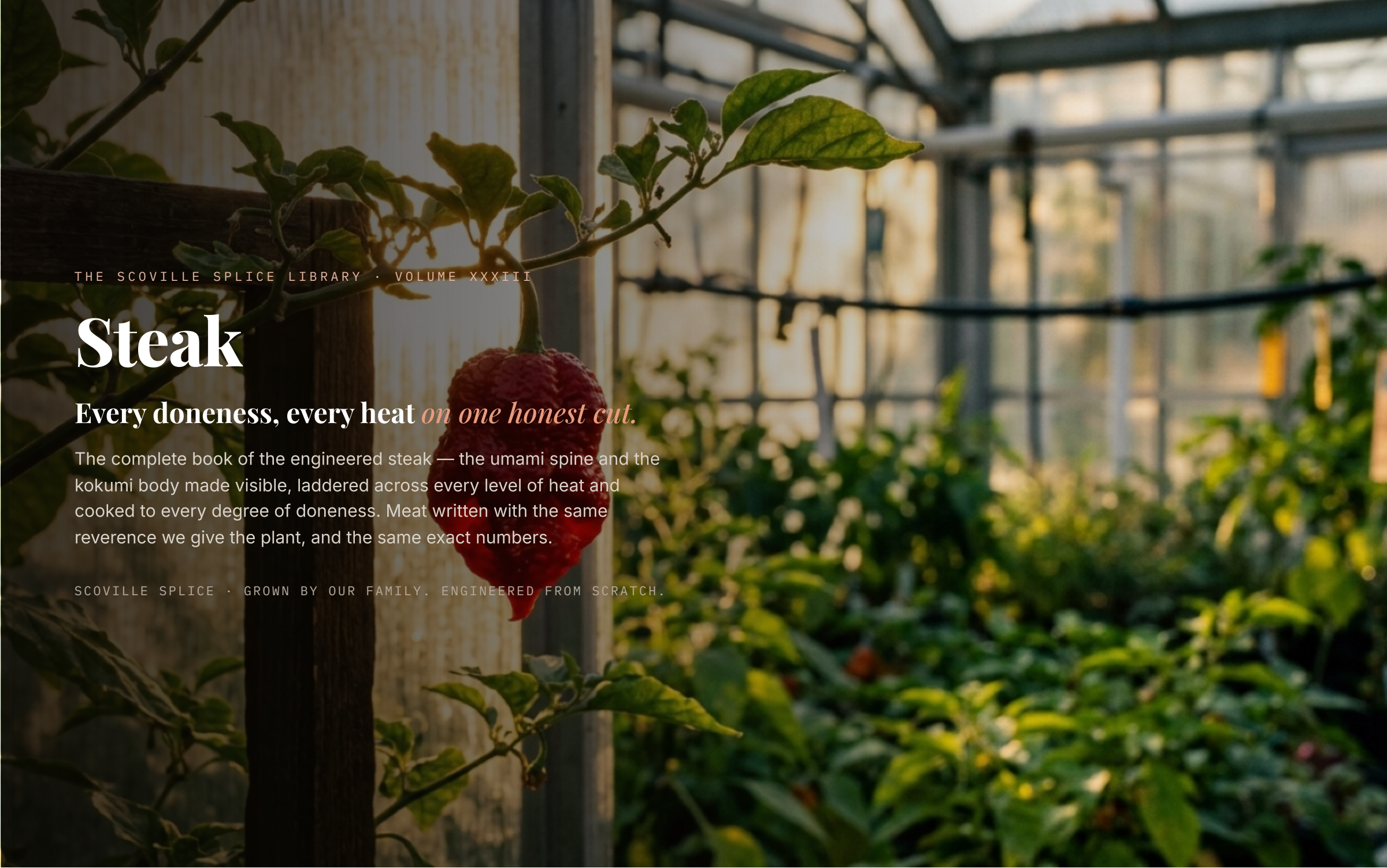

THE SCOVILLE SPLICE LIBRARY · VOLUME XXXIII

Steak

Every doneness, every heat *on one honest cut.*

The complete book of the engineered steak — the umami spine and the kokumi body made visible, laddered across every level of heat and cooked to every degree of doneness. Meat written with the same reverence we give the plant, and the same exact numbers.

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

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Opening essay · The honest cut

We are a vegetarian-first family, and this is a whole book about a steak. We want to say plainly, at the top, that there is no contradiction in that — and no apology coming either. Reverence for what we eat is not a diet; it is an attention. We have spent years learning to read a tomato down to the half-activation of a single receptor, and the same attention, turned on a seared crust and a rested interior, finds exactly as much to honor. A great steak is not a lesser subject. It is one of the densest flavor objects a kitchen ever handles, and almost everyone cooks it blind.

So we wrote it the way we write everything: reverent, and then exact, and then reverent again — because the numbers are a form of respect, and because you cannot cook well to a thing you cannot measure.



Dawn in the research greenhouse — the attention we bring to a tomato is the same attention this book brings to a crust.

Here is the thesis, and it runs under every page. **We do not engineer the animal.** We never have and we have no wish to. What we engineer are the plants that stand on the plate beside it — the tomato in the jus, the garlic in the butter, the koji on the dry-aged surface, the pepper in the crust — and we design them so that the whole plate speaks *louder and cleaner* on the eight axes of the Iyengar Flavor Index. A steak is already rich in the two savory axes, umami and kokumi; it carries them the way few foods do. Our work is to meet that richness with a pantry tuned to amplify it, to never fight it, and to hand you the dial for exactly how much heat rides alongside.

Every axis in this book is a single number anchored to a receptor:

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

EC_{50} is the concentration at which a compound drives its receptor to half of full response. Invert it against a fixed reference, scale by a thousand, and *loudness* becomes a score — so a dry-aged ribeye, a hit of green peppercorn, and a spoonful of designed tomato can be read against one another on a single card. We do not score a steak to replace the pleasure of it. We score it because the two things people most want from a steak — depth and doneness — are the two things a number controls best.

This book is built on a grid, and the grid is the promise on the cover: **every doneness, every heat.** Down one side runs the doneness ladder, which is nothing more romantic than the staircase of temperatures at which muscle proteins unfold — myosin near 50 °C, collagen near 62 °C, actin near 66 °C — and the exact degree where juice and tenderness are both still yours. Across the top runs the heat ladder, our ten proof-of-concept superhots from a 40-SHU whisper to **Phoenix at 4,200 IFI-H** — our model predicts approximately 2.95 million SHU, a plant we wrote gene by gene because the plant that could reach it did not yet exist. The whole book is the cells of that grid, filled in: this cut, this degree, this much fire, and the sauce and the side that complete it.

There is a quieter thing running under the rigor, too, and we will name it once and then let it hum. We believe food should be grown to carry the most it can — the most flavor and the most nourishment, which to us were never two separate projects — and that a meal eaten with intention is a meal that gives the body more of what it came for. That is a value, not a claim. We will make no promise here about your health; we will only cook, as we always do, as though what is on the plate matters. A steak, cooked to the degree and built out with plants grown to their fullest, is exactly that kind of meal. Let us show you how to read it.



PART I OF IV

How a Steak Speaks

IFI-U · mGluR1 / TAS1R1·R3 — IFI-K · CaSR — the Maillard crust — the doneness ladder

Chapter 1 · Umami, the spine — *the savory axis a steak was built to carry.*

Cut into a rested ribeye and the first thing the tongue registers, before heat and before fat, is a low brothy depth that seems to come from inside the meat rather than from any seasoning — the taste of something nourishing arriving. That depth is umami, and it is not a mood or a mouthfeel. It is a molecule finding a receptor, a billion times a second, and we can write down exactly which molecule and exactly which receptor and exactly how loud.

The molecule is L-glutamate, the free amino acid, unbound from any protein. The receptor is twofold, and the Index names both: the metabotropic glutamate receptor **mGluR1**, a class-C G-protein-coupled receptor on the tongue's taste cells, and the heterodimer **TAS1R1·TAS1R3**, which carries a large clamshell "Venus flytrap" domain in its extracellular reach. Glutamate settles into the cleft of that clamshell; the two lobes close around it; the closure is transduced inward as the signal we read as savory. IFI-U is anchored to the half-activation of that closure. A wild tomato scores near 300. The dry-aged beef on your board, before you have done anything to it but age it, is already speaking in this register — a muscle is a glutamate reservoir, and time only makes it louder.



FIG. 1 — A designed tomato in cross-section: the locular jelly around the seeds is where free glutamate concentrates. The steak and the tomato speak the same axis.

Here is where a steak becomes genuinely interesting, and where the mathematics earns its place at the table. Glutamate is only half of the savory story in meat. The other half is a nucleotide — **inosine-5′-monophosphate**, IMP — and IMP on its own is nearly tasteless. What IMP does is bind a second site on the TAS1R1 clamshell, adjacent to the glutamate cleft, and lock the flytrap shut. It is an allosteric potentiator: it does not add its own savor, it makes the glutamate's savor *carry further*. In the language of the Index, IMP does not add to IFI-U; it lowers the EC_{50} of glutamate — shifts the whole dose-

response curve to the left — and because IFI-U is the reciprocal of that EC_{50}, the score climbs. The potentiation is not small. The classic relation worked out by Yamaguchi for the perceived umami of a glutamate–nucleotide mixture takes the form

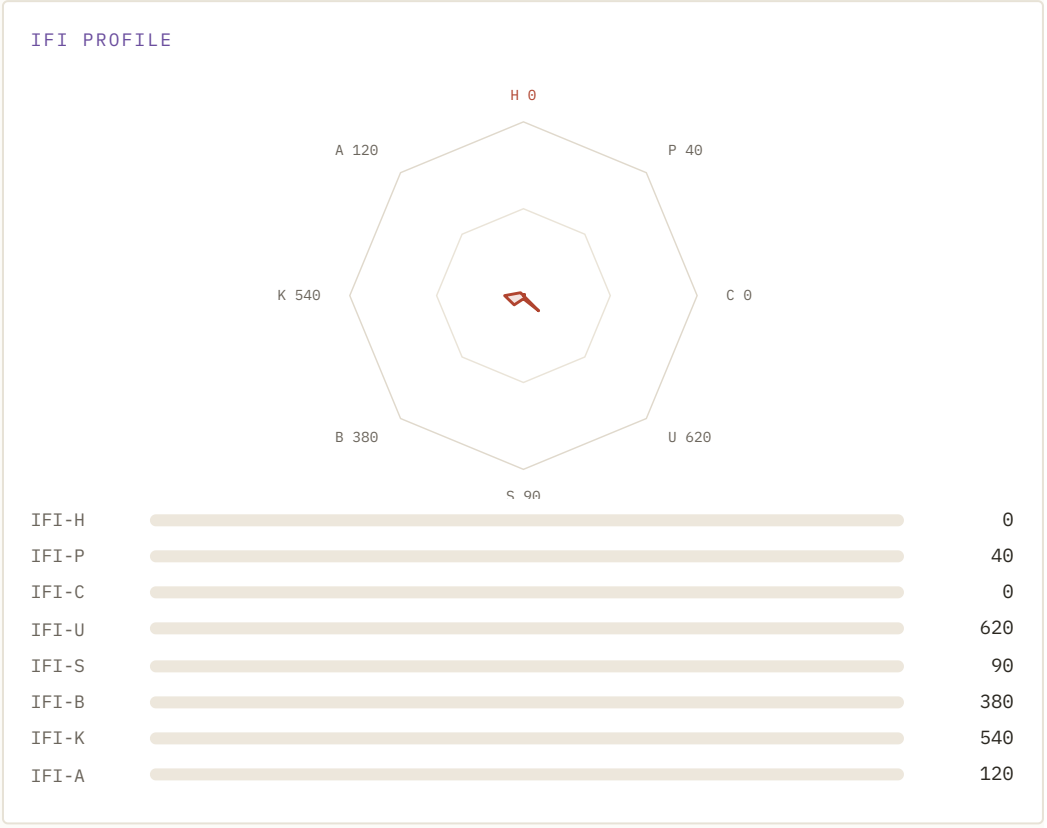
$$y = u + 1218 \cdot u \cdot v$$

where u and v are the glutamate and nucleotide fractions. That constant, 1,218, is the whole secret of a steak. A trace of IMP against a modest pool of glutamate multiplies the savory signal manyfold — in practice, up to roughly eightfold at the receptor. Meat carries both, in the same tissue, at the same time. That is why a steak tastes the way it does and a plain amino-acid solution does not.

But IMP is perishable in a way glutamate is not, and this is the hinge the rest of the book turns on. The moment an animal is harvested, the ATP in its muscle begins a one-way walk downhill:

STEP	SPECIES	TASTE
ATP → ADP → AMP	energy currency	neutral
AMP → **IMP**	the umami nucleotide	savory peak
IMP → inosine (HxR)	breakdown begins	fading
inosine → hypoxanthine (Hx)	end of the road	**bitter, off**

IMP builds in the first hours and then slowly erodes; hypoxanthine, which is frankly unpleasant, accumulates at the end. Fish scientists built a number for exactly this, the K-value — the fraction (HxR + Hx) of the whole nucleotide pool — and a low K-value means a high IMP, which means the glutamate you have is being amplified rather than wasted. A great steak lives inside a window: late enough that proteolysis has freed a generous pool of glutamate, early enough that the IMP has not yet walked off into bitterness. Dry-aging is the craft of widening that window on purpose, and we will give it its own chapter.



Above is the savory baseline we fight to beat: a competent supermarket steak, well seared, seasoned with nothing but salt. Real umami is there — U near 620 — but it is a muscle doing the work

alone, with no aging to build glutamate and a season-to-season swing of ±40 % batch to batch. Everything this book does to that number — aging it, meeting it with a designed tomato, finishing it in a koji butter — is a deliberate push leftward on the glutamate EC_{50}, and every push is a number we can predict before the pan is hot. A worked example makes it concrete. Take the wild-type tomato's glutamate half-activation as our reference, $EC_{50}(ref) = 1.00$ in normalized units. Our umami-restored tomato, with its free-glutamate pool rebuilt and a whisper of nucleotide alongside, activates at $EC_{50}(c) = 0.385$. Then IFI-U = 1000 · 1.00 / 0.385 ≈ **2,600** — the same restored tomato that, in the flagship volume, climbed from 300 to 2,600 through the native GAD/GDH1 route. That is not a tasting note. That is a target, and in the next chapters we spend it on a steak.

Chapter 2 · Kokumi, the body — *the axis you have tasted all your life and never had a word for.*

There is a quality in a long-aged ribeye, a mature Gouda, a spoonful of good fish sauce, a clove of roasted garlic, that umami alone cannot explain. Richness is the usual word, or depth, or body, or that uselessly perfect Japanese term *kokumi* — "rich taste." It is the sense that a flavor has *thickness* and *continuity*, that it fills the whole mouth and keeps arriving after the first hit, that it lingers and coats rather than flashing and leaving. For most of culinary history it was considered unmeasurable, a thing great cooks had and could not teach. It is the sixth axis of the Index, IFI-K, and it is not mysterious at all. It is a receptor, and it is a class of peptide, and we can build both.



FIG. 2 — Garlic, our densest kitchen source of γ-glutamyl peptides. Kokumi is why a head of roasted garlic changes an entire dish and why aged beef has a body young beef does not.

The receptor is the **calcium-sensing receptor**, CaSR — another class-C GPCR, cousin to the umami and sweet receptors, better known for its day job monitoring blood calcium than for sitting on the tongue. On taste cells it reads a particular class of molecules: **γ-glutamyl peptides**, short chains in which a glutamate is joined to its neighbor through its side-chain γ-carboxyl rather than the usual backbone bond. Glutathione — γ-Glu-Cys-Gly — is the archetype. γ-Glu-Val-Gly is one of the most potent kokumi peptides known, active at vanishingly low concentration. These peptides have almost no

taste of their own; what they do is bind CaSR and *modulate* — they amplify the perception of sweet, salty, and above all umami, and they add the continuity and mouth-filling persistence that is kokumi proper. Put plainly: umami is the note, kokumi is the sustain.

A steak is a γ-glutamyl peptide factory, and aging is what runs the machine. While it rests in the cold, the muscle's own enzymes — the calcium-activated **calpains**, the lysosomal **cathepsins**, the proteasome — dismantle myofibrillar proteins into peptides and free amino acids. That proteolysis is what raises the glutamate of Chapter 1; it is *also* what generates the γ-glutamyl peptides of this one, as γ-glutamyltransferase shuffles glutamyl groups onto free amino acids. A 35-day dry-aged ribeye does not merely taste "stronger" than a fresh one. It has climbed on two axes at once — louder umami and a body that was not there before — and the two climbs are the same enzymatic event read through two receptors.

This is the axis our designed pantry was, frankly, made for. The biosynthetic route to γ-glutamyl peptides is short, universal, and entirely enzymatic:

STEP	ENZYME	PRODUCT
Glu + Cys	γ-glutamylcysteine synthetase (GSH1 / γ-ECS)	`γ-Glu-Cys`
γ-Glu-Cys + Gly	glutathione synthetase (GSH2)	`glutathione (γ-Glu-Cys-Gly)`
γ-Glu-donor + amino acid	γ-glutamyltransferase (GGT)	`γ-Glu-X kokumi peptides`

Every step runs in garlic, in onion, in yeast, in soybean — and in each of those hosts we have pushed it. The 560-construct garlic library, the 240-construct yeast library, the kokumi-and-umami soybean at 360: all of them are, in the end, engines for raising the γ-glutamyl peptide pool so that a spoonful of the finished ingredient carries the CaSR signal of a food aged for months. When we fold a koji-and-garlic butter into a just-seared tenderloin, we are not "adding richness" as a figure of speech. We are delivering a bolus of CaSR agonist to a plate that already carries the glutamate and IMP to be amplified, and the kokumi number — which on a plain steak sits near 540 — our model predicts landing north of 2,500. The body you taste is a designed thing. We just made it on purpose.

Chapter 3 · The crust — *where sugar and protein become four hundred new molecules.*

Lay a dried steak surface on metal hot enough to hurt and something happens in the first ninety seconds that is, by any honest accounting, the most chemically generative event in the whole cook. The surface browns, then bronzes, then goes the deep lacquered mahogany of a proper sear, and as it does it throws off an aroma that did not exist a moment ago — roasted, nutty, savory, almost meaty in a way the raw meat never smelled. That aroma is not "cooked beef" in any simple sense. It is several hundred brand-new volatile compounds, built on the spot, by the reaction that bears Louis-Camille Maillard's name.



FIG. 3 — A superhot in cross-section; the deep lacquer of a seared crust is a Maillard landscape, hundreds of volatiles built in ninety seconds of controlled char.

The Maillard reaction is, at its root, a courtship between an amino group — from an amino acid or a peptide on the meat's surface — and a carbonyl, from a reducing sugar like glucose or ribose. They condense; the product rearranges (the Amadori rearrangement, if the sugar came first; the Heyns, if the amine did); and from that unstable intermediate the reaction fans outward into a combinatorial explosion. Strecker degradation strips amino acids down to

aldehydes and feeds the fire. The end state is melanoidins — the brown polymers themselves — but the glory is in the volatiles thrown off along the way:

COMPOUND	NOTE IT CARRIES	BUILT FROM
bis(2-methyl-3-furyl) disulfide	intense roast-meat	ribose + cysteine
2-furfurylthiol	roasted, coffee-like	pentose + sulfur
methional	savory, cooked-potato	methionine (Strecker)
2-acetyl-1-pyrroline	popcorn, toasted	proline + sugar
pyrazines (many)	nutty, roasted	Strecker condensations
4-hydroxy-2,5-dimethyl-3(2H)-furanone	caramel, sweet	hexose

That first compound, the one that smells overwhelmingly of roasted meat, is active at parts per *billion*. A crust is not a flavor; it is a bouquet of dozens of these at once, in proportions set by exactly how hot the surface got and how long it stayed there.

Which is the whole craft, because Maillard has a temperature window and so does its enemy. The browning accelerates meaningfully above about 140 °C and sings between roughly 150 and 165 °C — which is why a dry surface and a blazing pan matter, since any surface water pins the temperature at 100 °C until it boils away, and wet meat *steams* rather than browns. But push past about 180 °C and hold there and the reaction tips into pyrolysis: outright carbonization, and with it a rise in frankly bitter char. That bitterness is a real signal on a real axis — it lands on TAS2R38, the bitter receptor, the same channel the Index tracks as IFI-B. A little is the welcome edge of a grilled crust; too much, and the bitter swamps the savory the crust was built to frame.

Here our broader work pays an unexpected dividend. The platform's largest single effort on IFI-B is bitterness *attenuation* — the 20-to-65 % quieting of TAS2R38 signaling that lets a coffee or a brassica keep its character without its harshness. The same principle governs a crust. When we build a coffee-and-cocoa rub (Chapter 16) on bitter-attenuated beans and nibs, the roasted aromatics of the crust come through while the bitter stays in its lane — IFI-B held near 1,500 where an unmanaged char would push past 2,200 and drown the plate. We do not want a crust without bitterness; a steak is not a dessert. We want bitterness *scored and placed*, a frame and not a flood, and a frame is a number you choose rather than an accident you survive.

Chapter 4 · Doneness — *the one axis the cook controls absolutely.*

Everything so far has been chemistry you can influence. Doneness is physics you command outright, and it is the single most consequential decision between a great steak and a sad one. Doneness is nothing but a core temperature, and a core temperature is nothing but a report on which of the meat's proteins have unfolded. Learn the three thresholds and you never cook a steak by guess again.



FIG. 4 — The controlled chamber: holding a temperature to the half-degree is the whole of doneness. Muscle protein unfolds on a staircase you can climb exactly.

Three proteins, three thresholds, and the entire doneness ladder falls out of their order:

- **Myosin** begins to denature near **50 °C** and firms through the mid-50s. This is the good denaturation — the one that turns translucent raw muscle opaque and set, that gives a steak its sliceable structure and releases the first savory juices. Below it, a steak is raw; at it, a steak becomes a steak.
- **Collagen**, the connective sheathing, contracts sharply near **62–65 °C**, squeezing the muscle fibers like a wrung cloth and expelling water — the origin of the gray, drier band that creeps inward as you overcook. Held long and slow, that same collagen slowly converts to gelatin, which is the entire principle of a braise but the enemy of a quick-cooked steak.
- **Actin** denatures near **66 °C**, and this is the cliff. When actin unfolds, the fibers contract hard and wring out most of their remaining moisture. A steak taken past the actin threshold is, by physics, a drier steak. This is not an opinion about well-done; it is what the protein does.

The sweet spot writes itself: you want myosin fully set and actin fully intact, which is the band between roughly 52 and 60 °C. Here is the ladder in full, with the core temperatures we cook to and what each costs you in moisture:

DONENESS	CORE TEMP (°C)	CORE TEMP (°F)	STATE OF THE MUSCLE
Blue	48–50	118–122	myosin barely set; cool center
Rare	50–52	122–126	myosin set; actin fully intact; juicy
Medium-rare	**54–57**	**129–135**	the canonical window; maximal juice + tenderness
Medium	60–63	140–145	collagen contracting; juices visibly reducing
Medium-well	65–68	149–154	past the actin cliff; noticeably drier
Well	71+	160+	fully wrung; flavor now lives in the crust alone

Two numbers finish the chapter and arm the recipes. First, **carryover**: a thick steak pulled from high heat keeps climbing 2–4 °C as the hot exterior equalizes inward, so you pull *below* target and let it arrive during the rest. Second, the resting itself — five to ten minutes in which the pressure gradient that a hot cook builds up relaxes, so the juices redistribute through the fibers instead of flooding the board at the first cut. Resting is not politeness; it is the difference between juice in the meat and juice on the cutting board.

This is also where modern tools stop being gadgets and start being honesty. Sous-vide — a precisely held water bath — lets you park a steak at *exactly* 54.5 °C for as long as you like, so the entire interior arrives at one chosen doneness edge to edge, with no gray gradient, and a long enough hold also pasteurizes at that temperature through time rather than heat. The reverse sear does the same with a low oven or a cool side of the grill: bring the interior gently to ten degrees below target, then hit the dried surface with ferocious heat for the ninety-second Maillard sprint of Chapter 3 — crust without overcooking, because the two events are now separated in time. Every recipe in Part IV is, at bottom, one of these two strategies wrapped around the ladder above.



PART II OF IV

The Designed Pantry

the tomato · the alliums · koji & soy · the heat ladder · the sharp channel

Chapter 5 · The tomato that out-savors the stock cube — *umami you can spoon.*

We never change the steak. We change what sits beside it, and nothing we grow sits beside a steak more usefully than a tomato engineered to be a reservoir of pure savor. A jus, a confit, a raw summer salad against the richness of the meat — the tomato is the plant that carries the umami axis best, and the modern supermarket tomato, bred for shipping and shelf life, had most of that savor engineered *out* of it by accident. We put it back on purpose, and then we kept going.



FIG. 5 — Our umami-restored tomato. IFI-U 300 → 2,600, rebuilt through the native glutamate route the long-haul varieties left behind.

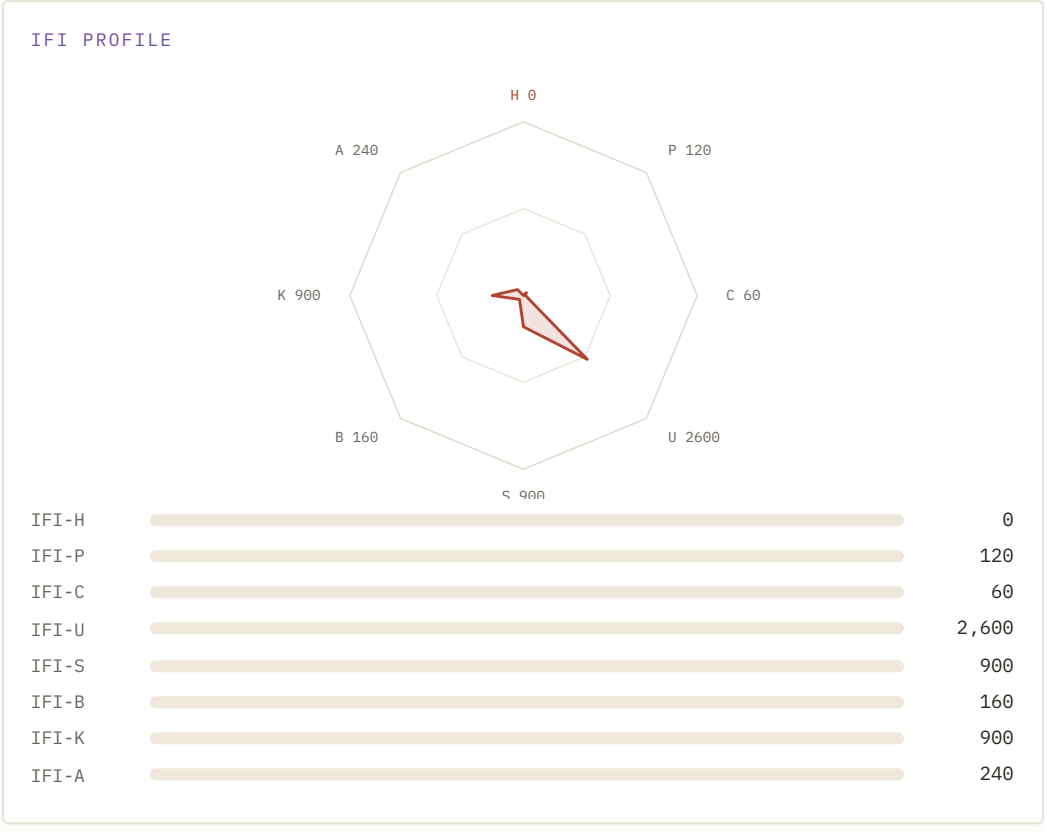
The tomato is the easiest organism in our catalog to reason about on the savory axis, which is why the library is the deepest — **2,040 constructs**, spanning sweetness, umami, full-spectrum, and multi-axis work. Umami in a tomato is free glutamate, and free glutamate is the output of a small, well-mapped loop of nitrogen metabolism that runs in every green cell. The job is to push flux toward the free amino acid and stop it leaking away:

STEP	ENZYME	REACTION	OUR MOVE
assimilation	glutamine synthetase (GS)	glutamate + NH_4^+ → glutamine	balance
transfer	glutamate synthase (GOGAT)	glutamine + 2-OG → 2 glutamate	up
direct	glutamate dehydrogenase (GDH1)	2-oxoglutarate + NH_4^+ ⇌ glutamate	**up**
drain	glutamate decarboxylase (GAD)	glutamate → GABA	**down**

That last row is the quiet key. GAD bleeds glutamate off into GABA; dial GAD down and push GDH1 up, and the free-glutamate pool rises without touching anything else the plant needs. A genome-scale flux-balance model confirmed, before a single edit, that the terminal glutamate pool — not upstream carbon or nitrogen supply — was the true rate limiter, so that is where we spent our edits. The result is the number from Chapter 1: EC_{50} dropping from a reference 1.00 to

0.385, **IFI-U climbing from 300 to 2,600**, with the characteristic ≤7 % batch-to-batch coefficient of variation that makes the designed pantry a formulator's instrument rather than a season's luck.

Against a steak, that number does specific work. The savory depth of the meat is a dense, close, almost heavy thing; a designed tomato brings the *same axis* in a bright, acidic, spoonable form that lifts the plate rather than piling onto it. A raw tomato salad beside a seared ribeye is not a garnish; it is a second umami source on a second texture, and because both read on IFI-U, the plate gains savor without gaining weight.



That is the designed tomato alone, raw, dressed with nothing but salt and oil — U at 2,600, a genuine 900 of clean sweetness, a faint kokumi from its own trace γ-glutamyl peptides. It is, by the Index, a more savory object than most finished sauces, and it has not seen a pan. When we reduce it into a jus (Chapter 15) we concentrate that further; when we ember-char it whole beside a tomahawk (Chapter 14) we lay a Maillard crust over a savory core and read both axes at

once. The tomato is where the designed pantry proves its thesis fastest: the plant does the heavy lifting, and the meat gets to be itself.

Chapter 6 · Garlic, onion, and the savory foundation — *kokumi and the sharp green edge.*

Ask any cook on earth to name the one thing they would not cook a steak without, and a surprising number will say garlic before they say salt. There is a reason, and it is the same reason across nearly every savory cuisine humans have built: the alliums carry two of our axes at once, kokumi and pungency, and they carry them in a form that transforms completely between raw and cooked. A clove is two different ingredients depending on what you do to it, and both are useful against beef.

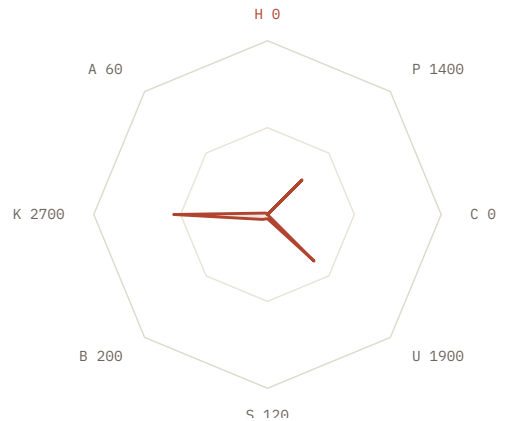


FIG. 6 — Onion, the quieter allium: sweet and deeply kokumi when cooked low, sharp and green when raw. The savory foundation under almost every steak sauce.

Raw garlic's bite is a defense the plant builds only when wounded. Intact, it stores a precursor, alliin; crush the cell walls and the enzyme **alliinase** is released to convert alliin into **allicin**, a volatile, unstable, pungent thiosulfinate. Allicin is an agonist of **TRPA1**, the sharp-channel receptor the Index reads as IFI-P — the same channel wasabi and mustard fire. That is the green heat of raw garlic in a chimichurri, a measurable pungency distinct from the TRPV1 warmth of chili. Cook the garlic and the allicin breaks down; the sharpness vanishes and what remains is sweet, round, and deeply kokumi — because garlic is, with onion and yeast, one of our richest natural sources of the **γ-glutamyl peptides** of Chapter 2.

This dual nature is exactly why the 560-construct garlic library and the smaller onion work are built the way they are — not to chase one axis but to let a cook dial the ratio. We push the γ-glutamyl peptide pool through the glutathione-and-GGT route of Chapter 2, so a roasted clove or a slow-cooked onion delivers more CaSR agonist per gram; and separately we can tune the alliin-to-alliinase balance that sets how much raw pungency a crushed clove throws. A garlic grown for a confit butter is tuned toward kokumi; one grown for a raw sauce keeps its TRPA1 edge. Same plant, two instruments.

IFI PROFILE



IFI-H	0
IFI-P	1,400
IFI-C	0
IFI-U	1,900
IFI-S	120
IFI-B	200
IFI-K	2,700
IFI-A	60

The scorecard above is our workhorse: a **garlic-koji compound butter**, kokumi pushed to 2,700 against the CaSR, pungency held at a confident 1,400, waiting to be folded molten into a just-seared tenderloin so the fat carries it into every fiber. It is the single most leveraged thing in this book — a pat of designed butter that raises a steak two full axes at the moment of serving. We build it formally in Chapter 15. For now the point is the foundation: before heat, before crust, before any flourish, the savory ground of nearly every steak on earth is an allium, and the allium is a plant we have tuned to speak louder on exactly the axes a steak most wants answered.

Chapter 7 · Koji, soy, and the aged edge — *fermentation as a shortcut through time.*

Dry-aging is the most revered thing a steak can undergo and also the slowest — weeks of cold, controlled rot in which the meat's own enzymes do the patient work of Chapters 1 and 2. There is an older, faster way to the same two axes, and it comes from a mold that Japanese and broader East Asian kitchens have cultivated for a thousand years to pre-digest the flavor out of soybeans and rice. It is called koji, and it may be the most elegant umami tool in any pantry, ours included.



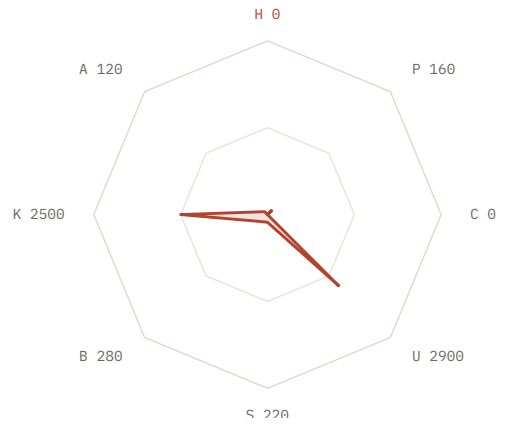
FIG. 7 — Soybean, the substrate that koji transforms. The same proteases and amylases that make miso and soy sauce will age a steak's surface in days instead of weeks.

Koji is the fungus *Aspergillus oryzae* grown on a grain or bean substrate, and what makes it a kitchen marvel is its enzyme arsenal. It secretes a flood of **proteases**, which cleave proteins down to free amino acids — glutamate chief among them — and **amylases**, which cleave starch to sweet sugars. Spread a koji culture, or a slurry of ground koji rice, over the surface of a steak and hold it cool and humid, and those proteases go to work on the muscle from the outside in. In forty-eight to seventy-two hours a koji-dressed steak develops the free-glutamate depth and the nutty, savory surface aromatics that a conventional dry-age takes three to five *weeks* to build. The mold is doing, fast and on purpose, exactly what the meat's own cathepsins do slowly: liberating the glutamate of Chapter 1 and seeding the γ-glutamyl peptides of Chapter 2.

Our **80-construct koji library** is a pure umami play — the host exists in our catalog to be an enzyme engine, and the edits push protease expression and the resulting free-amino-acid yield. Alongside it sit the organisms that koji's own tradition produces: the **360-construct soybean**, tuned on umami and kokumi together, the raw material of soy sauce and miso; the **240-construct yeast**, another U/K double; the umami mushrooms, shiitake among them, which carry their own nucleotide, GMP, the guanosine cousin of IMP that synergizes with glutamate on the very same TAS1R1 site. A splash of designed soy, a

spoon of miso, a dusting of koji, a scatter of umami mushroom — each is a plant or a ferment we have pushed toward the savory axes, and each one, laid against a steak, is a second and third and fourth source of the exact molecules the meat already carries.

IFI PROFILE



IFI-H	0
IFI-P	160
IFI-C	0
IFI-U	2,900
IFI-S	220
IFI-B	280
IFI-K	2,500
IFI-A	120

This is a **koji-creamed wild mushroom** (the full recipe is in Chapter 18): umami pushed to 2,900, nearly the normalization ceiling, through the triple stack of mushroom GMP, koji-liberated glutamate, and the designed soybean in the pan — all three landing on TAS1R1·R3 at once, all three amplified by one another's nucleotides. It is the most savory single thing in this book, and it never touched an animal. Beside a steak it does not compete; it completes, because savory plus savory on the same receptor is not addition, it is the synergy multiplier of Chapter 1 turned up on a plate.

Chapter 8 · The heat ladder — *ten peppers, one crust, and the dial you choose.*

Now the fire. A steak takes heat as gracefully as any food on earth, because its fat is the perfect solvent and vehicle for the molecule that makes heat — and because the savory depth we have spent five chapters building gives that heat something substantial to ride on. Chili on a lean, bland thing is an assault; chili on a dry-aged ribeye is a conversation. This is the axis the whole company was founded on, and it is the one where we can offer a cook something no spice rack ever could: a continuous, calibrated ladder from a warm glow to a number that did not exist in nature until we wrote it.



FIG. 8 — Phoenix (SS-0096), the first cultivar engineered to register on all eight axes at once, and the top rung of this book's heat ladder.

The molecule is capsaicin, and the receptor is **TRPV1**, a non-selective cation channel on the trigeminal nerve endings that also opens to real heat above 43 °C and to acid. Capsaicin does not raise the tissue's temperature; it lowers the channel's threshold, so the body sincerely reports a fire that is not there. Two facts make it a steak's natural partner. First, capsaicin is strongly lipophilic — it dissolves into fat and distributes through it — so on a marbled cut it spreads evenly and clings, building and lingering rather than flashing. Second, that same fat solubility means dairy and fat *relieve* it: the casein in a blue-cheese butter or a béarnaise literally strips capsaicin off the receptor, which is why a rich sauce lets you cook hotter than a lean plate ever could.

Our ten proof-of-concept superhots give the cook a true ladder, each rung a real cultivar with a real SKU, a predicted SHU, and a predicted IFI-H:

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

The ladder matters because a steak is forgiving of heat in a way few foods are, but only if the heat is *chosen*. SHU and IFI-H values in the table are computational predictions from our model. Which brings us to the grid this entire book is organized around — the two ladders crossed, doneness down the side and heat across the top, every cell a real plate:

DONENESS ↓ / HEAT →	CLEAN (H≈0)	WARM (H≈1,570)	HOT (H≈2,630)	SEVERE (H≈3,980)	PHOENIX (H 4,200)
Rare	koji butter ribeye	peppercorn crust	—	—	—
Medium-rare	**the canon**	four-alarm chimichurri	superhot crust	collector's sear	the full dial
Medium	wine-jus strip	hot-honey glaze	gochujang short rib	—	—
Well	braise territory	smoke & chili bark	—	—	—

The blank cells are not omissions; they are judgments. We do not put Phoenix-level heat on a well-done steak, because at that point the meat's moisture is gone and heat has nothing to ride — a counsel the grid makes visible. The dense center of the grid, medium-rare across the warm-to-hot bands, is where a steak and a chili do their best work together, and it is where most of Part IV lives.

The reason we can offer a *ladder* rather than a handful of hot peppers is the molecular work underneath, and it is worth seeing once. A 650-million-parameter protein language model scored every possible single-residue substitution in Pun1/AT3 — the acyltransferase that condenses vanillylamine with a branched-chain fatty acid to make capsaicin — by predicted catalytic efficiency against fold stability. Our flux model found that control sits upstream in the phenylpropanoid pathway, at 4CL and HCT/CCoAOMT; Pun1 is the terminal capsaicin synthase — it labels the product, it does not govern the rate.

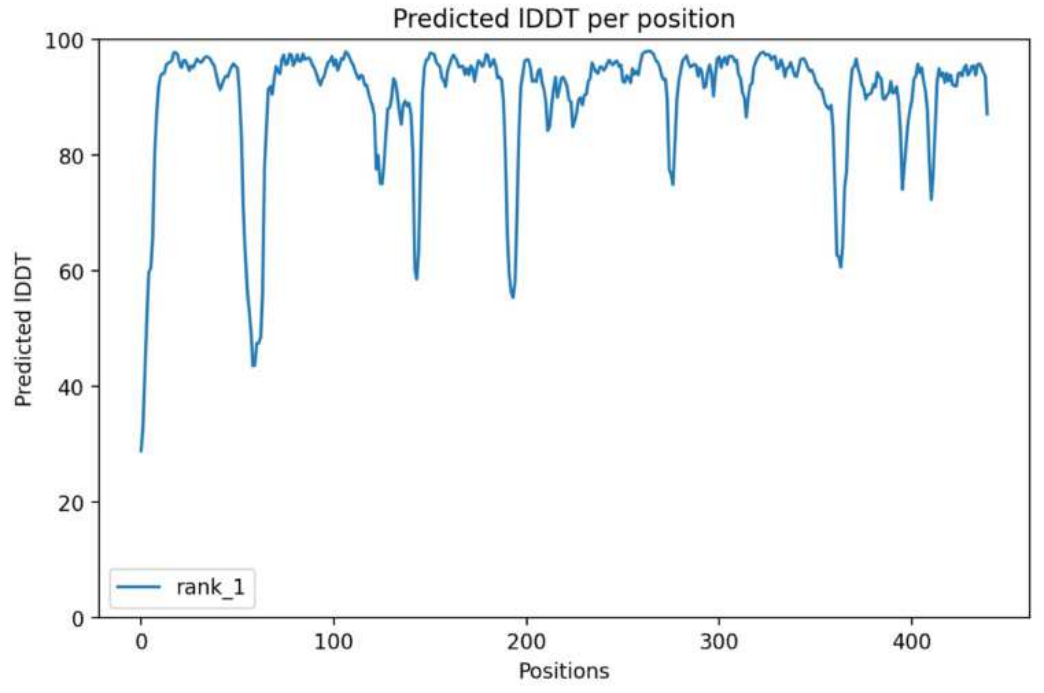


FIG. 9 — Pun1/AT3 coloured by pLDDT model confidence; the active-site cleft and binding domain are high-confidence, the regions our three edits target.

Two substitutions, never before combined in any pepper, make up the shipped construct — written in with CRISPR, they are designed to lift peak output to approximately 2.95 million SHU at a batch-to-batch CV of ≤7 %, against a wild-type swing of 42 %:

EDIT	EFFECT	ΔΔG (KCAL/MOL)
S39L	binding affinity ↑ (N-terminal)	−2.1
L345G	steric relief at the active-site cleft	−1.8
C175S	disulfide-misfold prevention (structural annotation; not in shipped construct)	−0.9

That reproducibility is the quiet thing that makes the heat ladder a cook's tool instead of a dare. When a recipe in this book calls for "Blaze heat," it means a specific, repeatable design target of approximately 1.72 million predicted SHU, batch after batch — a crust you can cook to the same way you cook to a core temperature. Heat you can trust is heat you can build a dish on.

Chapter 9 · The sharp channel — *mustard, horseradish, ginger, and the pungency that is not chili.*

There is a second heat, and it is one of the most underused tools a steak cook has. The sinus-lifting sharpness of English mustard, the clean nose-burn of fresh horseradish, the bright bite of ginger, the warmth of cinnamon and the snap of black pepper — none of these is chili heat, and the difference is not poetry, it is pharmacology. They act on a different receptor entirely, and a steak that uses both channels tastes layered in a way a steak that uses only chili never will.



FIG. 10 — Ginger, a TRPA1 agonist by way of gingerol. The sharp channel is a different receptor from chili heat, and a steak can play both at once.

The receptor is **TRPA1**, the Index's IFI-P, and it is gated not by capsaicin but by a family of reactive electrophilic compounds that covalently nudge cysteine residues on the channel: **allyl isothiocyanate** from mustard and horseradish and wasabi, **allicin** from the crushed garlic of Chapter 6, **gingerol** and **shogaol** from ginger, **cinnamaldehyde** from cinnamon, **piperine** from black pepper. Where TRPV1's capsaicin burn is slow, building, and deep, TRPA1's pungency is fast, volatile, and *high* — it flashes in the nose and sinuses and clears quickly, a top note where chili is a bass line. That is exactly why they combine so well: a mustard-crusted steak with a chili finish hits the front and the back of the sensation at once.

The brassica and spice side of our catalog is, in effect, a TRPA1 workbench. The **black mustard library runs to 2,790 constructs**, our second-largest after only the superhot peppers — mustard is engineered on pungency and multi-axis work because allyl isothiocyanate is so clean and so tunable. White mustard, ginger at 120 constructs, the aromatic herbs thyme and oregano, cinnamon — each is a host pushed on IFI-P, each delivering a measured dose of a specific electrophile. Allyl isothiocyanate is generated, like allicin, by a wound-triggered enzyme: the glucosinolate **sinigrin** sits inert until the enzyme **myrosinase** meets it on cell rupture and releases

the volatile, which is why a mustard crust must be built from freshly mixed powder and water and used within the window before the reaction spends itself.

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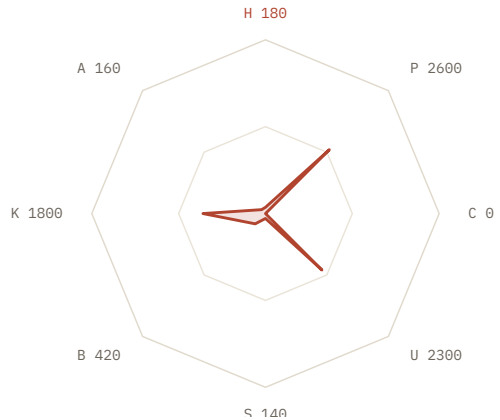

IFI-H	180
IFI-P	2,600
IFI-C	0
IFI-U	2,300
IFI-S	140
IFI-B	420
IFI-K	1,800
IFI-A	160

That is a **mustard-herb-crusted sirloin** (recipe in Chapter 16): pungency pushed to 2,600 on the TRPA1 channel from designed black mustard and horseradish, umami and kokumi held high by the meat and a backing of designed allium, and only a faint 180 of chili warmth — a steak that reads as *sharp* rather than *hot*, a completely different sensation than the four-alarm chimichurri of Chapter 14 even though a naive palate might call both "spicy." Teaching a cook to hear the two channels separately is one of the real gifts of the Index, and a steak, with its broad savory canvas, is the best place in the kitchen to learn the difference.



PART III OF IV

The Cuts, Read as Flavor

the marbled · the lean · the working muscles — each a different starting profile

Chapter 10 · The ribeye and the marbled cuts — *where fat is a flavor, not a garnish.*

A ribeye is the cut people fall in love with, and the reason is a single word that turns out to be two axes in disguise: marbling. The fine white web of intramuscular fat laced through a well-raised ribeye is not a seam to eat around. It is a flavor system — a reservoir of fat-soluble aromatics, a physical coater of the tongue, and a buffer that lets the cut take fire and salt and time better than any lean muscle can. To cook a ribeye well is to understand that the fat is doing more work than the meat.



FIG. 11 — Garlic in cross-section. A ribeye's intramuscular fat does for flavor what a clove's stored peptides do for kokumi: it carries and sustains.

Begin with what fat *is* on the tongue. Beef fat — tallow — is a blend of triglycerides with a melting range that straddles body temperature, roughly 40 to 50 °C for much of it, which is why a warm ribeye feels lush and a cold one feels waxy. The more monounsaturated the fat — the higher its oleic-acid fraction, the defining trait of wagyu and well-finished cattle — the lower that melting point, and the more the fat genuinely *melts at mouth temperature* into the sensation we call richness. On the Index, that richness reads as **kokumi**: not because fat is a γ-glutamyl peptide, but because fat's physical coating of the palate produces the same perception of continuity, body, and lingering fullness that the CaSR peptides produce chemically. Marbling is kokumi by mouthfeel, and it stacks with the kokumi-by-chemistry of a designed allium butter — which is why garlic butter on a ribeye is almost tautologically correct.

Fat is also where flavor lives and travels. Most of the compounds that distinguish grass-finished from grain-finished beef, that carry the "beefy" aromatics of the breed and the feed, are lipophilic — they dissolve in the fat and nowhere else. A lean steak has less of this library by simple volume. And the capsaicin of Chapter 8 is lipophilic too, so a marbled cut is the ideal canvas for engineered

heat: the chili dissolves into the fat and distributes evenly through every bite, building and clinging exactly where a lean cut would let it sit on the surface and spike.

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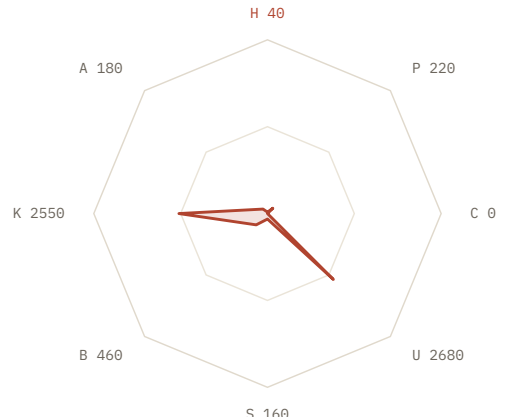

IFI-H	40
IFI-P	220
IFI-C	0
IFI-U	2,680
IFI-S	160
IFI-B	460
IFI-K	2,550
IFI-A	180

That is a 35-day dry-aged ribeye, reverse-seared, finished with nothing but salt and a knob of designed garlic butter — the full recipe opens Chapter 13. Note the shape of it: umami and kokumi both above 2,500, the two savory axes nearly maxed by the compounding of aging and fat and designed allium, and heat left almost silent at 40. This is the steak we would cook for someone who says they do not like spicy food, to show them that the savory axes alone, fully expressed, are a complete and overwhelming pleasure. The ribeye is where you prove that heat is an option, never a requirement, and that the deepest thing a steak can be is simply, exactingly, *savory*.

Chapter 11 · The lean cuts — *strip, tenderloin, sirloin, and the case for the designed pantry.*

If the ribeye is where fat does the talking, the lean cuts are where the designed pantry earns its keep. Strip, tenderloin, top sirloin — these are muscles with less intramuscular fat, cleaner and firmer and, in the tenderloin's case, so tender it is almost a texture before it is a flavor. They are prized, and rightly, but they start lower on the kokumi axis than a ribeye, and that gap is precisely the space our ingredients were built to fill. A lean cut is not a lesser steak; it is a steak that invites the plant to the plate.



FIG. 12 — A designed tomato, specimen view. Against a lean cut, a bright umami source lifts the plate where a ribeye's fat would otherwise carry it.

Take the tenderloin. It is the psoas major, a muscle that does almost no work in the living animal, which is why it is so tender and also why it is so mild — little connective tissue, little fat, a delicate and clean savor that the great French kitchens traditionally propped up with sauce precisely because the meat, alone, is understated. This is not a flaw to hide; it is a canvas, and it is the clearest argument in the book for cooking meat and plants as one system. A tenderloin finished with the garlic-koji butter of Chapter 6 arrives with a kokumi it does not natively own — CaSR agonist delivered in melting fat — and the lean, tender muscle becomes the perfect quiet ground for a loud, designed richness. The strip sits between: more fat and more chew than the tenderloin, more structure to stand up to a crust, a natural home for the peppercorn and mustard work of the sharp channel.

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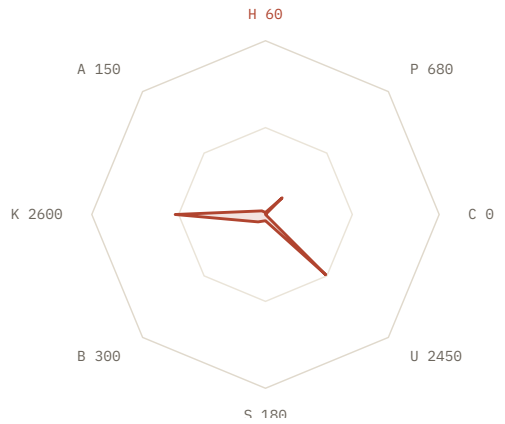


IFI-H		60
IFI-P		680
IFI-C		0
IFI-U		2,450
IFI-S		180
IFI-B		300
IFI-K		2,600
IFI-A		150

That is a sous-vide tenderloin, held to an exact 54.5 °C and finished with garlic-koji butter — the recipe is in Chapter 13. Read it against the ribeye of Chapter 10 and the lesson is plain: the native umami sits slightly lower (2,450 against 2,680, the lean muscle's smaller glutamate reserve) but the kokumi actually edges *higher* (2,600), because here the richness is not the cut's own fat but the designed butter's CaSR peptides, delivered deliberately and measured exactly. A lean cut lets you *choose* its body rather than inherit it. For a cook, that is not a compromise — it is control. The ribeye hands you richness; the tenderloin lets you dial it, and the designed pantry is the dial.

Chapter 12 · The working cuts — *flank, skirt, hanger, and the glutamate of a muscle that labored.*

The most savory steaks in the world are, by a cruel and wonderful irony, the cheapest. Flank, skirt, hanger, flat iron, the chuck steaks off the shoulder — these are the muscles that *worked* in the living animal, and a working muscle is a glutamate-dense muscle, because labor demands metabolism and metabolism traffics in amino acids. These cuts are chewy, coarse-grained, and uncompromising about technique, and they reward a cook who understands them with a depth of beefy savor that a tenderloin simply does not possess. They are also, not coincidentally, the cuts around which the marinating cultures of the world — Korean, Mexican, Vietnamese, Argentine — built their greatest steak traditions.

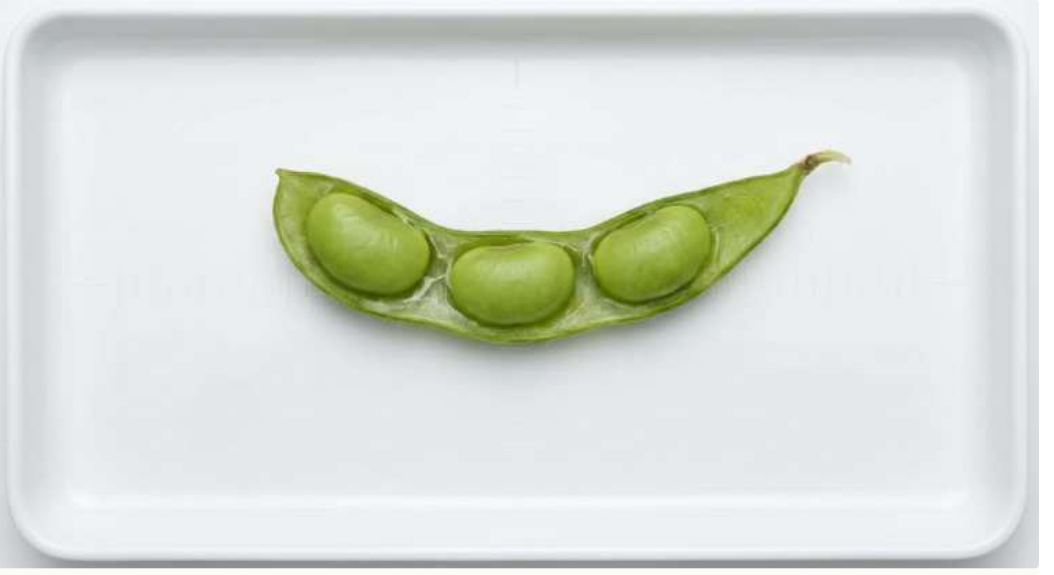
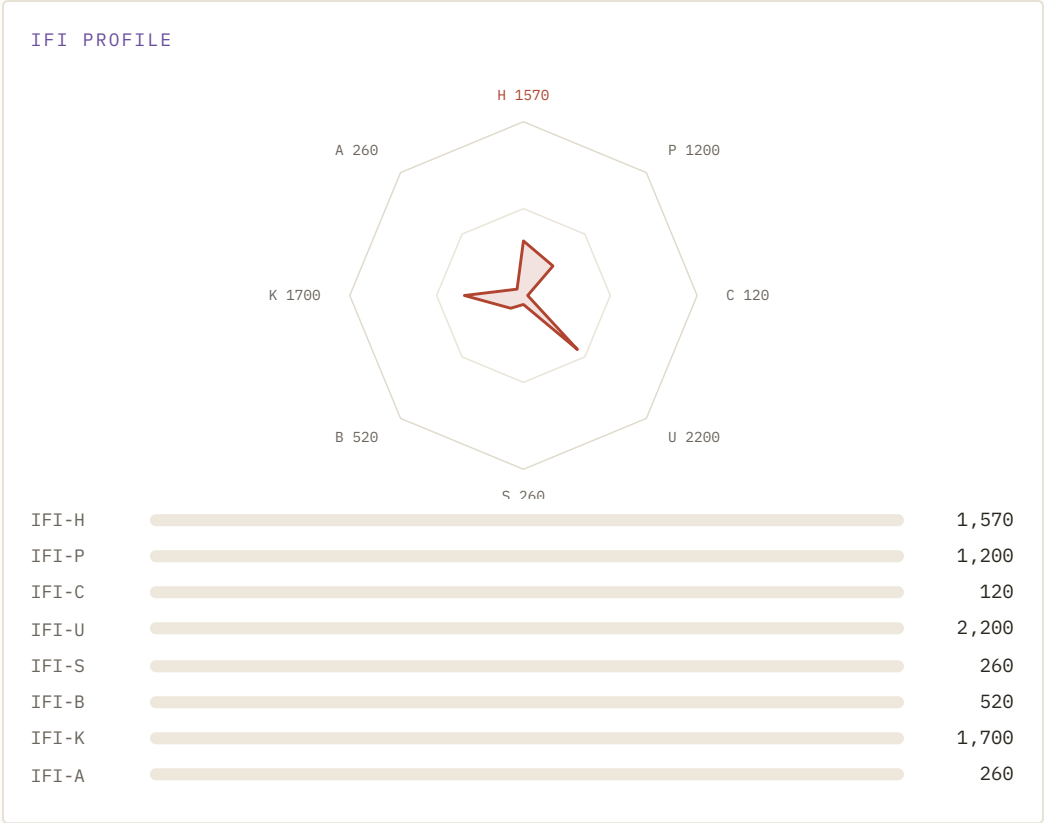


FIG. 13 — Soybean in cross-section, the raw material of soy and miso. The working cuts and the ferment jar belong together; both are glutamate at depth.

Two facts govern the working cuts, and both are mechanical. First, **the grain**. These muscles have long, coarse, highly aligned fibers, and a bite taken along the grain is a mouthful of tough parallel strands. The entire usability of a skirt or flank steak hinges on slicing it thinly *across* the grain after cooking, severing those long fibers into short, chewable segments — a knife technique that does more for tenderness than any marinade. Second, **the heat and the clock**. These are thin, lean, fast-twitch muscles best cooked hot and fast to a true medium-rare and no further; past the actin cliff of Chapter 4

they turn to rope, because they have little fat and little collagen to forgive you. Hot pan or hot coals, two minutes a side, rest, slice across the grain, and a two-dollar cut eats like a feast.

The marinade is where our pantry meets these cuts most naturally, and it is pure Chapter 7 logic. A working cut's glutamate reserve wants a nucleotide partner and a kokumi backing to complete it, and that is exactly what a ferment delivers: designed **soy sauce** (soybean, 360 constructs, U/K) brings glutamate and the synergy nucleotides; **miso** brings koji-liberated amino acids and γ-glutamyl peptides; a grated designed **allium** brings TRPA1 pungency and more kokumi. A marinade on a skirt steak is not merely seasoning the surface — it is laying our engineered umami and kokumi directly onto a muscle that already over-delivers on glutamate, so the savory synergy of Chapter 1 fires on contact.



That is a grilled skirt steak under a four-alarm chimichurri — Ember heat at 1,570, the raw-garlic and herb pungency of the sauce at 1,200 on TRPA1, the working muscle's own umami at a robust 2,200 — and it is the full recipe in Chapter 14. The working cuts are, to our mind, the democratic heart of this book: the place where the cheapest meat, the sharpest knife technique, and the most engineered pantry come together into the most flavor per dollar a steak can offer. Reverence is not reserved for the expensive cut. Often it is the labored, humble muscle that has the most to say.



PART IV OF IV

The Fire and the Recipes

reverse sear · live fire · sauces & butters · rubs & crusts · sweet heat · the plates that share the fire

Chapter 13 · The reverse sear — *the canonical cook, and the method the whole book is built on.*

If this book taught only one technique it would be this one, because the reverse sear resolves the central tension of Chapter 4 — that the crust you want (Maillard, 150–165 °C surface) and the interior you want (54–57 °C core) demand opposite amounts of heat — by refusing to do them at the same time. You bring the interior up slow and gentle until it is almost there, then you hit the dried surface with everything you have for ninety brutal seconds. Two events, separated in time, each done perfectly. Everything in this chapter and the next is a variation on that single idea.



FIG. 14 — The sequencer bench, where we read a pepper's genome to the base. A reverse sear reads a steak's interior to the degree; both are the same insistence on precision.

The physics is worth stating once more because it makes the method obvious. In a traditional screaming-hot-pan-from-raw cook, heat floods in from the surface faster than it can equalize, so by the time the center reaches medium-rare the outer centimeter has raced past the actin cliff into gray, overcooked meat — the dreaded gradient, the bullseye of doneness rings. Bring the interior up slowly instead — a 120 °C oven, a cool side of the grill, a 54.5 °C water bath — and the whole mass arrives at one temperature together, edge to edge, no gradient at all. *Then* the surface is dried and blasted, and because the ninety-second sear adds almost no heat to the already-warm interior (pull it a touch early for carryover), you get crust without casualty.

Reverse-Sear Dry-Aged Ribeye — *the canon, the steak the rest of the book answers to.*

SERVES 2 · 50 MIN ACTIVE + 35-DAY AGE

1 bone-in ribeye · 1.1 kg · 5 cm thick · dry-aged 35 d
Maldon salt · 12 g (≈1.1% of weight)
cracked black pepper · 4 g
neutral high-smoke-point oil · 15 ml
designed garlic-koji butter · 40 g (Ch. 15)
fresh thyme · 3 sprigs

TARGET CORE 54 °C (med-rare) · PULL AT 51 °C
SURFACE SEAR 230 °C+ cast iron, 90 s/side

1. Salt the ribeye on all faces and rest it uncovered on a rack in the refrigerator 12–24 hours. This both seasons to the center and, crucially, **dries the surface** — the single most important step for a crust, because a wet surface steams instead of browning (Chapter 3).
2. Heat the oven to 120 °C. Set the steak on a rack over a tray and cook until the core reads **51 °C** on a probe thermometer, roughly 40–55 minutes. Do not rush this; the gentleness is the whole point.
3. Rest the steak 10 minutes while you heat a cast-iron pan until it is genuinely smoking — 230 °C or hotter. A crust is a temperature, not a time.
4. Film the pan with oil, lay in the steak, and sear undisturbed **90 seconds**. Flip, add the butter and thyme, and baste the fat over the top for a final 90 seconds, tilting the pan. The core will carry over to 54 °C.
5. Rest 5 minutes more. Slice, pulling the knife across the grain, and finish with flaked salt at the table.

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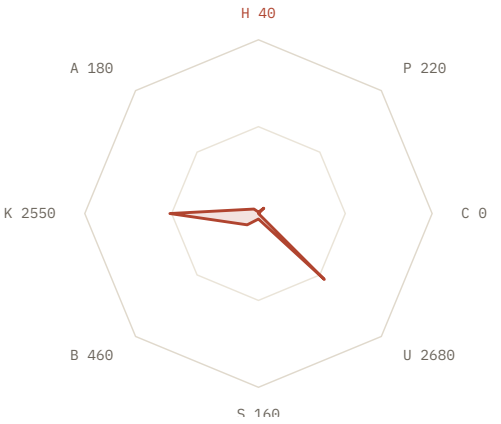

IFI-H	40
IFI-P	220
IFI-C	0
IFI-U	2,680
IFI-S	160
IFI-B	460
IFI-K	2,550
IFI-A	180

Sous-Vide Tenderloin, Garlic-Koji Butter — *doneness to the half-degree.*

SERVES 2 · 20 MIN ACTIVE + 2 H BATH

---

2 tenderloin medallions · 200 g each · 4 cm thick
fine salt · 4 g
designed garlic-koji butter · 30 g (Ch. 15)
grapeseed oil · 10 ml
flaked salt · to finish

BATH 54.5 °C · 2 h (pasteurizing hold)
SEAR blazing, 60 s total

1. Season the medallions, seal each with 10 g of the butter in a vacuum pouch, and submerge in a **54.5 °C** bath for 2 hours. The interior cannot overshoot; it arrives at exactly medium-rare edge to edge and stays safe through time at temperature (Chapter 4).
2. Remove, pat **bone-dry** — any surface moisture is the enemy of the sear.
3. Sear in a ripping-hot oiled pan 15–20 seconds per face, just long enough for color; a lean cut browns fast and overcooks faster.
4. Finish with the remaining butter, melted, and flaked salt.

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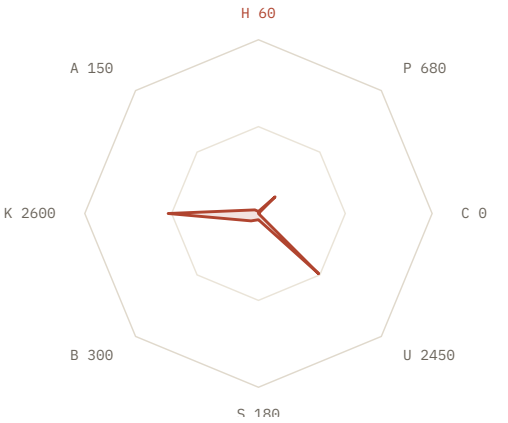


IFI-H	60
IFI-P	680
IFI-C	0
IFI-U	2,450
IFI-S	180
IFI-B	300
IFI-K	2,600
IFI-A	150

Two methods, one principle, and between them they cover every steak in this book. The reverse sear is for the thick, bone-in, crust-forward cuts; the sous-vide is for precision and for lean cuts that punish a moment's inattention. Master the separation of interior and crust and you have mastered the steak. Everything from here is flavor laid on top of a cook you already own.

Chapter 14 · Live fire — *char, smoke, ember, and the heat ladder applied.*

There is a reason the oldest way to cook meat is still, for many of us, the best — and it is not nostalgia, it is chemistry. Live fire gives a steak two things an oven cannot: the ferocious radiant heat that drives the Maillard crust of Chapter 3 faster and deeper than any pan, and the aromatic smoke that layers phenolic compounds — guaiacol, syringol, the sweet-woody vanillin notes — onto the surface as a whole second bouquet. Fire is also, not incidentally, where the heat ladder of Chapter 8 comes most alive, because the char and the chili and the smoke all speak to the same primal register. This is the chapter where we cook loud.



FIG. 15 — Solara (SS-0095), predicted ~2.72M SHU. Over live coals, a laddered chili crust and the fire's own char read as one deep heat.

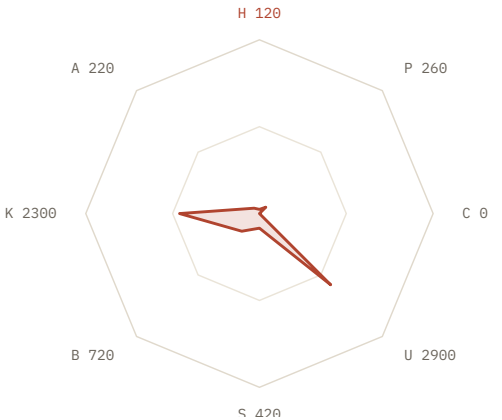
A word on managing fire like the instrument it is. Build a **two-zone fire** — coals banked to one side, nothing under the other — and you have rebuilt the reverse sear outdoors: the cool zone is your gentle 120 °C climb, the coals are your 90-second blast. This is the single technique that turns a grill from a thing that burns steaks into a thing that cooks them, and it is why the recipes below all specify zones. Smoke is dose-dependent and lipophilic like capsaicin, settling into the fat; a little is perfume, a lot is ashtray, so we smoke the thick cuts that can take a longer cool-zone stay and sear the thin ones fast.

Live-Fire Tomahawk with Ember-Charred Designed Tomato — *the showpiece.*

```
SERVES 3–4 · 1 H + 2-ZONE FIRE
──────────────────────────────
1 tomahawk ribeye · 1.2 kg · bone in
Maldon salt · 14 g
designed umami tomatoes · 4 whole  (Ch. 5)
designed garlic · 1 head, halved
olive oil · 30 ml
flaked salt + cracked pepper · to finish
──────────────────────────────
COOL ZONE  indirect, lid on, to core 50 °C
HOT ZONE  direct over coals, 90 s/side
EMBERS  tomatoes buried 6–8 min
```

1. Salt the tomahawk and air-dry in the refrigerator overnight (Chapter 13, step 1).
2. Cook on the **cool zone**, lid down, turning once, until the core reads **50 °C** — 35–45 minutes. The bone shields its own side, so probe the thickest meat away from it.
3. Meanwhile, nestle the whole designed tomatoes directly into the glowing embers and the halved garlic head cut-side down at the coals' edge. Char the tomatoes 6–8 minutes until the skins blacken and split and the interiors go molten and jammy — a Maillard crust over a 2,600-IFI-U core (Chapter 5).
4. Move the steak to the **hot zone** and sear 90 seconds a side directly over the coals for the crust and the smoke.
5. Rest 10 minutes. Slice across the grain off the bone; serve fanned over the ember tomatoes, their charred skins slipped off, and the softened garlic squeezed across the top.

IFI PROFILE



IFI-H	120
IFI-P	260
IFI-C	0
IFI-U	2,900
IFI-S	420
IFI-B	720
IFI-K	2,300
IFI-A	220

Grilled Skirt with Four-Alarm Chimichurri — *the working cut, laddered to warm.*

SERVES 4 · 30 MIN + 1 H MARINADE

1 kg skirt steak · trimmed
designed soy sauce · 30 ml (marinade)
— CHIMICHURRI —
flat-leaf parsley · 60 g, fine
oregano · 10 g, fine
designed garlic · 4 cloves, crushed raw
Ember chili (SS-0087) · 1, deseeded, minced
red wine vinegar · 60 ml
olive oil · 150 ml
salt · 6 g

HEAT BAND warm · IFI-H ≈ 1,570
GRILL direct, very hot, 2 min/side
SLICE thin, hard across the grain

1. Toss the skirt with the designed soy and rest 1 hour; the ferment's glutamate meets the working muscle's own (Chapter 12).
2. Make the chimichurri: combine everything, crushing the raw garlic so **alliinase** fires and the allicin blooms on TRPA1 (Chapter 6). Rest it 30 minutes to marry. The single deseeded Ember pod sets the heat at a measured, repeatable 1,570 — not a guess, a dose.
3. Grill the skirt over a very hot direct fire, 2 minutes a side to a true medium-rare and no further — past it, a working cut turns to rope (Chapter 12).
4. Rest 5 minutes. Slice thinly, hard across the grain. Spoon the chimichurri generously; the sauce is half the dish.

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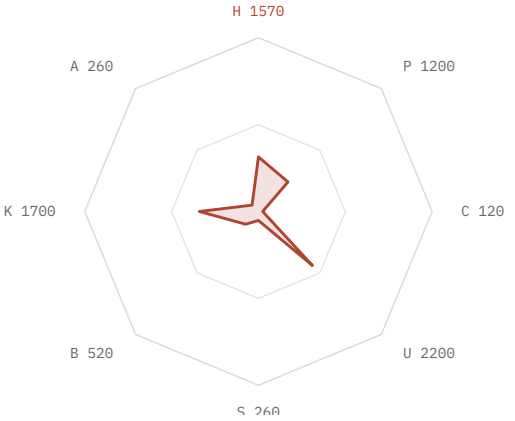

IFI-H	1,570
IFI-P	1,200
IFI-C	120
IFI-U	2,200
IFI-S	260
IFI-B	520
IFI-K	1,700
IFI-A	260

Live fire is where a cook stops managing a steak and starts conducting it — the cool zone, the coals, the embers, the smoke, the chili dose, all playing at once. It looks like the least precise cooking in the book and it is secretly the most, because every one of those variables is a number we have spent the whole book learning to read. The fire is old. The control is new.

Chapter 15 · Pan sauces, jus, and compound butters — *the savory axes, concentrated and spooned.*

A great sauce is the designed pantry at its most literal: it is the plants, reduced and clarified, laid against the meat as pure axis. Everything we have engineered — the tomato's umami, the allium's kokumi, the grape's astringency, the chili's heat — becomes, in a sauce, a controllable liquid dose. And the three classical forms cover the whole range: the **pan sauce** built from a steak's own fond, the **jus** reduced from stock and wine, and the **compound butter** that finishes everything. This is the most leveraged chapter in the book, because a sauce is where you add axes without adding a single degree to the cook.



FIG. 16 — Designed grape, our astringency host. A red-wine jus brings the tannin axis to the plate the way nothing else can.

Garlic-Koji Compound Butter — *the book's single most useful object.*

MAKES 200 g · 15 MIN + CHILL

---

cultured butter · 160 g, soft
designed garlic · 4 cloves, roasted to paste
koji rice · 15 g, ground fine (Ch. 7)
designed soy sauce · 5 ml
flat-leaf parsley · 10 g, minced
flaked salt · 3 g

AXES DELIVERED K↑↑ (CaSR) · P (TRPA1) · U
USE 40 g molten per steak, at the finish

1. Roast the designed garlic until sweet and soft; smash to a paste (the heat has quenched the raw allicin, leaving pure kokumi — Chapter 6).
2. Beat everything into the soft butter until uniform. The ground koji seeds glutamate and amylase-sweetness; the designed soy brings nucleotide synergy (Chapter 7).
3. Roll in parchment into a log, chill firm. Cut coins to finish any steak in this book — the fat carries the CaSR peptides into every fiber as it melts.

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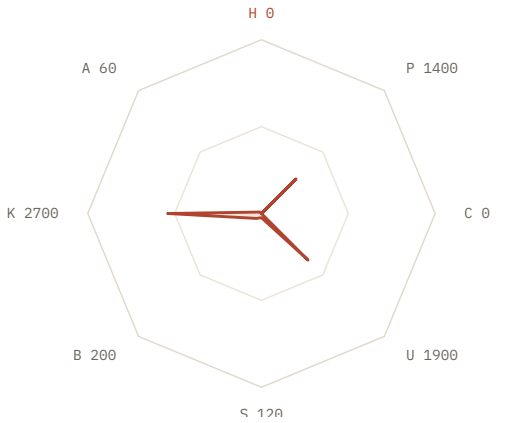

IFI-H	0
IFI-P	1,400
IFI-C	0
IFI-U	1,900
IFI-S	120
IFI-B	200
IFI-K	2,700
IFI-A	60

Red Wine & Bone-Marrow Jus — *umami and the tannin axis together.*

MAKES 250 ml · 40 MIN

---

beef or veal stock · 500 ml
designed red wine · 200 ml (grape, Ch. 18)
roasted bone marrow · 40 g
designed shallot · 1, minced
designed umami tomato · 1, concentrated to paste
thyme · 2 sprigs
cold butter · 30 g

AXES U↑↑ · A (PRPs) · K
REDUCE by three-quarters, glossy

1. Sweat the shallot; deglaze with the wine and reduce almost to a syrup — this drives off harsh alcohol and concentrates the grape's tannin, which will read on IFI-A at the finish.
2. Add stock, tomato paste, and thyme; reduce by three-quarters to a glossy nappe.
3. Off the heat, whisk in the marrow and cold butter for body and kokumi. Strain. The tomato paste pushes umami past 2,700; the wine's tannin lands astringency near 900 — a measured bitterness-adjacent grip that cuts the fat (Chapter 19).

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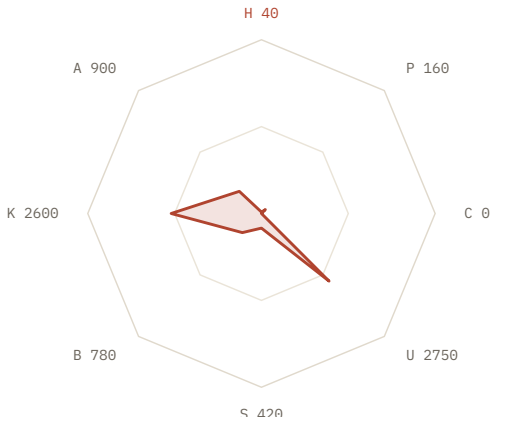

IFI-H	40
IFI-P	160
IFI-C	0
IFI-U	2,750
IFI-S	420
IFI-B	780
IFI-K	2,600
IFI-A	900

Steak au Poivre — *the sharp channel, classical.*

SERVES 2 · 20 MIN

---

cracked black + green peppercorns · 25 g
designed Ember chili · ¼, minced fine
cognac · 40 ml
beef stock · 120 ml
heavy cream · 100 ml
designed shallot · 1, minced
butter · 20 g

AXES P↑↑ (piperine, TRPA1) · K · H (laddered)

1. Press the cracked peppercorns onto a seared, rested strip steak. Piperine is a TRPA1 agonist — this is the sharp channel, not chili heat (Chapter 9).
2. In the fond, sweat the shallot, add the minced chili for a measured warmth, deglaze with cognac (stand back; it may flame).
3. Reduce with stock, then cream, to a coating sauce; finish with butter. The cream's casein tempers the chili's capsaicin, letting the peppercorn pungency stay the star (Chapter 8).

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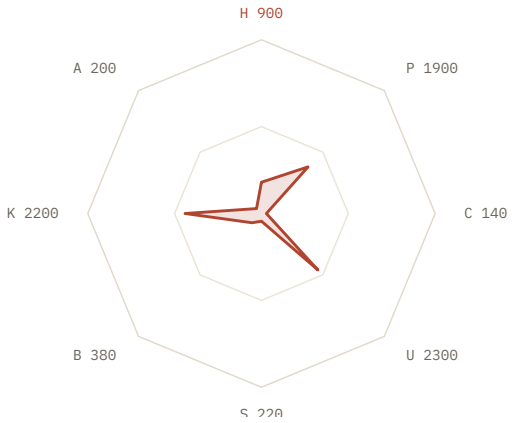


IFI-H	900
IFI-P	1,900
IFI-C	140
IFI-U	2,300
IFI-S	220
IFI-B	380
IFI-K	2,200
IFI-A	200

Three sauces, three different silhouettes on the Index — one a kokumi bomb, one umami-and-astringency, one a pungency showpiece — and not one of them touches the doneness of the steak. That is the quiet power of the sauce course: it is pure axis, added at will, after the physics of the cook is already settled. Learn to read what a plate is missing and a sauce is how you fill it in, by the number.

Chapter 16 · Rubs, crusts, and the dry side — *flavor built on the surface, before the fire.*

Where a sauce adds axes after the cook, a rub adds them before, and it plays a different and complementary game: it is the surface, the crust, the first thing teeth break through, and it works *with* the Maillard reaction rather than after it. A dry rub is a designed-pantry delivery system aimed at the one square millimeter of steak that gets the hottest and browns the most — and because that surface is where char-bitterness is born (Chapter 3), the rub is also where our bitterness-attenuation work does its most elegant job.



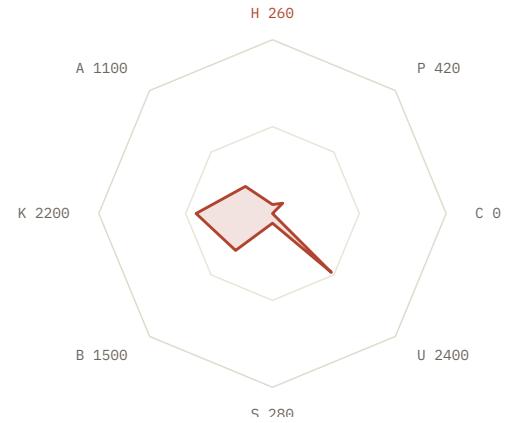
FIG. 17 — Designed coffee, bitterness-attenuated 20–65% on TAS2R38. A coffee-cocoa crust keeps the roast and loses the harshness.

Coffee-Cocoa Crust — *roast aromatics without the harsh edge.*

```
MAKES ENOUGH FOR 2 LARGE STEAKS · 10 MIN
──────────────────────────────────────
designed coffee · 15 g, fine espresso grind  (B-attenuated)
designed cocoa nibs · 10 g, ground
smoked salt · 10 g
muscovado · 8 g
Cinder chili (SS-0088) · 2 g, dried & ground
cracked black pepper · 4 g
──────────────────────────────────────
AXES  B (framed, not flooded) · H · A · U
APPLY  pat on both faces, rest 30 min, reverse-sear
```

1. Grind everything to a coarse rub. The designed coffee and cocoa are bitterness-attenuated on TAS2R38 — 20 to 65 % quieter — so the crust reads as *roasted and deep* rather than acrid (Chapter 3).
2. Pat firmly onto a dried steak surface; rest 30 minutes for the salt to draw and set.
3. Reverse-sear (Chapter 13). The sugar in the muscovado accelerates Maillard; watch the surface and pull before it tips to char.

IFI PROFILE



IFI-H		260
IFI-P		420
IFI-C		0
IFI-U		2,400
IFI-S		280
IFI-B		1,500
IFI-K		2,200
IFI-A		1,100

Mustard-Herb Crust — *the sharp channel as a coating.*

```
MAKES ENOUGH FOR 2 STEAKS · 10 MIN
──────────────────────────────────
designed black mustard · 20 g powder  (P, Ch. 9)
fresh horseradish · 10 g, grated
thyme + oregano · 8 g total, fine
designed garlic · 2 cloves, crushed
olive oil · 20 ml
salt · 6 g
──────────────────────────────────
AXES  P↑↑ (allyl isothiocyanate, TRPA1)
MIX FRESH  use within 20 min of wetting
```

1. Wet the mustard powder and let it stand 10 minutes: water triggers **myrosinase** to convert sinigrin into pungent allyl isothiocyanate (Chapter 9). Mix fresh and use promptly — the reaction is self-limiting.
2. Fold in the horseradish, herbs, crushed garlic, oil, and salt.
3. Coat a seared strip or sirloin and finish gently; high prolonged heat volatilizes the isothiocyanate, so crust *after* the hard sear, not before.

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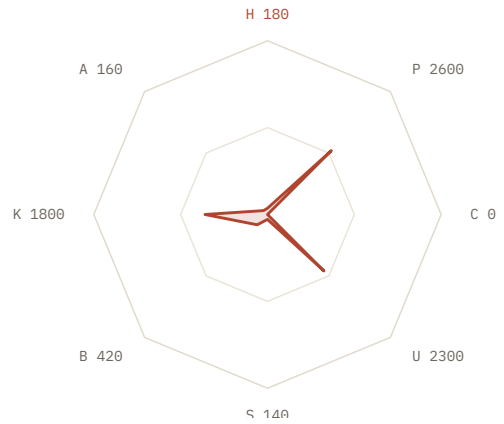


IFI-H	180
IFI-P	2,600
IFI-C	0
IFI-U	2,300
IFI-S	140
IFI-B	420
IFI-K	1,800
IFI-A	160

The Superhot Pepper Crust — *the full dial, for the collector.*

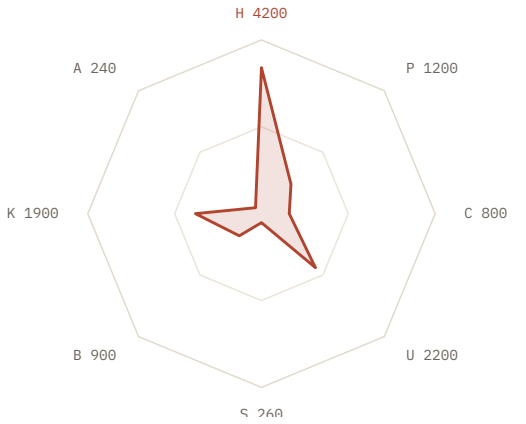
MAKES ENOUGH FOR 1 SHOWPIECE STEAK · 10 MIN

Phoenix chili (SS-0096) · 1 g, dried & ground ⚠ gloves
smoked paprika · 8 g (color + body)
flaked salt · 10 g
designed garlic · 4 g, granulated
muscovado · 4 g

HEAT BAND maximum · IFI-H 4,200
⚠ predicted ~2.95 million SHU — a trace is the dose

1. Wear gloves. Phoenix is designed to reach approximately 2.95 million predicted SHU; one gram, evenly spread, is a crust, not a punishment — the whole point of a ≤7 % CV design target is that "a trace" is a *repeatable* trace (Chapter 8).
2. Blend with the paprika for body and the salt and garlic for ground. Pat a whisper onto a well-marbled, well-rested ribeye — the fat will carry and temper the capsaicin (Chapter 10).
3. Reverse-sear and serve with something rich and dairy alongside; the casein is the off-switch.

IFI PROFILE



IFI-H	4,200
IFI-P	1,200
IFI-C	800
IFI-U	2,200
IFI-S	260
IFI-B	900
IFI-K	1,900
IFI-A	240

Notice how the superhot crust's profile echoes the Phoenix's own eight-axis signature — heat at 4,200, a real pungency and cool-burn alongside it — laid over the steak's native umami and kokumi. That is the thesis of the whole book in one scorecard: a plant engineered to speak on every axis at once, placed against a cut that already carries the two savory axes deeply, and the sum read honestly as a single number per axis. The rub is where the designed pepper meets the designed surface, and where "every heat" stops being a slogan and becomes a gram on a scale.

Chapter 17 · Sweet heat — *the glaze, the lacquer, and the swicy steak.*

Of all the flavor combinations that have swept modern cooking, none has proven more durable than the marriage of heat and sweetness — "swicy," the trade calls it now, hot honey and gochujang and chili-chocolate, and it is not a fad, it is a receptor truth. Sweetness and heat land on entirely different channels — TAS1R2·R3 for sugar, TRPV1 for capsaicin — and because they do not compete for the same receptor, they can both run at full volume at once, each making the other more vivid. On a steak, where the savory axes are already high, a sweet-hot glaze adds two more voices to the chord and lacquers the surface into something glossy and irresistible.



FIG. 18 — Cinder (SS-0088) in cross-section, predicted ~1.05M SHU. In a glaze, its heat runs alongside designed sweetness without either muting the other.

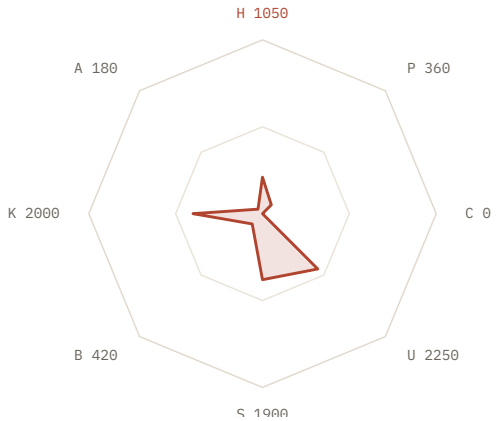
The craft of a glaze is sugar chemistry meeting heat management. Sugar on a hot surface caramelizes and, with the meat's own amino acids, drives a parallel Maillard — which is why a glazed steak browns darker and faster and must be watched like a hawk, applied late and over gentler heat so it lacquers rather than burns. Our sweetness host work makes this cleaner than sugar alone ever could: designed stevia, monk fruit, and the broader TAS1R2·R3 library deliver intense sweetness at a fraction of the fermentable-sugar load, so a glaze can read *sweet* without going instantly to char — sweetness as an axis, decoupled from the browning liability.

Hot-Honey Glazed Strip — *swicy, the gateway.*

```
SERVES 2 · 25 MIN
──────────────────────────────────────
2 strip steaks · 300 g each
── HOT HONEY ──
honey · 80 g
Cinder chili (SS-0088) · ½, sliced
designed monk-fruit sweetener · 2 g   (lifts S, not sugar load)
cider vinegar · 15 ml
flaked salt · 3 g
──────────────────────────────────────
HEAT BAND   warm-hot · IFI-H ≈ 1,050
GLAZE   final 2 min, off direct heat
```

1. Warm the honey with the sliced chili to infuse; the capsaicin is lipophilic but honey's trace volatiles carry enough for a measured 1,050 (Chapter 8). Add the monk-fruit to push sweetness past the honey's own without more fermentable sugar, then the vinegar for cut.
2. Reverse-sear the strips to medium-rare; in the last 2 minutes, off direct heat, brush on the hot honey and let it lacquer — watch closely, sugar chars fast.
3. Rest, slice, spoon the remaining hot honey over.

IFI PROFILE



IFI-H		1,050
IFI-P		360
IFI-C		0
IFI-U		2,250
IFI-S		1,900
IFI-B		420
IFI-K		2,000
IFI-A		180

Gochujang-Lacquered Short Rib — *fermented sweet-heat, deep.*

```
SERVES 4 · 30 MIN + 4 H LOW COOK
──────────────────────────────────
boneless short rib · 1 kg, thick-cut
── LACQUER ──
designed gochujang · 90 g  (fermented chili + soy + koji)
designed soy sauce · 20 ml
honey · 30 g
designed garlic · 4 cloves, grated
ginger · 15 g, grated
toasted sesame oil · 10 ml
──────────────────────────────────
HEAT BAND  warm · IFI-H ≈ 820
COOK  110 °C to tender, then glaze under broiler
```

1. The gochujang is the whole designed pantry in one paste: fermented chili (heat), koji and soy (umami + kokumi), and sugar (sweet) — a single condiment that reads on four axes.
2. Cook the short rib low (110 °C) until the collagen has rendered to gelatin and the meat is spoon-tender — this is the one cut in the book we take past medium on purpose, because it is collagen-rich enough to reward it (Chapter 4).
3. Brush with the lacquer and flash under a hot broiler to blister and gloss. The ginger and garlic add a TRPA1 sharpness over the TRPV1 warmth — both heats at once (Chapter 9).

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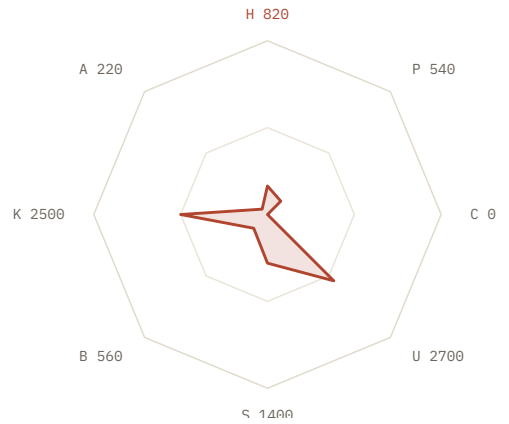


IFI-H	820
IFI-P	540
IFI-C	0
IFI-U	2,700
IFI-S	1,400
IFI-B	560
IFI-K	2,500
IFI-A	220

Sweet heat is where the Index's independence of axes becomes something you can taste in a single bite: sugar at 1,400–1,900, chili at 820–1,050, umami and kokumi both above 2,000, and none of them crowding the others because each has its own receptor and its own number. A naive cook reaches for sweet to "balance" heat, as if they were on a seesaw. They are not. They are separate instruments, and a swicy steak plays them in harmony — which you can only do deliberately once you stop treating flavor as one dial and start reading it as eight.

Chapter 18 · The plates that share the fire — *the sides, where the plant takes the lead.*

We are a plant-first family, and this is the chapter where that is not a caveat but the main event. A steak dinner is never only a steak; it is a plate, and on that plate the vegetables are not an obligation or a garnish — they are the other half of the meal, and in our kitchen they are as engineered, as measured, and as revered as anything that touched the fire. The sides are where the designed pantry stops supporting the meat and simply *is* the cooking, and where the nourishment that hums under this whole book comes nearest the surface: plants grown to carry the most they can, cooked to give the body the most they hold.



FIG. 19 — Designed broccoli, bitterness-attenuated for the plate. Charred hard and dressed in kokumi-garlic, it is not a side to the steak; it is its equal.

Umami-Restored Tomato Salad — *the designed tomato, raw and unarguable.*

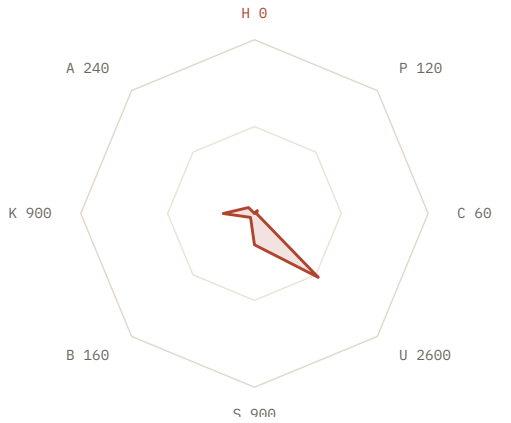
SERVES 4 · 10 MIN

designed umami tomatoes · 600 g (Ch. 5), mixed sizes
flaked salt · 4 g
designed olive oil · 30 ml
designed red onion · 40 g, shaved
basil · a handful, torn
— no vinegar: the tomato's own acid is enough —

AXES U↑↑ (2,600) · S · K
SERVE cool, against the hot steak

1. Cut the tomatoes in a mix of wedges and halves, salt them, and let them sit 10 minutes to weep their savory juice — that liquid is free glutamate in solution, IFI-U 2,600, and you will not waste a drop.
2. Dress with oil, shaved onion, and basil. No vinegar: a designed tomato carries its own acid, and added acid would only mask the glutamate. The salad is a cool, bright, savory counterweight to the hot richness of the meat (Chapter 5).

IFI PROFILE



IFI-H	0
IFI-P	120
IFI-C	60
IFI-U	2,600
IFI-S	900
IFI-B	160
IFI-K	900
IFI-A	240

Charred Broccoli with Kokumi-Garlic — *bitterness, attenuated and placed.*

SERVES 4 · 20 MIN

designed broccoli · 500 g (B-attenuated), in large florets
designed garlic · 4 cloves, sliced
olive oil · 30 ml
chili flakes (Ember) · 1 g
lemon · ½
flaked salt · to taste

AXES K · P · B (gentled, not gone)
CHAR hard, cast iron or coals

1. The designed broccoli is bitterness-attenuated on TAS2R38 — 20 to 65 % quieter — so it can be charred *hard*, to real blackened edges, without the acrid bitterness that char would otherwise stack onto a brassica's own (Chapter 3).
2. Blister the florets in a smoking pan or over coals; add the sliced garlic and chili flakes at the end so the garlic's allicin stays sharp on TRPA1 (Chapter 6).
3. Finish with lemon and salt. The broccoli keeps a pleasant vegetal bitterness as a *frame* — placed, not flooded.

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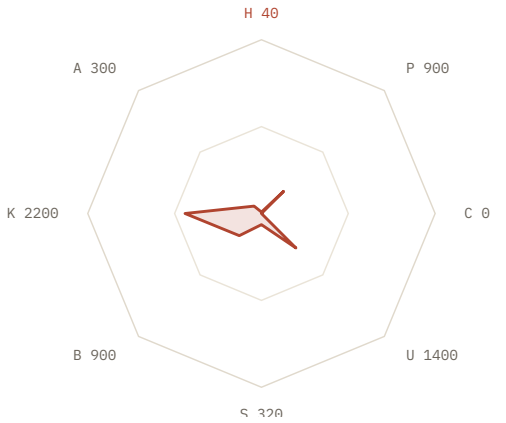

IFI-H	40
IFI-P	900
IFI-C	0
IFI-U	1,400
IFI-S	320
IFI-B	900
IFI-K	2,200
IFI-A	300

Koji-Creamed Wild Mushrooms — *the most savory thing on the table.*

SERVES 4 · 25 MIN

mixed mushrooms · 500 g (incl. shiitake)
koji rice · 15 g, ground (Ch. 7)
designed soy sauce · 15 ml
heavy cream · 150 ml
designed garlic · 2 cloves
thyme · 2 sprigs
butter · 20 g

AXES U↑↑ (2,900) · K
THE SYNERGY GMP × glutamate, on one receptor

1. Sear the mushrooms hard and dry first — their own GMP, the guanosine nucleotide, is the synergy partner to glutamate on TAS1R1 (Chapter 7).
2. Add garlic, thyme, the ground koji (glutamate + amylase sweetness), and the designed soy; deglaze and reduce with the cream.
3. Finish with butter. Umami lands near 2,900 — nucleotide and glutamate and designed soybean stacking on one receptor, the synergy multiplier of Chapter 1 made into a side dish.

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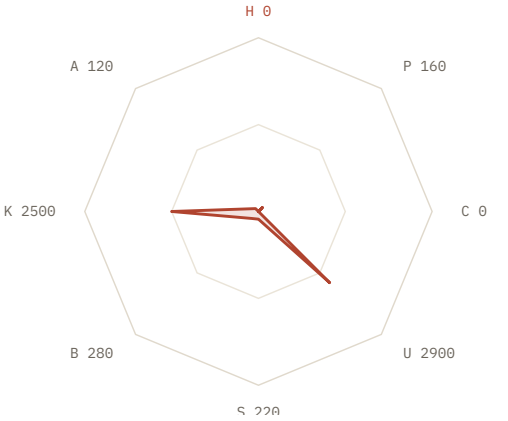

IFI-H	0
IFI-P	160
IFI-C	0
IFI-U	2,900
IFI-S	220
IFI-B	280
IFI-K	2,500
IFI-A	120

Beef-Fat Smashed Potatoes — *kokumi by rendered fat.*

SERVES 4 · 40 MIN

small waxy potatoes · 800 g
rendered beef fat · 40 g (from the steak's trim)
flaked salt · to taste
designed garlic · 3 cloves, crushed
rosemary · 2 sprigs

AXES K (fat-borne) · U

1. Boil the potatoes whole until tender, drain, and dry.
2. Smash each flat, then crisp in hot rendered beef fat with the garlic and rosemary until lacquered and shattering at the edges. The fat is not a cooking medium only — it is a kokumi delivery vehicle, coating the palate the way marbling does (Chapter 10), and it carries the steak's own flavor onto the plant.

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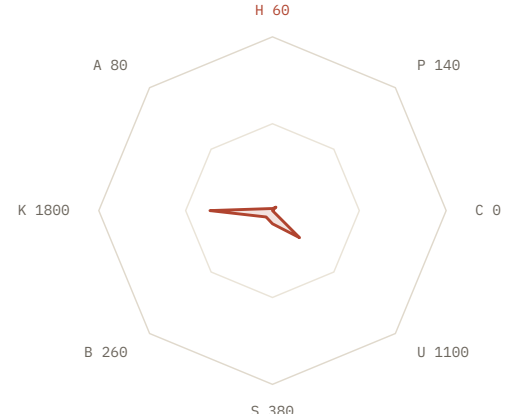

IFI-H	60
IFI-P	140
IFI-C	0
IFI-U	1,100
IFI-S	380
IFI-B	260
IFI-K	1,800
IFI-A	80

Four plates, and not one of them is an afterthought. The tomato salad out-scores most sauces on umami; the mushrooms out-score the steak itself; the broccoli stands up to hard char because we built it to; the potatoes borrow the meat's own fat and give back kokumi. This is what we mean when we say vegetarian-first is not a restriction but a center of gravity: the plants are where the cooking is most *designed*, and a steak is honored most not by standing alone but by sharing a plate with vegetables grown and cooked with equal care. The fire is shared. So is the reverence.

Chapter 19 · The finish — *wine, salt, the last word, and why we cooked this at all.*

A steak is nearly done and so is this book, and both want the same two things at the end: a final seasoning that lands, and a drink that answers. The finish is not an afterthought — it is the eighth axis, the one we have saved, and it is also where the quiet ethos of the whole library gets to speak plainly for a page.



FIG. 20 — Designed grape in cross-section. Astringency is the tannin's grip on the tongue, and it is why red wine and red meat have always belonged together.

Astringency — IFI-A — is the odd one out among the eight, because it is not, strictly, a taste. It is a *tactile* event: the tannins and polyphenols in wine, in tea, in dark chocolate, bind and precipitate the proline-rich proteins in your saliva, the lubricating **PRPs**, and the sudden loss of that lubrication is the puckering, drying grip we call astringency. The Index reads it at the salivary PRPs themselves. And here is why it has been the companion to red meat for all of recorded dining: fat coats the tongue, and tannin strips it — the astringency of a structured red wine literally clears the palate of a rich bite's residue, resetting the mouth for the next forkful. Fat and tannin are not a pairing of flavors; they are a pairing of physics, a coating answered by a scour.

STEAK	DOMINANT AXES	WINE ANSWER	WHY
Dry-aged ribeye	U, K (high fat)	high-tannin red (IFI-A ↑)	tannin scours the fat
Lean tenderloin	U, K (designed)	softer, rounder red	less fat to cut, less grip needed
Peppercorn strip	P (TRPA1)	spicy, peppery red	echo the pungency
Swicy / glazed	H, S	off-dry or fruit-forward	sweetness tempers the burn
Superhot crust	H (4,200)	low-tannin, chilled, a touch sweet	tannin amplifies heat — go soft

That last row is a receptor warning worth its place: tannin and capsaicin *stack*, both read as a kind of harshness, so a high-astringency wine against a superhot steak makes the fire worse, not

better. The 1,610-construct grape library — engineered on bitterness, astringency, and multi-axis work through the ANR tannin route — exists precisely so a winemaker can place that astringency on purpose, soft where it should be soft and structured where it should grip, the same ≤7 % precision we bring to heat brought at last to the oldest partner at the table.

And the salt. We have said it in every recipe and we will say it once more as principle: the last flaked salt, added at the table, is not redundant with the salt in the cook. Salt does not merely taste salty — the sodium ion potentiates umami and suppresses bitterness at the receptor level, so a final crunch of Maldon on a rested slice raises the savory axes and quiets any char-edge in the same stroke. It is the cheapest flavor-design tool in the kitchen and the one most cooks under-use. A steak is finished with salt because salt is the volume knob on everything else.

So: why a vegetarian-first family of scientists wrote a whole book about a steak. Because reverence does not get to be selective. We revere the plant, and we have spent years learning to grow it to carry the most it can — the most flavor and, inseparably, the most nourishment, which is the single value that runs under every book in this library and becomes the whole subject of its final shelf. That same reverence, turned on meat, does not look away and does not apologize. It pays attention. It learns that a steak is a glutamate reservoir and an IMP clock and a Maillard engine and a staircase of unfolding proteins, and that each of those is a number, and that the numbers are how you honor the thing by cooking it as well as it can possibly be cooked. We gave you the plants to stand beside it, the ladder of heat to ride on it, and the eight axes to read the whole plate at once.

These are computational designs; Scoville Splice's cultivars and constructs have not been experimentally validated in a laboratory.

The rest is the degree, the fire, and the people you cook for. Pull it at 54. Rest it. Salt it at the table. And share the plate — with the tomato grown back to its full savor, the broccoli charred without apology, the mushrooms more savory than the meat — because a steak eaten with intention, among people, built out with plants grown to their fullest, is exactly the kind of meal we built this whole company to make possible. Every doneness. Every heat. One honest cut, and a table worth setting it on.