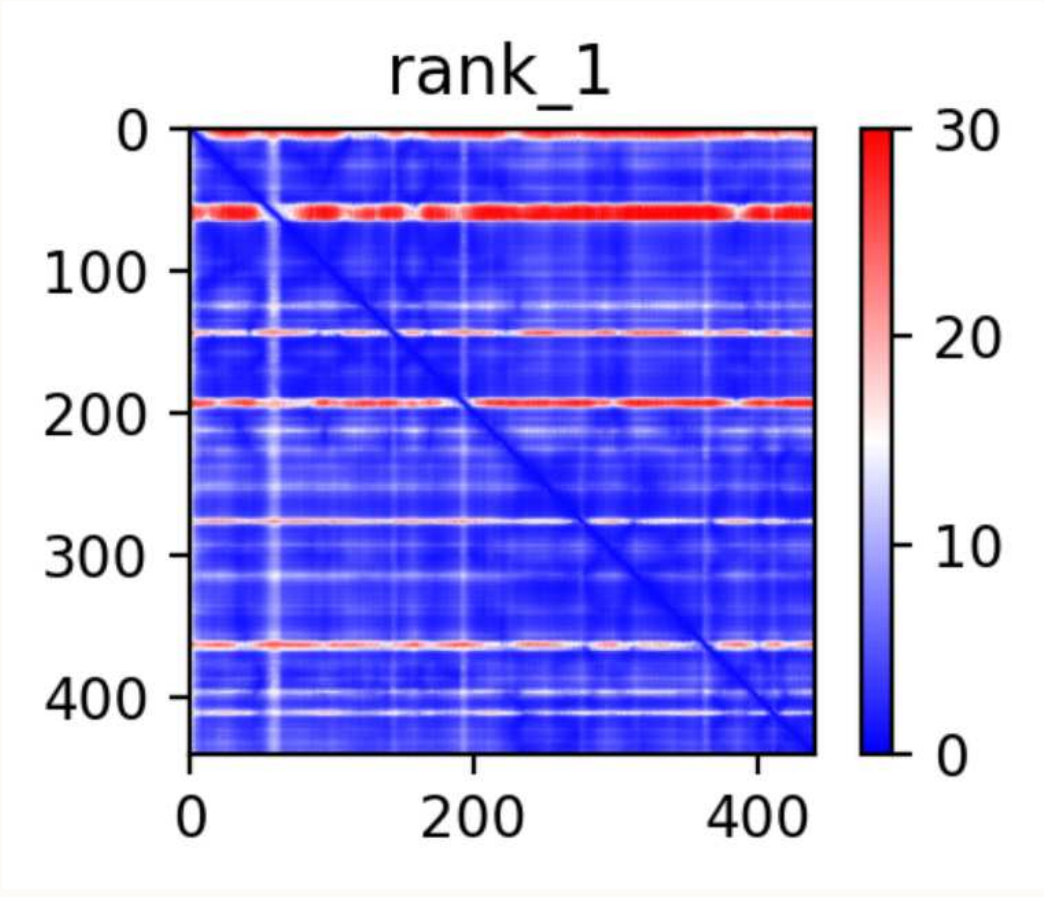


FIG. — the predicted aligned error map from our structural modeling; the same mathematics that validates an enzyme model governs how axes compose on a plate.

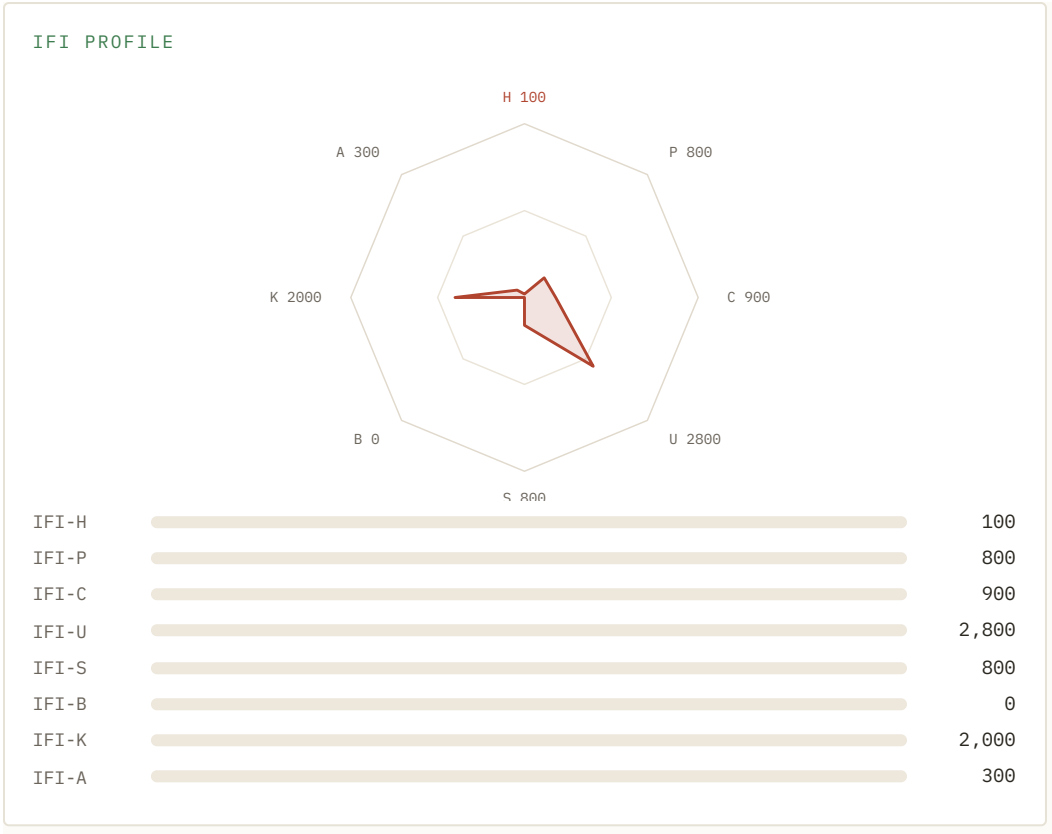
Axes interact — they do not simply add

The crucial fact, and the one that separates real cooking from stacking strong flavors, is that the axes are not independent. They interact at the level of the receptor and the nerve, sometimes multiplying, sometimes cancelling:

- **Umami × kokumi (synergy).** Kokumi's γ-glutamyl peptides on CaSR directly amplify and lengthen the umami signal. This is the most important synergy in the book; it is why the mushroom ragù and the braised tofu taste so deep. On the Index, a dish's perceived savor runs ahead of the sum of its U and K scores.
- **Umami × ribonucleotides (synergy).** The 1,218·g·r product term from Chapter 3 — the glutamate-GMP multiplier — is a second, independent savory multiplication.
- **Sweet × heat (contrast enhancement).** A trace of TRPV1 warmth sharpens perceived sweetness; a little sweetness rounds the edge of heat. They do not cancel — they frame each other. This is the swicy principle, and it runs the strawberry-and-chili dessert.
- **Heat × cool (cancellation).** Capsaicin on TRPV1 and menthol on TRPM8 report opposite imaginary temperatures on neighbouring nerves; served together, each dulls the other's edge. This is why the mint raita tames the braise.
- **Astringency × richness (balance).** Tannins on the PRPs cut the coating of fat and kokumi, resetting the palate. Richness without astringency cloys; astringency without richness scours.
- **Bitter × sweet (masking).** Sweetness partially masks bitterness at the perceptual level, which is the old trick of sugar in coffee — and why attenuating bitterness directly (IFI-B) lets you use far less sweetness to reach balance.

A worked composition

Think of a plate as a vector of eight numbers, and balance as a shape rather than a height. A plate that scores high on one axis and zero on the rest tastes loud and thin — a single note held too long. A plate that holds a thoughtful handful of axes at moderate values tastes complete. Consider the braised-tofu bowl over rice, with a spoon of ginger-scallion oil and a side of mint-cucumber raita — a full dinner, read as one scorecard:



Read the shape: a deep savory core (U 2,800, K 2,000, amplified by their synergy), a bright pungent lift from the ginger and scallion (P 800), a cooling counter from the raita that keeps the richness from closing in (C 900), and just enough sweetness (S 800) to round the tamari's salt. No single axis dominates; the plate is a balanced polygon, not a spike. That is what *complete* looks like as a number. You will not cook with a calculator. But once you can see the shape, you can feel when a plate is missing a side — too rich with no grip, too hot with no cool, too savory with no lift — and reach, precisely, for the axis that finishes it.

The interaction matrix

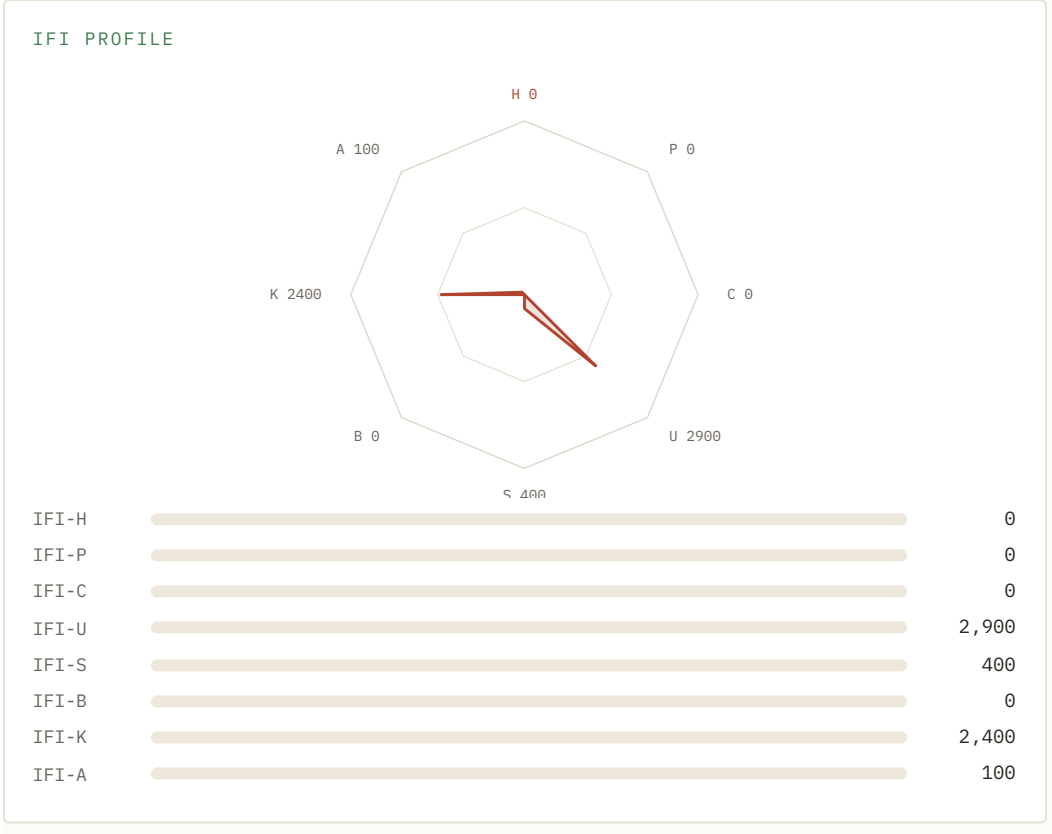
Here is the whole grammar of composition on one card — how each axis behaves when it meets another. Read a row as *this axis, in the presence of that one*:

PAIRING	INTERACTION	WHAT IT DOES ON THE PLATE
Umami × Kokumi	synergy (CaSR amplifies glutamate)	the deepest savor; the meatless braise
Umami × Ribonucleotide	synergy (1,218·g·r product)	the mushroom-in-tomato multiplier
Sweet × Heat	contrast enhancement	each frames the other; the swicy lift
Sweet × Bitter	masking	sweet hides bitter; so less sweet is needed once bitter is tuned down
Heat × Cool	cancellation	opposite false temperatures; mint tames chili
Astringent × Rich	balance	tannin cuts fat and kokumi; resets the bite
Salt × Umami	threshold lowering	salt unmasks glutamate; savory tastes louder
Astringent × Sweet	structure	grip keeps a sweet dish from going slack

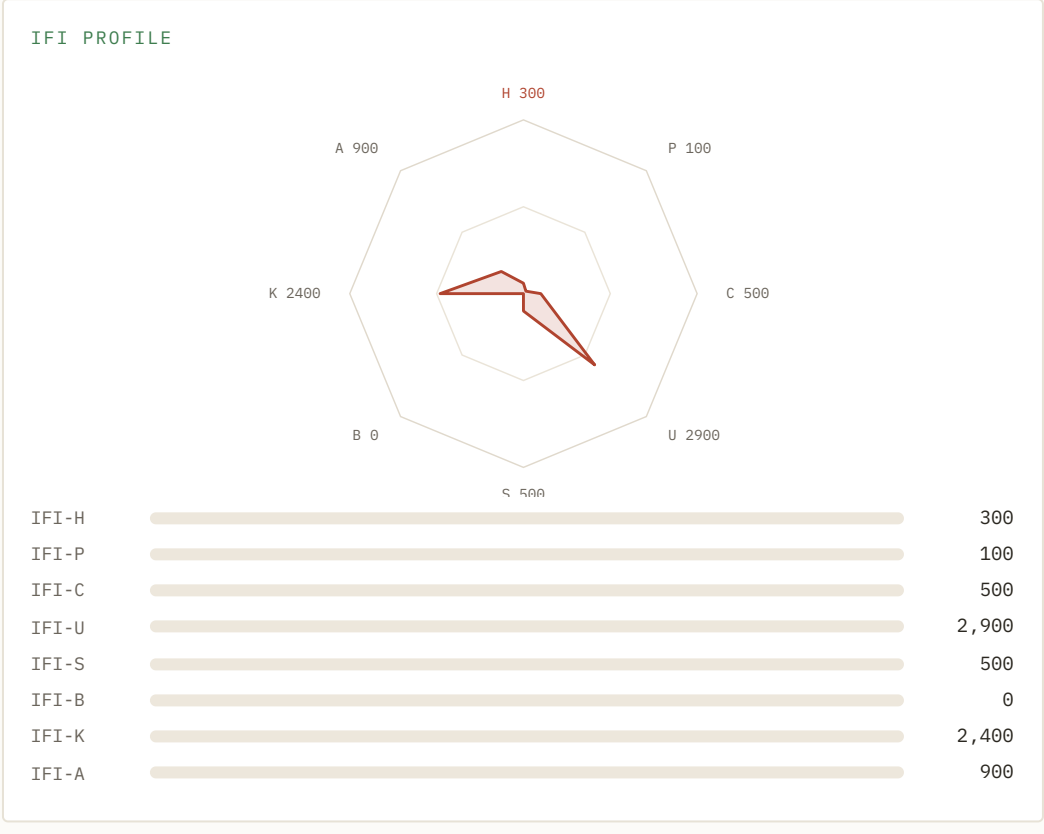
Memorize nothing. Cook a hundred dinners and the matrix becomes instinct — but the instinct is this, and seeing it written is how you get there faster.

Fixing a plate by its numbers

The most useful thing composition offers is a diagnosis. A plate that disappoints is almost never *bad*; it is almost always *missing a side*. Suppose you have made a rich mushroom-and-bean stew and it reads, honestly, like this:



Powerful — and slightly oppressive. The savory core is enormous (U 2,900, K 2,400) and there is almost nothing to cut it: astringency at 100, no acid lift, no bright top. The tongue, flooded with richness and given no grip, reads the bowl as heavy and begins to tire of it by the third spoonful. The matrix tells you exactly what to reach for. A hard squeeze of lemon and a scatter of pomegranate seeds lift astringency and acid; a few torn mint leaves add a cool top; a pinch of chili wakes the whole thing on TRPV1. The second scorecard:



Nothing was removed; the savor is untouched. But the plate now has sides — grip (A 900) to cut the richness, a cool top (C 500), a warm edge (H 300) — and it tastes, suddenly, finished. This is the whole discipline: not making flavors louder, but noticing which side of the polygon is flat and filling it in. A vegetarian kitchen, which builds its richness on purpose, needs this diagnosis more than any other, because grown-in umami and kokumi are generous to a fault. The axis you add last is usually the one that makes the meal.

Chapter 15 · A Week of Dinners, Scored — *the proof, seven nights running.*

Here is a week of weeknight dinners, each built from the principles of this book, each fast, each scored. They are not showpieces. They are Tuesday. The point of scoring them is not to cook by number but to show that balance is reproducible — that a plant kitchen, grown and composed on purpose, delivers a complete plate every night without a single thing borrowed from an animal and without anything missing.



The everyday harvest — what a week of dinners is grown from, long before it reaches the pan.

Monday · Tomato & white bean stew. The Twenty-Minute Sugo (Chapter 2) loosened with a ladle of bean broth and a tin of white beans, finished with oil and basil. Savory, round, fast.

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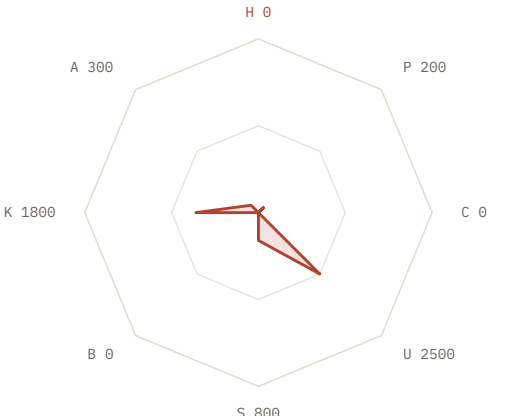

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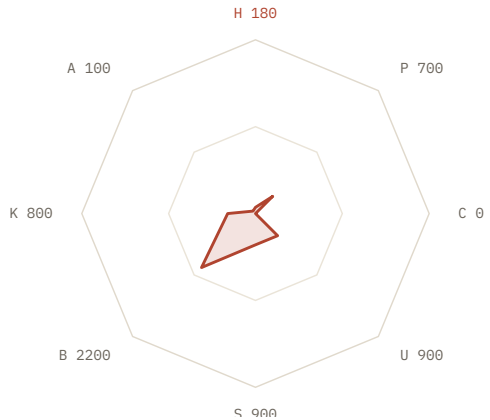
IFI-C	0
IFI-U	2,500
IFI-S	800
IFI-B	0
IFI-K	1,800
IFI-A	300

Tuesday · Charred broccoli, soft egg, rice. The Charred Broccoli (Chapter 6) over rice with a jammy egg and ginger-scallion oil. The egg's richness, the broccoli's sweet char, the oil's lift.

IFI PROFILE



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IFI-U	900
IFI-S	900
IFI-B	2,200
IFI-K	800
IFI-A	100

Wednesday · Shiitake noodle bowl. Vegetarian dashi (Chapter 3) over noodles, the soft steeped shiitake, greens, a spoon of chili oil. The multiplier in a bowl.

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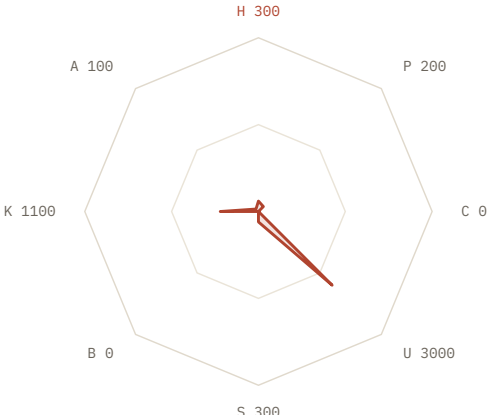

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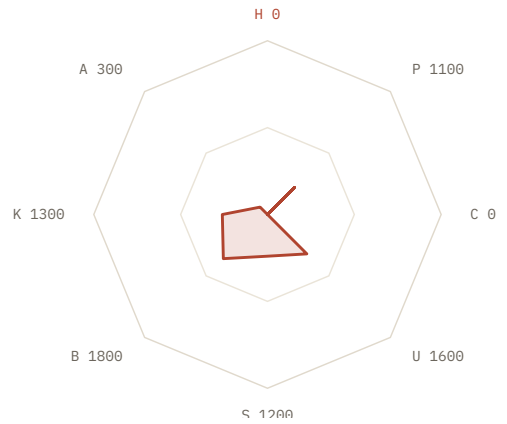
IFI-P	200
IFI-C	0
IFI-U	3,000
IFI-S	300
IFI-B	0
IFI-K	1,100
IFI-A	100

Thursday · Cabbage steaks, beans, salsa verde. The Cabbage Steaks (Chapter 6) with a scoop of the Big Pot of Beans and a spoon of garlic-scape salsa verde. Sweet, savory, sharp.

IFI PROFILE



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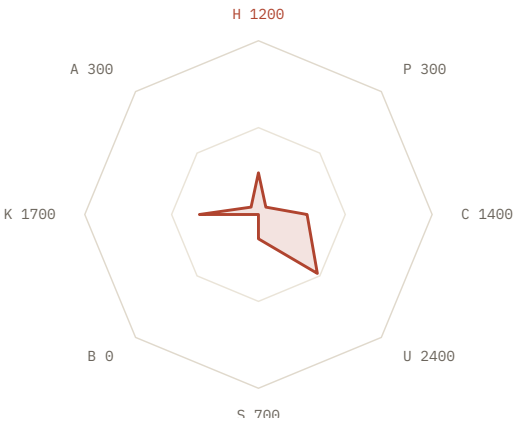
IFI-C	0
IFI-U	1,600
IFI-S	1,200
IFI-B	1,800
IFI-K	1,300
IFI-A	300

Friday · Three-alarm braise, rice, raita. The laddered braise (Chapter 8) with rice and the cucumber-mint raita (Chapter 10), heat to each diner's rung. The whole table, one pot.

IFI PROFILE



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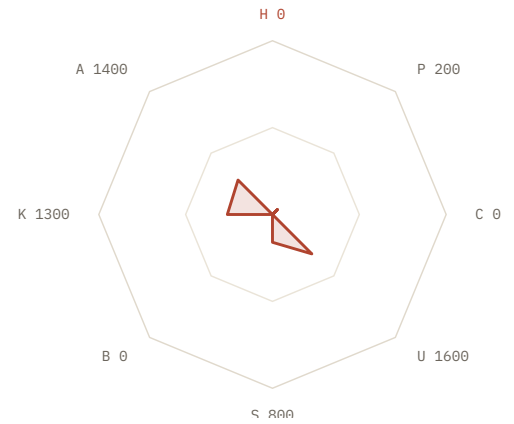
IFI-U	2,400
IFI-S	700
IFI-B	0
IFI-K	1,700
IFI-A	300

Saturday · Pomegranate eggplant, flatbread, yogurt. The glazed eggplant (Chapter 12) torn into warm flatbread with yogurt and herbs. Rich, dry-bright, balanced.

IFI PROFILE



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IFI-S	800
IFI-B	0
IFI-K	1,300
IFI-A	1,400

Sunday · Mushroom ragù, polenta. The ragù (Chapter 3) over soft polenta — the slow dish for the end of the week, savory and deep, standing where a meat sauce used to.

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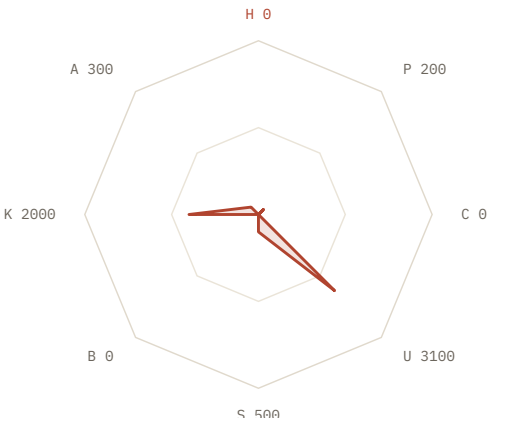

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IFI-P	200
IFI-C	0
IFI-U	3,100
IFI-S	500
IFI-B	0
IFI-K	2,000
IFI-A	300

The pantry this week runs on

None of these dinners is a project, because all of them draw on the same short list of grown-in and cultured savor. Keep these on hand and the week assembles itself: a jar of **vegetarian dashi** (or just dried shiitake and kombu to make it), a tub of **engineered nutritional yeast**, a jar of **shio koji**, a bottle of **tamari**, the week's **big pot of beans** in its broth, **restored tomatoes** fresh or tinned, a head of **garlic** and a bag of **onions**, a knob of **ginger**, a bunch each of **mint** and **scallions**, a jar of **chili** in a form you trust, and a bottle of good

olive oil. That is the whole savory engine of this book — glutamate, ribonucleotides, kokumi peptides, pungency, heat, and cool, in nine or ten ingredients that keep for weeks. Everything else is the fresh vegetable of the day, which is the part that should change with the season anyway.

Look back across the seven scorecards and you will see the shape of a well-fed week: umami always present as the floor, kokumi riding with it for body, the other axes rotating through — a bitter-attenuated night, a cooling night, a pungent night, an astringent night — so the palate is never bored and never, on any night, left wanting. That is the whole claim of this book, served as dinner and shown as data.

Chapter 16 · The Nourishment Note — *where taste and goodness turn out to be one act.*

We have kept something quiet through fifteen chapters, and it is time to say it plainly, once, carefully. The reason we cook this way, and the reason we design plants at all, is not only flavor. It is that flavor and nourishment, when you trace them back into the living plant, keep turning out to be the same project — and a vegetarian kitchen is where that truth is easiest to see and most worth honoring.



The whole plant, grown toward the most it can hold — because the pathways that pool the flavor pool the nourishment with it.

Recall the mechanisms, now read for what else they carry. When we restored the tomato's umami by tuning its native nitrogen metabolism — the GAD/GDH1 balance — we did not only pool free glutamate. We restored the amino acid metabolism that also governs the fruit's protein and its antioxidant content; the lycopene and the vitamin C ride home on the same restored pathways as the savor. When we attenuated the Brassica's bitterness, we did it by shifting the glucosinolate profile *while preserving* the precursors that yield sulforaphane — so the broccoli that finally tastes good keeps the chemistry that made it worth eating. When we let a fruit reach and hold its true ripeness, we let it hold its full complement of the compounds that ripeness builds. Flavor was the signal all along. A tongue that seeks glutamate is seeking protein; a tongue that trusts sweetness is seeking safe energy; a tongue wary of bitterness is an ancient, imperfect guard. We are not overriding that wisdom. We are tuning the plant so the signal and the substance line up again, the way they did before breeding pulled them apart.

> Food should be grown to carry the most nourishment it can, and the body should be able to draw the most from it. Designing flavor and designing nourishment are, in the plant, the same act. We will not make a claim of it. We will only keep growing it that way.

There is a second half to that sentence worth sitting with: *the body should be able to draw the most from it.* Nourishment is not only what a food contains but what the body can actually take up from it — its bioavailability — and here, too, flavor and goodness keep turning out to be the same lever pulled twice. The fat in the olive oil that carries a dish's aroma is the same fat that ferries its fat-soluble vitamins and its lycopene across the gut wall; a tomato eaten with oil gives up far more of its lycopene than a tomato eaten dry. The gentle cooking that caramelizes a Brassica and softens its bitterness is the same heat that breaks down cell walls and frees the nutrients inside. The fermentation that deepens a tempeh's savor is the same microbial work that neutralizes the anti-nutrients blocking its minerals. Again and again, the technique that makes a plant taste better is the technique that lets the body have more of it. We did not arrange this. We only noticed it, and stopped treating taste and nourishment as if they were ever at odds.

And still we hold the line, because the line is the honest thing. These are attributes and intentions — measurable, modest, real — never claims. We do not say any plate in this book treats or prevents or cures. We say that a plant grown toward its fullest flavor is grown toward its fullest self, that a meal composed with care and eaten with pleasure is a good way to give your body the plants it was built to want, and that the humility about the rest is not a hedge but the respect the subject deserves. The nourishment is real. We let the food be food, and we set the table with intention. That is the whole of it.

Here is the line we hold, and the reason we hold it. This is a value and an intention, never a claim. We do not say any dish in this book cures, treats, detoxifies, or heals anything, because that is not ours to say and it is not true in the way such words pretend. We say only, and exactly, what is measurable: that a plant grown toward its fullest flavor is a plant grown toward its fullest self, and that a plate composed with intention is a good way to give your body the plants it was built to want. The nourishment is real. The humility about it is the point. We feed the people we love with care, and we let the food be food.

Chapter 17 · A Closing Grace — *on feeding the people you love, on purpose.*

We did not write this book to convert anyone, and not to prove that plants can stand in for meat. We have never thought of our cooking as standing in for anything. We wrote it because we have eaten this way our whole lives — a family at a table, night after night — and because we finally have the tools to say, down to the receptor, why those plates were always enough.



Dawn in the greenhouse, where it begins — a plant grown back to all of itself, for a table it will never see.

Everything in these pages comes back to one small, stubborn idea: that the flavor of a plant does not have to be an accident. That a tomato can be grown back to all of itself, that a vegetable can be made to taste the way it was meant to instead of the way a truck preferred, that heat can arrive with a shape and sweetness without a cost, that the savory floor meat was always invited in to hold can be grown and cultured and composed from plants alone — not imitated, not faked, *built*, from the plant's own biochemistry, measured on eight honest axes.

And meat, where it belongs on other tables, we honor with the same respect — no apology runs under this book, in either direction. We simply cook what we have always cooked, now on purpose, now with the numbers to show the intention. The Index was never meant to replace the pleasure or the love. It was meant to let us grow dinner deliberately, and to prove to anyone who doubted that a plate without meat is not a plate with a hole in it. It is whole. It was always whole.

Cook these for the people you love. These are computational designs; Scoville Splice's cultivars and constructs have not been experimentally validated in a laboratory. Grow the plants back toward themselves if you can, taste the intention, and read it on the scorecard if you like — but mostly, just set the table. That was always the whole point of measuring anything.

— written, as all of these are, in the family "we," from a kitchen that never needed meat to be full.