

THE SCOVILLE SPLICE LIBRARY · THE CUISINES

Engineered Indian

Every spice, to the number. *The kitchen the Index is named for.*

A vegetarian-first Indian kitchen where the spice was designed on purpose — the tadka sharp, the heat laddered, the savory grown back in — and every dish scored on the eight axes it stands on.

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

Contents

01 Opening essay · The kitchen the Index is named for

02 Chapter 1 · The Six Rasas, Measured — the old map, given coordinates.

03 Chapter 2 · The Tadka — pungency, delivered.

04 Chapter 3 · The Heat Ladder — the chile, to the number.

05 Chapter 4 · Garam Masala, as a Vector — the blend as a point in eight-space.

06 Chapter 5 · The Trinity — onion, ginger, garlic, and the savory floor.

07 Chapter 6 · The Tomato, Grown Back — the umami a century of shipping bred out.

08 Chapter 7 · Dal — the kokumi of patience.

09 Chapter 8 · Sabzi — the dry curry, and the taste of fire itself.

10 Chapter 9 · Paneer & the Dairy Axis — kokumi you can cut with a knife.

11 Chapter 10 · The Bean Gravies — rajma, chana, and the sour that isn't on the chart.

12 Chapter 11 · Biryani — the one-pot composition, and the aroma that isn't a taste.

13 Chapter 12 · The Cold Side — chutney, raita, and the cooling channel.

14 Chapter 13 · Achaar — the pickle, where heat and ferment meet.

15 Chapter 14 · The South — coconut, curry leaf, tamarind, and the overnight batter.

16 Chapter 15 · The Regional Heat Map — Kashmir to Andhra, and the Portuguese accident.

17 Chapter 16 · Designing a Simmer Sauce — the spec in the jar.

18 Chapter 17 · The Molecular Kitchen — how a spice gets designed.

19 Chapter 18 · The Full Plate — the thali, and all eight at once.

Opening essay · The kitchen the Index is named for

The Index carries our family's name because this is the kitchen it was first read in. Long before there was a number for any of it, there was a steel plate with a low wall of rice at its center and a ring of small bowls set around it — each one a different taste, placed in a particular order, because the order *was* the meaning. The sour went here, the sweet there, the one that stung the back of the throat kept to the edge where a cautious hand could find it last. We did not know we were being taught to read flavor. We thought we were being fed.

Indian cooking has always been a composition problem solved by hand. Centuries before anyone spoke of receptors, a tradition we come from named six tastes and said a complete meal should hold them all at once: *madhura*, the sweet; *amla*, the sour; *lavana*, the salt; *katu*, the pungent sting; *tikta*, the bitter; *kashaya*, the astringent grip that dries the tongue. Six *rasas* on one plate, balanced so that none of them wins and none goes missing. That old map was not wrong. It was only unmeasured — a recipe for the whole mouth, written in an age that could feel *how* but never say *how much*.



Our family in the research greenhouse at dawn — the work is many hands; the computing was one pair of them.

What we have done is slide a number under the intuition. Pungency is *katu* measured — allyl isothiocyanate and the gingerols firing TRPA1, the sharp channel. Astringency is *kashaya* measured — tannins cross-linking the proline-rich proteins that keep saliva slick, so the mouth goes briefly, deliberately dry. Bitter is *tikta* at TAS2R38, the receptor evolution built as a warning and that a cook learns to use as a shadow. Sweet is *madhura* at the TAS1R2·TAS1R3 heterodimer. Four of the six old tastes land cleanly on an axis of the Index. And three axes the old map had no single word for — the slow fire of heat on TRPV1, the brothy pull of umami on mGluR1, the round continuity of kokumi on the calcium-sensing receptor — turn out to

be exactly the three a vegetarian kitchen leans on hardest, because they are how you build depth when there is no meat on the plate to lean on.

That is the quiet truth of this cuisine, and the reason the nourishment that runs under this whole library sings loudest here. Indian cooking is vegetarian-first by nature and by long habit, and it has therefore had to manufacture richness from plants alone — the most sophisticated flavor engineering humans managed before there was a lab. The tempering of whole spices in hot fat. The slow browning of onion to a dark jam. The overnight ferment of a rice-and-lentil batter. The pinch of asafoetida that stands in, molecule for molecule, for the allium a stricter table leaves out. Every one of those moves is a way of placing a compound on a receptor, on purpose, at the right instant. We grew up inside that work. The Index is only what happened when one pair of hands in the family carried the work into the code, and the rest of the family kept cooking while it did.

No cuisine on earth feeds more people, more often, from plants alone. This is a tradition in which the everyday meal — not the feast, the *everyday* — is expected to be complete: protein and grain and vegetable and the full spread of tastes, assembled twice a day, for a subcontinent, mostly without meat. The stakes of this book are therefore ordinary and enormous at once. We are not chasing a restaurant's showpiece; we are after the dal that gets made on a Tuesday, the sabzi thrown together from what the week left in the basket, the pot of rice that anchors a family's table. Get the everyday right — the tomato savory, the mustard sharp, the heat where you meant it — and you have improved not a banquet but a billion quiet dinners. That is the only kind of cooking we have ever cared about.

So this is not a book about making Indian food *modern.* It is a homecoming. Every recipe here rests on a plant we tuned toward what it was always meant to be — a tomato grown back to the umami a century of shipping bred out of it, a mustard seed grown for the exact sharpness the tadka asks of it, a chile laddered to a number instead of a wish — and every dish carries its eight-axis scorecard, so you can taste the balance and read it in the same breath. We mapped eight axes of taste computationally so we could cook, deliberately, the way the women before us cooked by feel. This is the kitchen the whole library is named for. We are glad to be back in it.



PART I OF V

The Grammar

The six rasas · the tadka · the heat ladder · the masala as a vector

Chapter 1 · The Six Rasas, Measured — *the old map, given coordinates.*

Begin with the plate, because the plate came first. A traditional *thali* is not a serving suggestion; it is an argument about completeness. The classical texts hold that a meal is whole only when it carries all six *rasas* — sweet, sour, salt, pungent, bitter, astringent — and that the body reads their balance the way an ear reads a chord. Leave one out and the meal is heard as a chord with a note missing: edible, unsatisfying, strangely unfinished an hour later. We were raised to build that chord without thinking about it. The Index let us finally look at what we had been building.

Four of the six rasas map, cleanly and without strain, onto an axis of the Index — because four of them are read by the same families of receptors the Index was built around. *Madhura*, sweetness, is the TAS1R2·TAS1R3 heterodimer answering to sugars and to the sweet proteins; it is IFI-S. *Katu*, the pungent sting of mustard and ginger and raw spice, is TRPA1, the sharp fast channel; it is IFI-P. *Tikta*, bitterness, is the TAS2R family — TAS2R38 our reference receptor — the warning taste a cook uses as a cook uses a shadow, to give the light somewhere to fall; it is IFI-B. *Kashaya*, astringency, is not a chemical taste at all but a mechanical one: tannins binding the proline-rich proteins of saliva, precipitating them, stripping the mouth's lubrication so the tongue reports a dry grip. It is IFI-A, and it is the hardest of the six to cook with because it has no flavor of its own — only a texture it imposes on everything near it.

That leaves two rasas with no axis. This is not a flaw in the Index; it is a fact about the receptors. *Amla*, sourness, is the detection of protons — free hydrogen ions — by the OTOP1 proton channel and the acid-sensing ASIC channels on the tongue. *Lavana*, saltiness, is sodium itself passing through the ENaC epithelial channel. Both are ion-channel senses, direct and electrical, and neither is a ligand-and-receptor system of the kind the eight axes measure. We say so plainly, because a number is a form of respect and a false one is an insult: **sour and salt sit outside the eight.** You will taste them in every dish in this book — the tamarind, the amchur, the pinch of salt that makes everything else legible — and you will not find them on a scorecard, because we do not have an honest EC_{50} to give them. A cook still commands them. They are simply commanded by hand, as they always were.

$$IFI(c) = 1000 \cdot EC_{50}(\text{ref}) \,/\, EC_{50}(c)$$

And then the surprise, the thing that made us understand why this particular cuisine and this particular Index belonged together. Three of the eight axes have no name in the six-rasa system at all. Heat — capsaicin on TRPV1 — the classical framework files not as a *rasa* but as *virya*, the heating or cooling *potency* of a food, a separate dimension layered over taste. Umami — glutamate and the 5′-nucleotides on mGluR1 and the TAS1R1·TAS1R3 heterodimer — has no classical word because it was not isolated as a distinct taste anywhere on earth until the twentieth century. Kokumi — the γ-glutamyl peptides on the calcium-sensing receptor, the sensation of body and continuity and mouth-filling richness — had no word in *any* tradition until a flavor chemist gave it one in 1989. These three unnamed axes are precisely the ones a meatless kitchen must master, because they are the axes meat delivers for free. A cuisine that refused meat for two thousand years became, of necessity, the world's deepest practical school of umami and kokumi — and never had the vocabulary to say so. The Index is, in part, that missing vocabulary.



A pepper in cross-section — six tastes are a chord; the color is only the part of it you can see.

The old framework runs deeper than the six rasas alone, and it is worth honoring in full, because its structure anticipated ours. Beyond *rasa* — the taste read at first contact — the classical system named *anurasa*, the after-taste that surfaces as the first fades; *virya*, the heating or cooling *potency* of a food, its thermal character on the body; and *vipaka*, the taste-quality it takes on after digestion. Heat, in that scheme, is *virya* — not a taste at all but a potency laid over taste — which is precisely how modern sensory science files capsaicin: not as a flavor molecule binding a taste receptor on the tongue's surface, but as a trigeminal agent acting on the heat-and-pain channel TRPV1, a *somatosensory* event the brain fuses with taste into a single experience. The tradition split taste from potency

two thousand years before anyone could record a current across a channel, and it put heat on the potency side. It was right. We have simply given the potency a number.

Here is the whole correspondence on one page — the old map and its coordinates:

RASA	GLOSS	READS ON	RECEPTOR	ON THE INDEX?
madhura	sweet	IFI-S	TAS1R2·TAS1R3	yes
amla	sour	—	OTOP1 / ASIC (protons)	outside the eight
lavana	salt	—	ENaC (sodium)	outside the eight
katu	pungent	IFI-P	TRPA1	yes
tikta	bitter	IFI-B	TAS2R38	yes
kashaya	astringent	IFI-A	salivary PRPs	yes
—	*(heat / virya)*	IFI-H	TRPV1	yes, unnamed
—	*(savory)*	IFI-U	mGluR1 · TAS1R1·R3	yes, unnamed
—	*(richness)*	IFI-K	CaSR	yes, unnamed
—	*(cooling)*	IFI-C	TRPM8	yes, unnamed

Read it down the right-hand column and the thesis of this book is already there. The Index does not replace the six rasas; it finishes them. It gives sweet, pungent, bitter, and astringent a dial where they had only a direction. It admits honestly that sour and salt live on a different kind of nerve. And it names the three great unnamed axes — heat, umami, kokumi — that this cuisine has been quietly engineering by hand since before any of its cooks had a word for what their hands were doing. The rest of this book is what happens when you take the plate our grandmothers built by intuition and build it again on purpose, each taste tuned at the plant, each dish scored as it leaves the pan. We start where every Indian meal starts: with thirty loud seconds in a small, hot pan.

Chapter 2 · The Tadka — *pungency, delivered.*

Every Indian meal begins or ends with thirty loud seconds. Ghee or oil goes into a small pan and comes up to a shimmer; mustard seeds go in and *pop*, scattering against the lid; then cumin, a pinch of asafoetida blooming to a hiss, a torn dried chile darkening at the edges, a fistful of curry leaves crackling and curling translucent. You pour the whole bright-smelling slick over a waiting pot of dal or a bowl of yogurt, and it does not season the dish so much as *detonate* in it. That is the *tadka* — the tempering, also called *chaunk* or *baghar* — and it is the most pungency-forward technique in any cuisine on earth. A cook who understands the tadka understands half of what this book is about, because the tadka is a delivery system, and what it delivers is a receptor agonist at full volume at the exact moment of serving.

Underneath the romance, the tadka is applied physical chemistry. The sharp, front-of-mouth lift of mustard and ginger and raw spice — the sensation that arrives *before* the heat and leaves *before* the heat, bright and nasal and clean — is TRPA1, the pungency channel, the same one that answers to wasabi and horseradish. Its principal agonist in Indian cooking is allyl isothiocyanate, AITC, and AITC does not exist in an intact mustard seed at all. What the seed stores is a stable, water-soluble precursor, the glucosinolate **sinigrin**, kept in one cellular compartment, and the enzyme **myrosinase**, a thioglucosidase, kept carefully in another. Crack the seed — with a grinder, with teeth, with the mechanical shock of a hot pan — and the two compartments break open together. Myrosinase finds sinigrin, cleaves off its glucose, and the unstable aglycone rearranges in milliseconds to allyl isothiocyanate. The burn of mustard is a wound response. The plant builds it to punish whatever broke the seed; we break the seed on purpose and call it dinner.



Ginger in cross-section — the gingerols sit in the resin cells, fat-soluble, waiting for heat.

Ginger works in parallel and answers to both sharp channels. Its pungency is carried by the **gingerols** — 6-gingerol chief among them — which agonize TRPA1 and, more weakly, TRPV1. Dry or cook the ginger and the gingerols dehydrate to the **shogaols**, which are hotter and sharper still; this is the entire difference in heat between

fresh ginger in a chutney and dried ginger (*sonth*) in a spice blend, and it is why a tadka made with slivered fresh ginger lifts the front of the mouth while *sonth* in a masala sits lower and longer. Cinnamon in the pan contributes **cinnamaldehyde**, another TRPA1 agonist; clove, when it appears, brings **eugenol**, which touches both TRPA1 and TRPV1. The tadka is, in receptor terms, a TRPA1 chord with a TRPV1 undertone, assembled in sequence over thirty seconds because each compound surrenders to the hot fat at its own rate.

And that is the quiet genius of the technique: the hot fat is not flavor, it is *solvent*. Every one of these pungent molecules — AITC, the gingerols, cinnamaldehyde, eugenol, the capsaicin in the torn chile — is fat-soluble and locked inside intact plant tissue. Water cannot reach them; long simmering only dulls them. Ghee at just below its smoke point, somewhere around 180–190 °C, is the one medium that pulls them out whole, suspends them, and carries them onto the tongue undiluted. Bloom a spice in fat and you deliver its agonist at full concentration to the receptor. Stir the same spice into a watery gravy and you deliver a shadow of it. The tadka is the difference between speaking into a microphone and speaking from the next room.

We grow our mustard for exactly this moment. The designed **Black Mustard** host — **2,790 constructs**, tuned primarily on IFI-P and the multi-axis library — is bred toward a clean, high, reproducible AITC burst: more uniform glucosinolate loading across the seed, myrosinase activity matched to it, so that when the seed cracks in the ghee it releases a sharper and more *exact* pungency than a seed selected only to survive a burlap sack and a year on a shelf. A commodity mustard seed's heat is a lottery. Ours is a number. On the Index the tadka made with it lands near **IFI-P 2,000** — the AITC driving TRPA1 to half-maximal response at half the reference seed's concentration, which is what an IFI of 2,000 *means* — with the torn chile held low and warm around IFI-H 400 and a quiet savory floor from the asafoetida.

The Everyday Tadka

Makes enough for one pot of dal, a bowl of raita, or a plate of rice · 2 minutes · the first thing we ever learned to cook

The technique is the recipe, and once your hand knows it, it seasons half this book. Keep the heat high, keep the spices moving, and trust your nose over the clock — the tadka is finished the instant the curry leaves go crisp and the kitchen smells like it does right before everyone comes to the table.

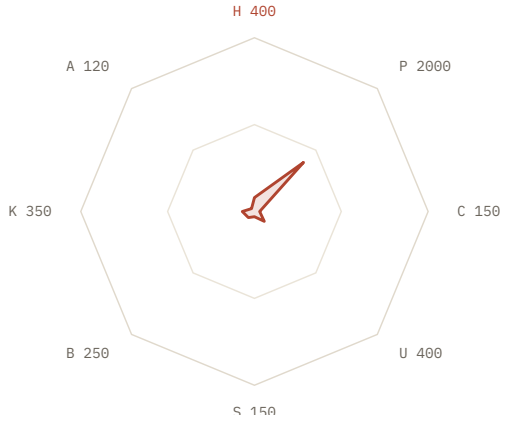
2	tbsp	ghee (or a neutral oil, for a vegan pot)
1	tsp	black mustard seeds, designed · high-IFI-P
1	tsp	cumin seeds
1	pinch	asafoetida (hing)
2		dried red chiles, torn · to IFI-H 400
12		fresh curry leaves, patted dry
1	inch	ginger, finely slivered · designed

1. Heat the ghee in a small steel pan until a single mustard seed dropped in spins and cracks at once. If it sits and sulks, the fat is too cool and the pungency will stew instead of leap.

2. Add all the mustard seeds and cover for three seconds while they pop against the lid. Uncover, add the cumin, and let it sizzle until it darkens one shade and smells toasted — perhaps ten seconds, no more.
3. Add the hing, the torn chiles, the curry leaves, and the ginger all at once. It will hiss and crackle hard and throw a little fat; stand back and count to five.
4. Pour it over whatever it is seasoning while it is still loud. A tadka waited on is a tadka wasted — the agonists oxidize and soften within a minute of leaving the heat.

Why it works — Mustard and ginger carry their pungency as fat-soluble molecules locked inside raw tissue; nothing reaches the tongue until heat and oil set them free. Blooming them in ghee just below its smoke point extracts those molecules whole and suspends them, so they arrive at TRPA1 sharp and intact rather than blunted by water or softened by a long simmer. The hing does a second, quieter job: its organosulfur compounds read as savory and faintly allium, which is why a strictly meatless, onionless pot can still land with depth. This is pungency and a whisper of umami, placed by hand, in half a minute, at the precise moment of serving.

IFI PROFILE



IFI-H	400
IFI-P	2,000
IFI-C	150
IFI-U	400
IFI-S	150
IFI-B	250
IFI-K	350
IFI-A	120

Nourishment note, quietly: the oils that carry this sharpness are the seed's own — the flavor and the good of the plant pulled from the same cell by the same heat. We do not separate them, and we would not know how to.

Chapter 3 · The Heat Ladder — *the chile, to the number.*

Indian heat is not one thing, and pretending it is has ruined more pots than any other single mistake. It is the gentle, almost sweet warmth of a Kashmiri chile added for its deep red color more than its fire. It is the green, grassy sting of a serrano crushed raw into a chutney. It is the dark, dry smolder of a Guntur chile steeping in mustard-oil pickle. And at the far frontier it is a burn that ends conversations and reorders an afternoon. The trouble has always been the unit. "Two green chiles" means one thing in a Punjabi kitchen in January and something entirely different in an Andhra kitchen in July, because the chiles are different, the hands are different, and the word "medium" is a memory, not a measurement.

A number ends the argument. On the Index, heat is IFI-H, anchored to TRPV1 — the receptor that also answers to literal fire above 43 °C and to acid, the one capsaicin hijacks by lowering its thermal threshold so the tongue reports a burn that is not there and no tissue is harmed. "Medium" is a wish. **IFI-H 700** is an instruction, and it tastes the same in August and in February, in Madras and in Montecito, because it is pinned to the half-activation of a receptor and not to anyone's childhood. Recall the formula: a candidate whose capsaicin drives TRPV1 to half-maximal response at the same concentration as our reference pepper scores 1,000; drive the receptor to half-max at a *quarter* of that concentration and you score 4,000. Potency is the inverse of the concentration it takes to speak. That inversion is the whole trick of the Index.



A cultivar in cross-section — the capsaicin lives in the placental tissue, not the seed, whatever your uncle told you.

It helps to hold two scales at once. **Scoville Heat Units** measure the *concentration* of capsaicinoids — how much fire-molecule is present, by dilution or by chromatography. **IFI-H** measures the *loudness* — how hard that molecule drives the receptor, reference-anchored and dimensionless. They track each other closely across cultivars because the same molecule is doing both jobs, but they answer different questions. SHU tells a formulator how much capsaicin is in the jar. IFI-H tells a cook how the mouth will read it.

For designing a dish you want the loudness; for costing a batch you want the concentration. We publish both and keep them from drifting.

For everyday cooking, the ladder stays low. This is the single most important correction we can offer an eager cook: the great Indian dishes do not live at the top of the scale. They live between **IFI-H 300 and 900**, where heat is a warmth and a shape and a reason to keep eating, not a test to be survived. Here is the cooking band, given as honest targets — no invented cultivar names, because the everyday rungs are heat *levels*, achieved with whatever chile hits the number:

BAND	IFI-H TARGET	THE FEEL	WHERE IT LIVES
Color, barely warm	60–150	Red, round, almost sweet	Kashmiri-type; a gentle korma
Gentle	200–400	A low hum under the spice	Most dals; a mild sabzi
The home default	500–750	Present, pleasurable, sustained	Chana, bhindi, most gravies
Bright and green	800–1,100	Sharp, grassy, forward	Raw-chutney heat; a kick in a pickle
Serious	1,200–1,800	A committed burn	Andhra-leaning; vindaloo paste

And then the frontier, where the real cultivars live — the ten proof-of-concept superhots, every one a sequenced, CRISPR-edited *C. chinense*, used in this cuisine not in a bowl but in a *drop*: a single edited pod steeping a whole jar of pickle, a pinhead of mash standing in for a fistful of commodity chile. This is the ladder a chilihead reads for sport and a pickle-maker reads for leverage.

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
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 number that matters more than any single rung is the one that does not appear in the table: **≤7%.** That is the batch-to-batch coefficient of variation on our heat, against roughly **42%** in a wild-type field crop. A commodity chile's Scoville rating is an average with a shrug around it; two pods from the same plant can differ threefold. Ours do not, because the heat is written into the genotype and specified by computational design rather than selected by hope. For a home cook, ≤7% means the dish you nailed last Sunday is the dish you get next Sunday. For a sauce brand, it means a label that does not lie and a customer who is not ambushed. Precision is not the opposite of soul in cooking. Precision is what lets you *repeat* the thing that had soul, which is the only way anyone was ever taught to

cook in the first place — by repeating a grandmother until your hands knew it. We just made the grandmother reproducible to seven percent.

Where does the capsaicin come from, so a cook can respect it? Not the seeds — that is folklore. It is synthesized and secreted by the glands of the **placental tissue**, the pale pithy ribs the seeds cling to, and the pathway that builds it is the subject of Chapter 17. For now, the kitchen fact is enough: deseed and derib a chile and you have pulled most of its heat while keeping its fruit and its color; keep the ribs and you keep the fire. A cook laddering a dish by hand does it with a knife at the ribs. A cook laddering a dish with our chiles does it with a number, and then never has to guess again.

Chapter 4 · Garam Masala, as a Vector — *the blend as a point in eight-space.*

A single spice is a note. A *masala* is a chord, and *garam masala* — "warm spice," the toasted, ground, late-added finishing blend of the north — is the most-played chord in the cuisine. Every family has its own, and every family is right, because a masala is not a recipe so much as a *position*: a point in the eight-dimensional space of the Index, reached by a particular combination of plants, that a household has decided tastes like home. Once you see a masala as a vector — a set of coordinates on the eight axes — you can read anyone's blend, reproduce it to a number, and move it deliberately in any direction you like. This is the chapter where the cuisine stops being inherited and starts being *designed*, without losing an ounce of what made it worth inheriting.

Consider the classic warm core and what each plant contributes, by receptor:

SPICE	PRINCIPAL MOLECULE	AXIS IT DRIVES	WHAT IT ADDS
Cinnamon / cassia	cinnamaldehyde	IFI-P (TRPA1)	sweet-sharp warmth
Clove	eugenol	IFI-P (TRPA1·TRPV1)	penetrating, numbing edge
Black cardamom	— (smoky terpenes)	aroma + faint IFI-C	resin, cool, smoke
Green cardamom	1,8-cineole, terpinyl acetate	faint IFI-C (TRPM8)	lift, eucalyptal cool
Cumin	cuminaldehyde	aroma (olfactory)	earth, the backbone
Coriander seed	linalool	aroma (olfactory)	citrus, roundness
Black pepper	piperine	IFI-H + IFI-P	heat and bite
Bay	eucalyptol	aroma + faint IFI-C	green top-note

Two things jump out of that table, and both matter for design. First, a great deal of a masala is *aroma*, not taste — cumin and coriander and bay work mostly through the olfactory epithelium, not the tongue's receptors, which is why the Index scores them near zero on every axis and why they still make or break the blend. We are rigorous about this: the eight axes measure taste, retronasal aroma is its own country, and a masala lives in both. We score the taste and we revere the smell, and we do not pretend the number is the whole of it. Second, the blend's taste coordinates are dominated by a few

loud plants — cinnamon and clove on pungency, black pepper on heat and bite, a faint cool thread from the cardamoms — sitting on a near-silent aromatic bed. Design the loud ones and you design the blend.



A sequencer bench — a masala, like a genome, is a set of coordinates you can read and then write.

Now the mathematics, and the one place a naïve cook goes wrong. It is tempting to think a blend's IFI is the sum of its parts — add the cinnamon's pungency to the clove's pungency and read off the total. **It is not additive, because they compete for the same receptor.** Cinnamaldehyde and eugenol both bind TRPA1; past a certain occupancy the channel is already near its half-max and the next molecule has less and less room to push it. The combined response follows a saturating curve, not a straight line, and the correct model is competitive co-agonism on a shared site — closer to the way two weak acids share a buffer than the way two lamps add their light. In practice a blend's IFI-P sits *below* the arithmetic sum of its pungent spices and climbs with sharply diminishing returns as you add more. This is not a nuisance. It is a gift. It means a masala *self-limits* — it is hard to make it harsh by accident on the pungent axis — and it means the lever that actually moves the blend is *proportion*, not quantity. Double every spice and the vector barely moves; change the ratio of clove to cardamom and it swings across the plate.

So we design masalas the way we design a construct: pick the target coordinates, then solve for the proportions that reach them under the competitive-binding model, then build it from plants tuned to hit their marks. Our designed **Cinnamon** host (**40 constructs**, IFI-P) carries a cleaner, more consistent cinnamaldehyde load than bark graded by appearance; the black pepper's piperine and the chile's capsaicin come in on the heat axis from hosts we have characterized to the same ≤7% CV. The cardamom and cumin and coriander we have not touched at all — some plants you leave exactly as they are, and the green cardamom pod is one of them; its job is a fragrance we have no wish to improve and would not know how to. A masala, in our kitchen, is a few designed loud notes placed precisely on a bed of plants left wild on purpose.

The House Garam Masala

Makes about ½ cup · 15 minutes · the blend this book cooks from

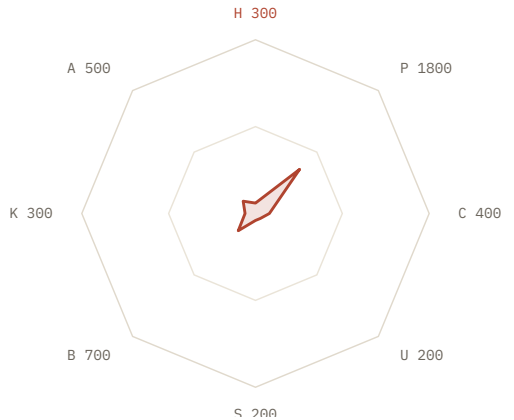
Toast whole, grind fresh, store in the dark, and make it in small batches — a masala is a volatile thing, literally, and the aromas that make it worth the trouble are gone from a jar within a month or two. We grind ours weekly and never regret it.

3	tbsp	coriander seeds
2	tbsp	cumin seeds
2		black cardamom pods
8		green cardamom pods
1		cinnamon stick (3 in) · designed · high, clean cinnamaldehyde
20		cloves
1	tsp	black peppercorns
1		bay leaf
¼	tsp	grated nutmeg (off the heat)

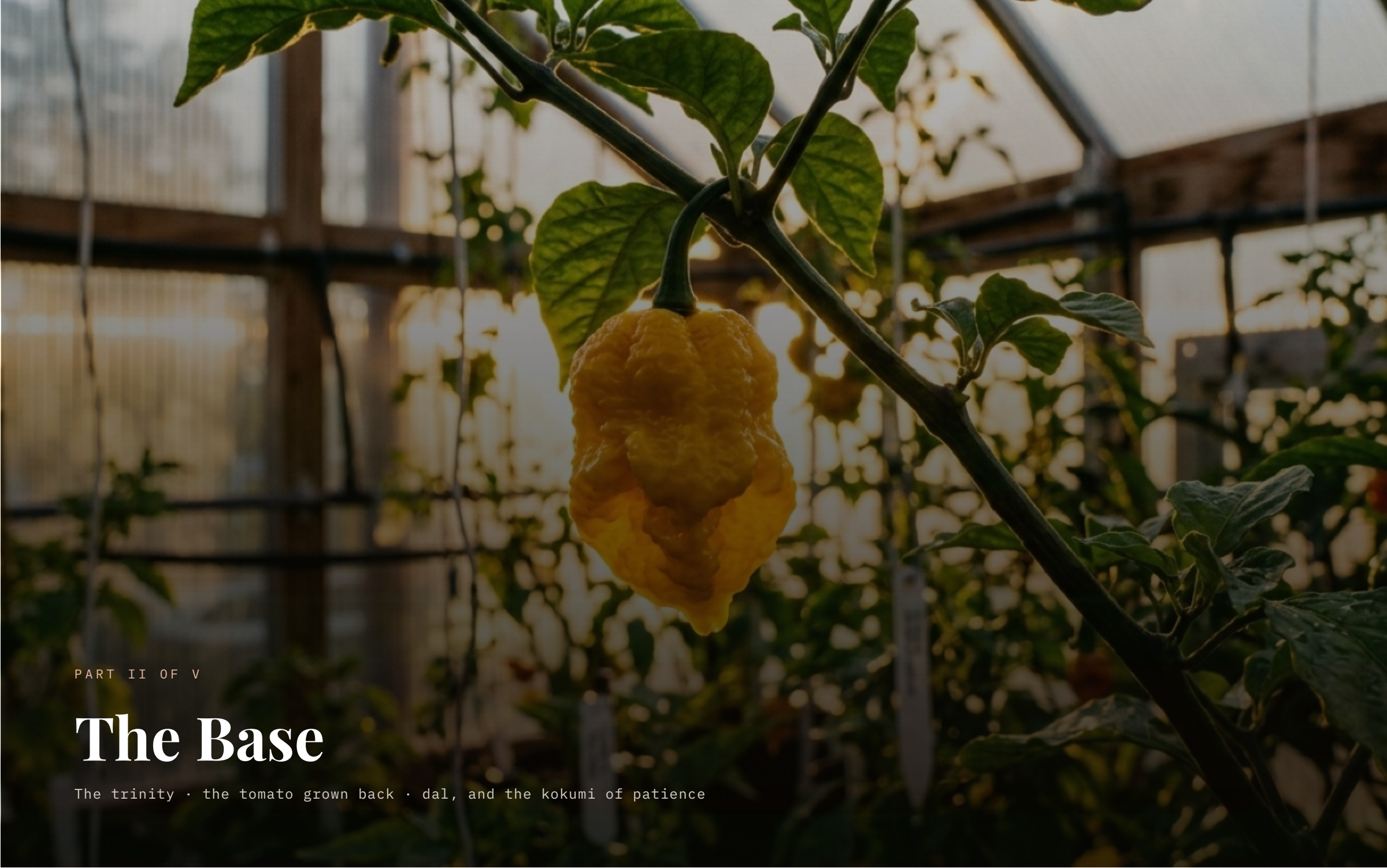
1. Warm a dry, heavy pan over medium. Add the coriander and cumin first — they take the longest — and toast, shaking constantly, until they darken a shade and smell nutty and the kitchen fills, about 3 minutes.
2. Add the cardamoms, cinnamon broken into pieces, cloves, peppercorns, and bay. Toast another 2 minutes, until the cloves swell slightly and the whole pan is fragrant to the point of insistence. Do not let it smoke; bitterness past this point is TAS2R38 answering to scorched compounds, and it does not cook out.
3. Tip everything onto a cold plate and let it cool fully — grinding warm spice cakes the grinder and dulls the blade's cut. Grind to a fine powder with the nutmeg.
4. Store airtight, away from light and heat. Add it *late* — stirred into a dish in the last few minutes, or dusted over at the table — so the aromatics reach the nose intact rather than cooking off into the exhaust fan.

Why it works — The warm core of the blend lands on TRPA1 through cinnamaldehyde and eugenol, with piperine adding heat and bite, while the real body of the smell — cumin, coriander, cardamom — reaches you retronasally and never touches the tongue's taste receptors at all. Adding it late is not a flourish; it is chemistry. These are volatile molecules with low boiling points, and a long simmer boils the best of them out the top of the pot. Late addition keeps the vector where you designed it.

IFI PROFILE



IFI-H	300
IFI-P	1,800
IFI-C	400
IFI-U	200
IFI-S	200
IFI-B	700
IFI-K	300
IFI-A	500



PART II OF V

The Base

The trinity · the tomato grown back · dal, and the kokumi of patience

Chapter 5 · The Trinity — *onion, ginger, garlic, and the savory floor.*

If the tadka is where an Indian dish ends, the *base* is where it begins, and in most of the north and much of the rest it begins with three plants cooked together until they become a fourth thing. Onion, ginger, garlic — the trinity — sweated and then browned in fat until the raw sting is gone and a dark, glossy, almost sweet foundation remains, into which the tomatoes and spices will go. This is the *bhuna*, the slow frying-down of the base, and it is the single most important twenty minutes in the cuisine, because it is where a meatless dish earns its depth. There is no stock here, no bone, no searing of flesh. The savory floor of an entire tradition is built from an allium, a root, and a bulb, cooked correctly. The Index let us finally see what "correctly" means.

Start with what the raw trinity is. Garlic's sting and its medicinal sharpness come from **allicin**, which — exactly like mustard's AITC — does not exist in the intact clove. The clove stores **alliin**, an odorless amino-acid derivative, and the enzyme **alliinase** separately; crush the clove and alliinase converts alliin to allicin in seconds, an organosulfur compound that is both pungent on TRPA1 and the source of garlic's whole aromatic character. Onion runs the same machinery with a twist: its alliinase produces, alongside the pungent compounds, a volatile called the *lachrymatory factor* — the molecule that makes you cry — and a family of sulfur compounds that, crucially, read as **kokumi**. Ginger brings the gingerols, pungent on TRPA1 and TRPV1 as we have seen. Raw, the trinity is a sharp, eye-watering, aggressive thing — all pungency and no depth. Everything good happens when you cook it.



Garlic in cross-section — the alliin and the alliinase wait in separate cells for the knife.

What cooking does is a controlled demolition and rebuild on two of the eight axes at once. On the pungency axis, heat destroys alliinase and drives off or transforms the volatile sulfur compounds — the raw IFI-P of the base falls steadily as it browns, which is exactly what you want, because you are converting assault into depth. On the kokumi axis, two things rise. First, the onion's natural **γ-glutamyl peptides** — short chains of glutamate linked through an unusual γ-

bond — survive and concentrate as water cooks off; these are direct agonists of the calcium-sensing receptor, CaSR, and CaSR is the kokumi receptor. They have almost no taste of their own. What they do is make *other* tastes bigger, rounder, and longer — they add body and continuity, the sensation that a mouthful is full and that it does not end abruptly. Second, as the sugars in the onion caramelize and its amino acids enter the **Maillard reaction**, a cascade of new savory and kokumi-active compounds appears, which is why a pale sweated onion tastes thin and a deeply browned one tastes like it has been enriched with something it never contained.

This is the deepest answer to the question a meatless kitchen is always answering: where does the richness come from? It comes from CaSR. Kokumi is the axis that delivers *mouthfulness* — the quality a long-simmered meat broth has and a thin vegetable stock lacks — and it is delivered by γ-glutamyl peptides and a handful of other CaSR agonists that a browned allium base, a lentil cooked soft, and aged dairy all happen to be rich in. A cuisine that could not use bones learned, without ever naming the receptor, to flood the plate with CaSR ligands. We named the receptor, and then we grew the plants to carry more of its ligands. Our **Onion** host (**40 constructs**, IFI-K) and **Garlic** host (**560 constructs**, IFI-K and IFI-P) are tuned up on kokumi — elevated γ-glutamyl peptide content, so the base reaches a given depth faster and holds it more consistently — while the garlic keeps the pungency we want from it and loses only the harshness we never did.

HOST	CONSTRUCTS	PRIMARY AXES	DIFFICULTY
Garlic	560	K · P	Moderate
Onion	40	K	Moderate
Ginger	120	P	Moderate

The Bhuna Onion Masala — the mother base

Makes enough for 4 servings of almost any north-Indian gravy · 25 minutes · the one you make before you know what you're making

This is a mother sauce in the truest sense — the foundation under the makhani of the next chapter, under the chana, under half of what follows. Learn to read it by sight: raw and sharp, then soft and sweet, then dark and glossy and deep. You are not just cooking onions. You are raising kokumi and lowering pungency on a curve you can taste.

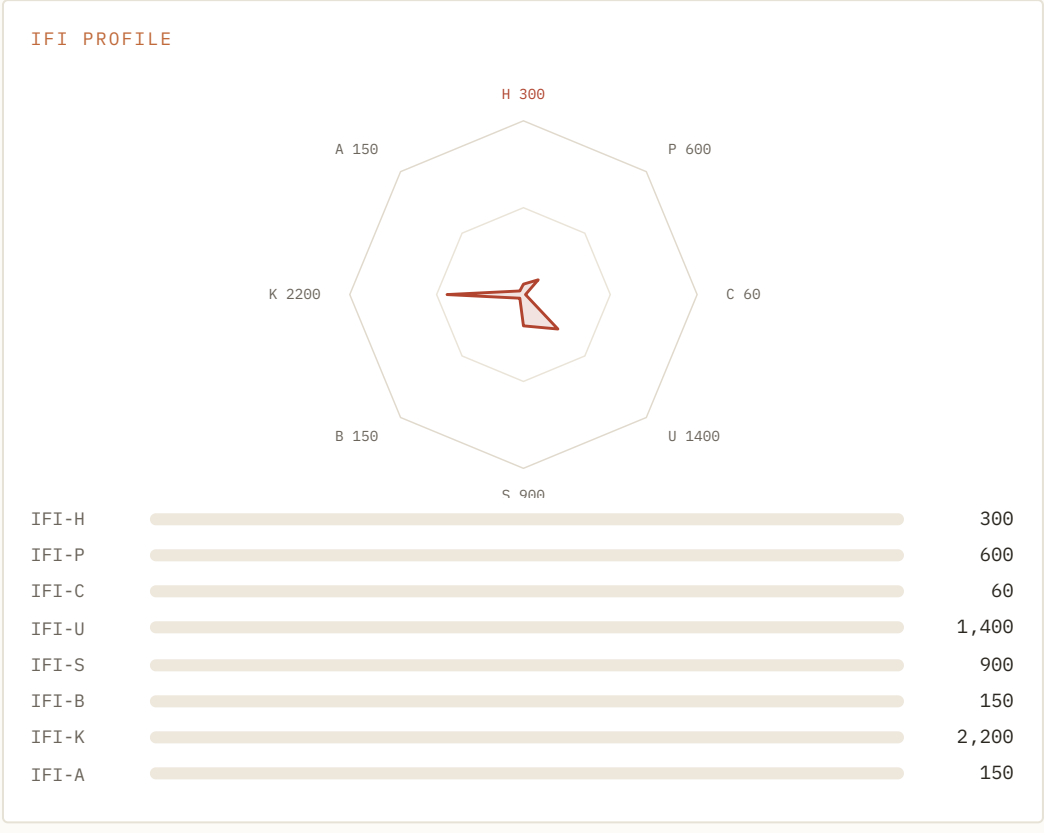
```
3     tbsp    ghee or neutral oil
2     large   onions, finely chopped · designed · high-IFI-K
1     tbsp    ginger, grated · designed
6             garlic cloves, grated · designed · high-IFI-K
½     tsp     turmeric
1     tsp     ground coriander
½     tsp     ground cumin
½     tsp     kashmiri chile · to IFI-H 300
            salt, to taste
```

1. Heat the fat in a heavy pan over medium. Add the onions and a pinch of salt (the salt pulls out water and speeds the browning) and cook, stirring often, 12–15 minutes, until they pass through soft and translucent and arrive at a deep, even gold. Do not rush

this with higher heat; you want Maillard browning, not scorching, and the two look alike for only a moment before one becomes the other.

2. Push the onions aside, add a touch more fat, and cook the ginger and garlic in it for 1 minute, until the raw edge lifts off and the kitchen sharpens — you are watching pungency fall and aroma bloom.
3. Add the turmeric, coriander, cumin, and chile. Stir constantly for 30 seconds to bloom them in the fat, then add a splash of water to keep them from catching.
4. Lower the heat and *bhuna* — fry the base down, stirring, adding water a spoonful at a time whenever it sticks, until the fat separates and glistens at the edges and the whole mass is dark, thick, and glossy, about 8 minutes. The fat separating is the signal: the base is done, the water is gone, the kokumi is concentrated. From here, it becomes any dish you like.

Why it works — The long, patient browning runs the Maillard reaction on the onion's sugars and amino acids, generating savory and kokumi-active compounds while heat destroys the harsh raw-sulfur pungency; meanwhile the onion's own γ-glutamyl peptides concentrate as the water cooks off, loading the base with CaSR agonists that give every dish built on it a mouth-filling continuity no vegetable stock can match. The ginger and garlic add a measured pungency that the cooking has already tamed from a sting to a warmth.



Chapter 6 · The Tomato, Grown Back — *the umami a century of shipping bred out.*

The tomato is where this book's thesis becomes personal, because the tomato is the plant the whole platform first set out to rescue, and the Indian kitchen is where its rescue matters most. A northern Indian gravy — a makhani, a tikka masala, the base of a hundred weeknight dinners — is, in flavor-chemistry terms, a tomato-glutamate delivery system enriched with dairy kokumi and warmed with chile. The tomato is not a garnish here. It is the *umami organ* of the dish, the plant doing the job that meat does in other cuisines. And the tomato most people can buy has been quietly gutted of exactly the thing the gravy needs it for.

Here is what happened, told straight because the numbers are a form of respect. Over roughly a century, the commodity tomato was bred for the truck, not the tongue — for uniform ripening, for a thick skin that survives shipping, for shelf life and yield and the particular red a buyer expects under supermarket light. Flavor was not selected against on purpose; it was simply not selected *for*, and what is not defended erodes. The casualty was umami. A vine-ripened heirloom carries free **glutamate** — the amino acid that is the primary agonist of the umami receptors, mGluR1 and the TAS1R1·TAS1R3 heterodimer — at levels that make a raw slice taste savory and complete. The shipping tomato carries a fraction of it. By our assays, the free-glutamate content a hard commercial tomato delivers to the receptor can sit near **IFI-U 300** against a properly grown tomato's **2,600**. The gravy built on it tastes thin, and the cook, not knowing why, reaches for more salt, more cream, a pinch of sugar — patching an absence with crutches.



A tomato in cross-section — the glutamate lives in the jelly around the seeds, the part a hard tomato barely makes.

We grew it back. The designed **Tomato** host — **2,040 constructs**, our second-largest library after the habanero, tuned on sweetness, umami, the full-spectrum and multi-axis programs — restores free-glutamate production through the plant's own native route, the **GAD /**

GDH1 pathway (glutamate decarboxylase and glutamate dehydrogenase, the enzymes that govern the glutamate pool), lifting IFI-U back toward where a tomato grown for taste would sit. Nothing exotic is added; the capacity was always in the genome, bred dormant, and we woke it. The result is a tomato that tastes like a tomato is supposed to — which, in a makhani, means a gravy that is savory to its foundation and needs no crutch to stand.

Then comes the part that makes umami feel less like a flavor and more like a law of nature: **synergy.** Glutamate alone is savory. Glutamate *in the presence of* a 5′-ribonucleotide — inosinate (IMP) or guanylate (GMP) — is savory to a degree neither could reach alone. The nucleotide binds a second site on the TAS1R1·TAS1R3 receptor and holds it in a conformation where glutamate binds far more tightly; the combined response is **supra-additive**, climbing to several times the sum of the two tastes measured apart. The classic measurement puts the synergy as high as roughly eightfold at the right ratio. This is why a pinch of dried mushroom or a spoon of certain ferments makes a tomato gravy bloom: the mushroom brings GMP, the tomato brings glutamate, and the receptor multiplies them. An Indian kitchen reaches this synergy through the back door constantly — the tomato's glutamate meeting the nucleotides liberated from a long-cooked lentil, from a pinch of asafoetida's sulfur compounds working alongside, from the dairy. We make the tomato carry its half of the equation at full strength so the synergy has something to multiply.

The Makhani Gravy

Makes a base for 4 · 35 minutes · the gravy that taught a generation to love Indian food, grown back to the plant that deserves it

A makhani — "buttery" — is the silk-smooth, mildly sweet, deeply savory tomato-and-cream gravy under butter paneer, under dal makhani, under the dish the rest of the world calls butter chicken and that we build here around vegetables with no less love. Its whole character is a conversation between tomato umami and dairy kokumi, warmed by a restrained heat. Grow the tomato back and the gravy needs almost nothing else.

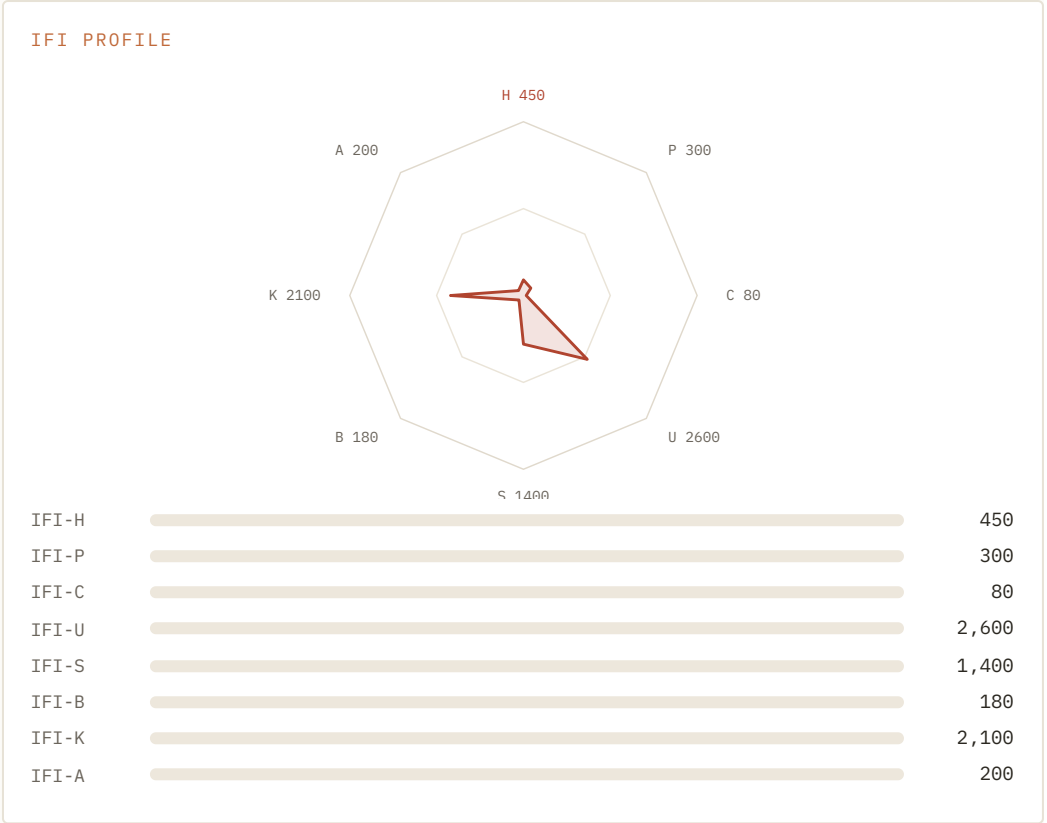
```
2   tbsp   ghee or butter
1   recipe  Bhuna Onion Masala (Chapter 5), or a quick aromatic base
800 g      tomatoes, designed · high-IFI-U · chopped (or good passata)
10         cashews, soaked (for body and a little sweetness)
1   tsp    kashmiri chile · to IFI-H 450
1   tsp    garam masala (Chapter 4)
1   tsp    dried fenugreek leaf (kasuri methi), crushed
100 ml     cream, or a cashew cream for a vegan pot
½   tsp    sugar, only if the tomatoes ask for it
         salt, to taste
```

1. Simmer the chopped tomatoes with the soaked cashews and a splash of water, covered, 15 minutes, until collapsed and soft. Blend smooth and, for a true makhani, pass through a sieve — the silk is non-negotiable and the skins are its enemy.
2. In the same pan, warm the ghee and the bhuna base. Add the tomato-cashew purée and the chile, and simmer, stirring, 10 minutes, until it darkens and the fat begins to separate at the

edges — the same signal as the base, meaning the water is gone and the flavors have concentrated.

3. Stir in the garam masala and the crushed kasuri methi (crush it between your palms to wake its aroma). Taste: if the tomatoes were grown for taste, you will likely not reach for the sugar at all. If they were shipping tomatoes, this is the moment the crutch would go in — and the moment you will notice you don't need it.
4. Off the heat, swirl in the cream. Do not boil it hard afterward; a makhani is finished gently. Rest it five minutes before serving — the kokumi continuity builds as it sits.

Why it works — The restored tomato brings its free glutamate to the umami receptors at full strength; the dairy brings kokumi-active peptides and fat that carry the aroma and lengthen the finish on CaSR; the cashew adds body and a whisper of sweetness that rounds the acid. The synergy is doing quiet work throughout — the glutamate meeting the ribonucleotides freed by cooking — which is why the gravy tastes richer than the sum of a few vegetables has any right to. The heat is held low on purpose; a makhani is a dish about depth, and the chile is there to frame the savory, not to fight it.



A note in the first person, because this one is mine: the first dish I ever cooked that made someone close their eyes was a makhani, and it was made with a winter tomato that had no business tasting of anything. I spent the next decade learning why it had tasted thin. The answer was a number — IFI-U 300 — and the fix was to grow the tomato back to 2,600. That is the whole company, in one gravy. — P.

Chapter 7 · Dal — *the kokumi of patience.*

No dish is more central to this cuisine and less celebrated outside it than dal. Lentils or split peas, simmered soft with turmeric and salt, finished with a tadka — it is the daily bread of the subcontinent, the thing eaten more often than any curry, the quiet protein spine of a vegetarian nation. It is also, read on the Index, a small masterpiece of kokumi engineering, because a pot of well-made dal does something a pot of merely-boiled lentils does not: it tastes *whole*. It fills the mouth. It lingers. It satisfies in the specific, bodily way that a meat broth satisfies, and it does so with nothing but a pulse, some fat, and time. Understanding why is understanding the deepest trick in the vegetarian larder.

The protein question first, because it is the honest one. A dal is roughly a quarter protein by dry weight, and the legume's amino-acid profile — rich in lysine, light in the sulfur amino acids — is the near-perfect complement to rice and wheat, which run the other way. Eaten together, as they almost always are, dal-and-rice or dal-and-roti forms a complete protein without a gram of meat. This is not a modern discovery; it is two thousand years of culinary wisdom arriving at a nutritional truth by taste alone, and it is the clearest case in the whole cuisine of the quiet principle that runs under this library: that food built to nourish and food built to satisfy are, more often than not, the same food. We say this as a fact about amino acids, not as a claim about health. The body does what it does with lysine. We only grow and cook the plant.



Soybean — the legume we tuned hardest on the savory axes, and the kin of every pulse in the pot.

Now the depth, which is where the engineering lives. A raw or barely-cooked lentil tastes starchy and flat. A lentil cooked long and slow tastes savory and round, and the transformation is kokumi being born. Three things happen over a long simmer. First, the legume's proteins slowly break down, and among the fragments are **γ-glutamyl peptides** — the same CaSR agonists the browned onion brings — which accumulate as cooking proceeds. Second, free **glutamate** is liberated from the protein, bringing umami and setting up the synergy of the previous chapter. Third, the pot concentrates as water cooks off, raising every savory compound at once. The

sensation we call "well-cooked dal" — the mouth-filling, continuous, satisfying body of it — is the calcium-sensing receptor reading a rising tide of γ-glutamyl peptides, amplified by glutamate on the umami receptors. Patience is not a virtue in dal-making; it is the mechanism. You are not softening a lentil. You are running an enzymatic and thermal process that manufactures CaSR ligands, and it takes the time it takes.

Our **Soybean** host — **360 constructs**, tuned on umami and kokumi, listed in our libraries at the frontier of difficulty — is the legume we have pushed hardest on exactly these axes, and while a soybean is not a red lentil, the biochemistry of the pulse family rhymes: the same peptide chemistry, the same savory potential, the same reward for time. What we learn tuning the soybean's γ-glutamyl and glutamate pathways teaches us what to reach for across the pulses. And then there is the tadka, which is why dal is the recipe that most needs the first chapter of this part: the pungent, bright finish poured over the deep, soft base is the whole cuisine in one bowl — kokumi from patience, pungency from thirty hot seconds, the slow and the sharp in one spoonful.

Tarka Dal

Serves 4 · 45 minutes, mostly unattended · the everyday one, the one we could make asleep

The humblest recipe in the book and, we would argue, the one that best repays getting right. Cook the dal longer than you think you should — the extra twenty minutes are where the kokumi lives — and finish it loud.

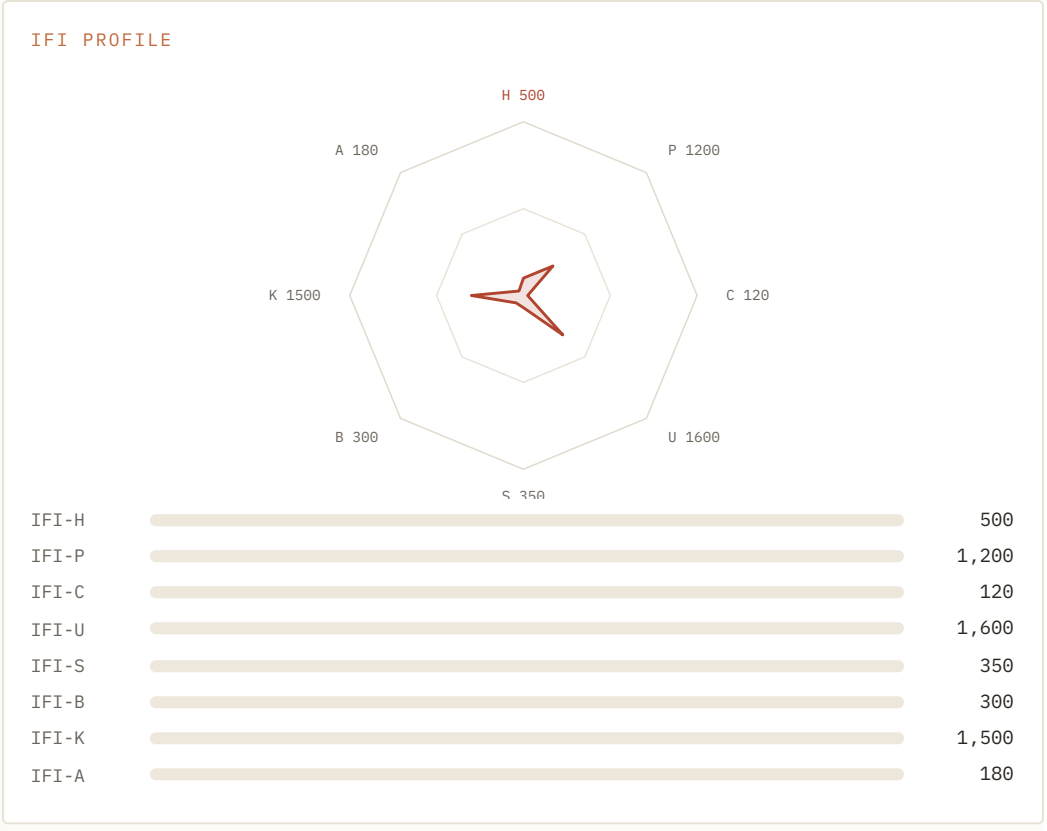
```
200 g      red lentils (masoor dal), rinsed until the water runs clear
750 ml     water
½   tsp    turmeric
1   tsp    ginger, grated · designed
1          tomato, designed · high-IFI-U · chopped
         salt, to taste

— for the tadka —
2   tbsp   ghee
1   tsp    cumin seeds
1   tsp    black mustard seeds, designed
1   pinch  asafoetida (hing)
2          dried red chiles, to IFI-H 400
3          garlic cloves, sliced · designed
10         curry leaves
¼   tsp    kashmiri chile powder (off the heat, for color)
```

1. Bring the lentils, water, turmeric, ginger, and tomato to a boil, skim the froth, then lower to a bare simmer and cook partly covered, 30–40 minutes, stirring now and then, until the lentils have completely collapsed into a soft, thick pool. Do not stop at "cooked." Go to "melted." Add water if it thickens too far. Salt it near the end.
2. Whisk the dal briefly to the consistency you like — some like it rough, some silk. Keep it warm and a little loose; it thickens as it sits.
3. Make the tadka: heat the ghee until a mustard seed cracks at once. Add the mustard and let it pop, then the cumin until it darkens, then the hing, chiles, garlic, and curry leaves. When the

garlic is pale gold and the leaves are crisp, kill the heat and stir in the kashmiri chile powder off the flame so it blooms red without burning.

4. Pour the loud, bright tadka over the quiet, deep dal and bring it to the table before it settles. Stir it through at the table if you like a little theater; it earns the theater.

Why it works — The long simmer is the point: it breaks the lentil's protein into γ-glutamyl peptides and liberates free glutamate, loading the pot with CaSR and umami agonists so the base tastes mouth-filling and complete rather than starchy. The restored tomato adds glutamate for synergy. Then the tadka lands a sharp TRPA1 pungency and a warm TRPV1 heat on top of that deep base — the sharp over the round, the fast over the slow — which is the architecture of satisfaction in this cuisine, built from a pulse and a spoon of fat.



Dal Makhani

Serves 6 · 2 hours plus an overnight soak · the feast-day dal, where kokumi is the whole point

If tarka dal is the weekday, dal makhani is the wedding. Whole black lentils (*urad*) and kidney beans, simmered for hours with butter and cream until the pot is dark and glossy and so thick a spoon stands in it. Everything this part of the book has argued about kokumi comes

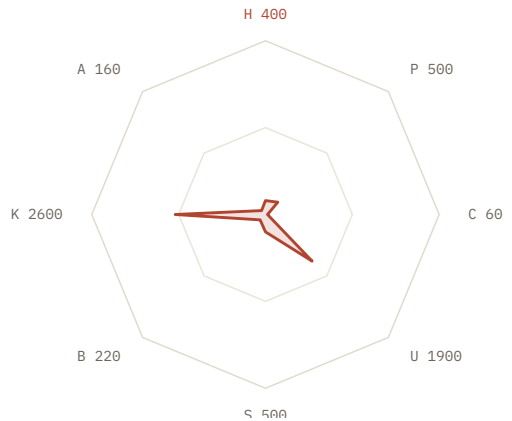
to a head here: this is the dish where patience is pushed to its limit and the calcium-sensing receptor is driven as hard as a vegetarian pot can drive it.

```
200 g      whole black urad lentils, soaked overnight
50  g      kidney beans (rajma), soaked overnight
1   recipe  Bhuna Onion Masala (Chapter 5)
2          tomatoes, designed · high-IFI-U · puréed
1   tsp    kashmiri chile · to IFI-H 400
1   tsp    garam masala (Chapter 4)
2   tbsp   butter, plus more to finish
100 ml     cream
1   tbsp   dried fenugreek leaf (kasuri methi)
         salt, to taste
```

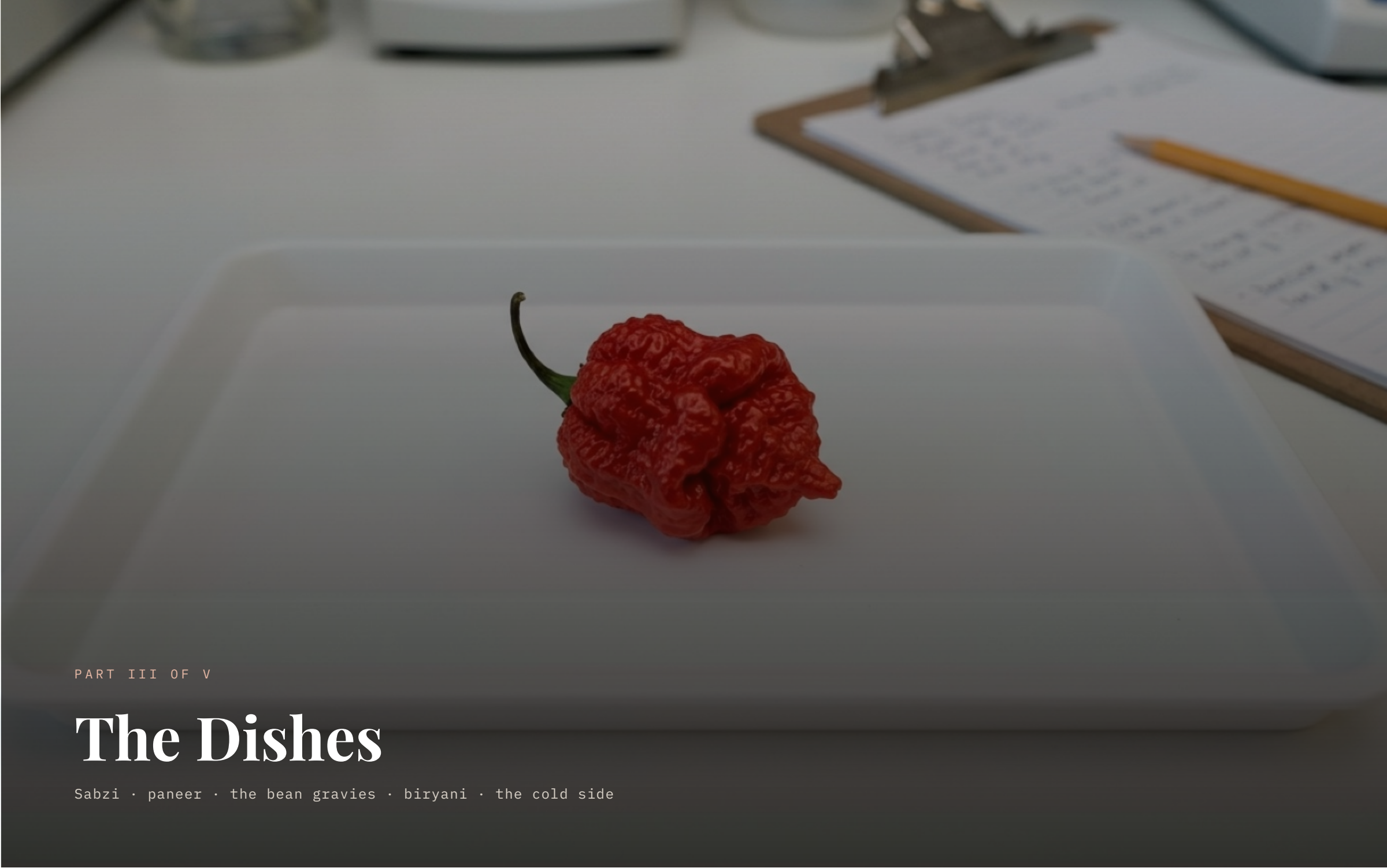
1. Drain the soaked lentils and beans and simmer them in fresh water, partly covered, 1 to 1½ hours, until completely tender and beginning to break. Do not drain the starchy cooking liquid; it is doing structural work.
2. Stir in the bhuna base, the tomato purée, the chile, and a good pinch of salt. Simmer, uncovered, on the lowest heat you can hold, 45 minutes to an hour, stirring often so it does not catch, mashing some of the lentils against the side to thicken the body. This long, low phase is where the kokumi is made; there is no shortcut and the dish knows it.
3. Stir in the butter and let it melt into the pot, then the cream, then the garam masala and the crushed kasuri methi. Simmer ten minutes more.
4. Finish with a last knob of butter melting on top. Serve with rice or naan, and understand that the richness in the bowl came from lentils and time, not from anything that walked.

Why it works — Hours of low simmering break the whole lentils' protein into a steady accumulation of γ-glutamyl peptides, pushing CaSR toward the mouth-filling continuity that defines the dish, while the starch released from the broken lentils gives the body its spoon-coating weight. The butter and cream add dairy kokumi and the fat that carries aroma and lengthens the finish. This is the clearest demonstration in the cuisine that kokumi — the richness axis — is a function you can cook *into* a plant-only pot, if you are willing to wait.

IFI PROFILE



IFI-H	400
IFI-P	500
IFI-C	60
IFI-U	1,900
IFI-S	500
IFI-B	220
IFI-K	2,600
IFI-A	160



PART III OF V

The Dishes

Sabzi · paneer · the bean gravies · biryani · the cold side

Chapter 8 · Sabzi — *the dry curry, and the taste of fire itself.*

Not every dish swims in gravy. The daily workhorse of the vegetarian table is the *sabzi* — the dry or semi-dry vegetable, cooked down with spices until the vegetable itself is the dish and the masala merely clings to it. Aloo gobi, bhindi, baingan, a dozen regional greens: these are the plates that make up most meals, and they teach a different lesson than the gravies. A gravy builds flavor around a vegetable. A sabzi builds flavor *into* it, by cooking, and the chief tool is one the Index measures only at its edges: the taste of char, of smoke, of the Maillard reaction run to its dark conclusion on the surface of a vegetable in a hot, nearly dry pan.

Consider the eggplant, *baingan*, and the dish that is its masterpiece: *baingan bharta*, where a whole eggplant is charred black over an open flame until its skin blisters and its interior collapses to smoke-scented cream, then mashed and folded into a spiced onion-tomato base. The flavor that makes bharta unmistakable — the deep, almost meaty smokiness — is not a spice at all. It is the eggplant's own sugars and amino acids undergoing Maillard browning and pyrolysis at the charring skin, generating a cloud of savory, smoky, umami-adjacent compounds that soak inward as the flesh softens. The eggplant is a famously bland vegetable made magnificent by fire, and what fire does is manufacture savory molecules on its surface that the Index reads as a lift in umami and a smoky complexity around the edge of the eight axes. A meatless kitchen learned to taste meat-adjacent depth in a scorched nightshade, and the whole technique is Maillard chemistry performed with a matchstick.



Eggplant in cross-section — bland until fire; the smoke of bharta is Maillard chemistry run to char.

We should be honest about the eggplant's place in our libraries, because honesty about the data is a rule in this house. The eggplant is not yet one of our forty-two validated hosts; it sits on the roadmap, in the first tier of the Beyond-Peppers program, as the concept we call *Dark Matter* — a nightshade close enough to the pepper, genetically, that the terminal heat enzymes should transfer with four to five edits, the named series running Smolder,

Nightshade, Eclipse, Obsidian, Event Horizon. Today, when we cook bharta, we cook it with an ordinary eggplant and all our love, and we char it the old way, because the old way is already perfect at the one thing that matters. The potato in the aloo gobi, by contrast, *is* a validated host — **80 constructs**, tuned on the bitter axis, where its value is attenuating the faint green bitterness of an under-cured tuber. The cuisine is a mix of plants we have designed and plants we have simply respected, and a sabzi is the plate where that mix is most visible.

The other great lesson of the sabzi is restraint in moisture. These dishes want a hot, nearly dry pan, because water is the enemy of browning — as long as the surface of a vegetable is wet, it cannot climb past 100 °C, and Maillard browning needs 140 °C and up. Crowd the pan, or add water too soon, and you steam the vegetable to a sad gray softness. Keep it hot and spacious and patient, and you brown it, and browning is flavor. This is why a sabzi is cooked in a wide pan, in stages, with the lid off. The cook is managing a temperature, whether she thinks of it that way or not, and the temperature she is managing is the one where plant sugars turn to savory.

Baingan Bharta

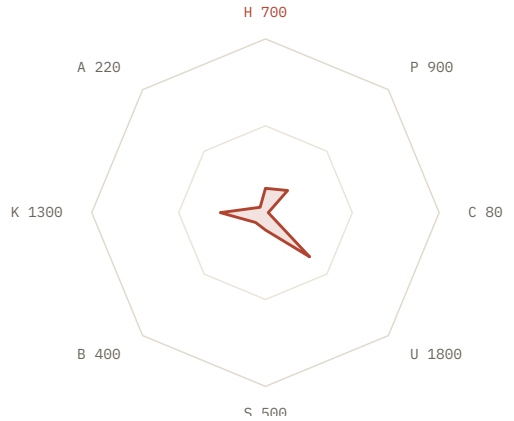
Serves 4 · 40 minutes · the dish that proves fire is a flavor

```
2   large  eggplants
2   tbsp   mustard oil or ghee
1          onion, finely chopped · designed · high-IFI-K
1   tbsp   ginger-garlic, grated · designed
2          tomatoes, designed · high-IFI-U · chopped
2          green chiles, to IFI-H 700 · chopped
½   tsp    turmeric
1   tsp    ground coriander
1   tsp    garam masala (Chapter 4)
       salt, and chopped coriander leaf to finish
```

1. Char the whole eggplants directly over a flame — a gas burner, a grill, a broiler turned to its limit — turning until the skin is blistered black all over and the flesh has collapsed, 12–15 minutes. This is not optional and it is not an accident; the black skin is where the flavor is made. Cool, peel off the charred skin, and roughly mash the smoky flesh.
2. Heat the oil until shimmering and cook the onion to deep gold, 10 minutes. Add the ginger-garlic and the green chiles, cook 1 minute, then the tomatoes, turmeric, and coriander, and cook down until the fat separates, 8 minutes.
3. Fold in the mashed eggplant and cook, stirring, 5–8 minutes, letting it catch very slightly on the pan and mashing it into the base so the smoke runs through the whole dish.
4. Stir in the garam masala and salt, scatter with coriander leaf, and serve with roti. The smoke should be the first thing you taste and the last.

Why it works — The open-flame char runs Maillard browning and controlled pyrolysis on the eggplant's own sugars and proteins, manufacturing the smoky, savory compounds that are the dish's entire identity — a depth that reads on the Index as a lift in umami with a smoky complexity around the edge of the measured axes. The onion base carries kokumi underneath, the restored tomato adds glutamate, and the green chile frames it with a forward, grassy heat.

IFI PROFILE



IFI-H	700
IFI-P	900
IFI-C	80
IFI-U	1,800
IFI-S	500
IFI-B	400
IFI-K	1,300
IFI-A	220

Aloo Gobi

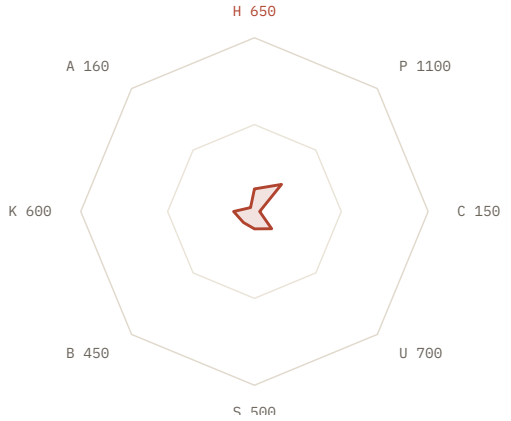
Serves 4 · 35 minutes · potato, cauliflower, turmeric, and the discipline of a dry pan

3	tbsp	oil or ghee
1	tsp	cumin seeds
500	g	potatoes, designed · diced small
1	small	cauliflower, cut into small florets
1	tsp	ginger, grated · designed
2		green chiles, to IFI-H 650 · slit
½	tsp	turmeric
1	tsp	ground coriander
½	tsp	amchur (dried mango powder, for a sour lift — amla, by hand)
		salt, and coriander leaf to finish

1. Heat the oil, crackle the cumin, then add the potatoes and cook, stirring occasionally, in a wide pan with room to spare, until their edges are browned and a knife meets slight resistance, 10 minutes.
2. Add the cauliflower, ginger, chiles, turmeric, and coriander. Cook uncovered over medium-high, stirring only now and then — you want the florets to catch color on their flat sides — until both vegetables are tender and browned in patches, 12–15 minutes. Resist the urge to add water; if it threatens to burn rather than brown, lower the heat, do not wet it.
3. Finish with salt, the amchur for its sour brightness, and a shower of coriander leaf. It should be dry, each piece glazed in spice and freckled with brown, not a stew.

Why it works — The dry, spacious pan keeps the vegetables' surfaces above the browning threshold, running Maillard chemistry on the potato and cauliflower for a savory depth that boiling would forfeit. Turmeric contributes its earthy, faintly bitter note — curcumin reads low on the bitter axis and adds color more than taste — while the amchur supplies the sour rasa the Index does not score but the plate still needs, placed by the cook's hand as it always has been.

IFI PROFILE



IFI-H	650
IFI-P	1,100
IFI-C	150
IFI-U	700
IFI-S	500
IFI-B	450
IFI-K	600
IFI-A	160

Chapter 9 · Paneer & the Dairy Axis — *kokumi you can cut with a knife.*

Dairy is the vegetarian kitchen's great ally, and nowhere more than here, where a fresh cheese pressed from curdled milk — *paneer* — gives the plant-first table a protein-rich, neutral, forgiving canvas that soaks up spice and carries richness without a hint of meat. But paneer is more than a convenience. On the Index it is a kokumi delivery vehicle, and understanding why reveals the deepest reason dairy and vegetarian cooking grew up together across so much of India: milk is nature's kokumi concentrate, and a cuisine that forgoes meat and leans on milk is a cuisine that has swapped one source of the richness axis for another.

The kokumi of dairy comes from several directions at once. Milk is rich in **glutathione** and other γ-glutamyl peptides — the γ-Glu-Cys-Gly tripeptide and its kin — which are among the most potent natural agonists of the calcium-sensing receptor; these are the molecules that make a splash of cream lengthen and round a dish out of all proportion to its quantity. Milk fat carries aroma and coats the mouth, extending the finish and giving body. And the calcium in dairy is itself a CaSR ligand — the receptor is, after all, the body's calcium sensor first and a taste receptor second. Paneer concentrates the protein and fat of milk into a solid, and so concentrates its kokumi potential into something you can dice and brown. When a cube of paneer is seared until golden, it adds Maillard savor to its dairy kokumi, and the two stack.



Spinach — the green that becomes palak, bitterness and astringency folded into dairy's round body.

The classic pairing of paneer with a dark leafy green — *palak paneer*, with spinach — is a lesson in balancing the eight axes against each other. Spinach brings two difficult tastes: a faint **bitterness** from its glucosinolate and phenolic content on TAS2R receptors, and a distinct **astringency** from its oxalic acid and tannins, which bind the saliva's proline-rich proteins and leave the

mouth with that characteristic dry, chalky grip — the famous "furry teeth" of too much raw spinach. Left alone, these would make the green harsh. The dairy answers both: the fat and the γ-glutamyl peptides of the paneer and the finishing cream blunt the bitterness and, more importantly, *re-lubricate* the mouth against the astringency, replacing the proteins the tannins stripped. Palak paneer is, in Index terms, a negotiated settlement between IFI-B and IFI-A on one side and IFI-K on the other — bitterness and astringency from the leaf, softened and surrounded by the richness of the milk. The cuisine solved this equation centuries ago by taste. We can now write it down.

Paneer itself is a small act of applied chemistry worth understanding before you cook with it. Milk is a colloid — casein proteins suspended as micelles, held apart by their negative surface charge and an outer shell of kappa-casein. Add acid (lemon juice or vinegar) to hot milk and you neutralize that charge; near the caseins' isoelectric point the micelles can no longer repel one another, and they aggregate into curds, trapping fat and water as the whey drains away. Press the curd and you have paneer — a fresh, unaged, rennet-free cheese that, because it was set with acid rather than enzyme and never ripened, does not melt but holds its shape and browns, which is exactly what a cook wants from a cube simmered in gravy. It is the simplest cheese there is and one of the most useful, made in twenty minutes from nothing but milk and a squeeze of something sour.

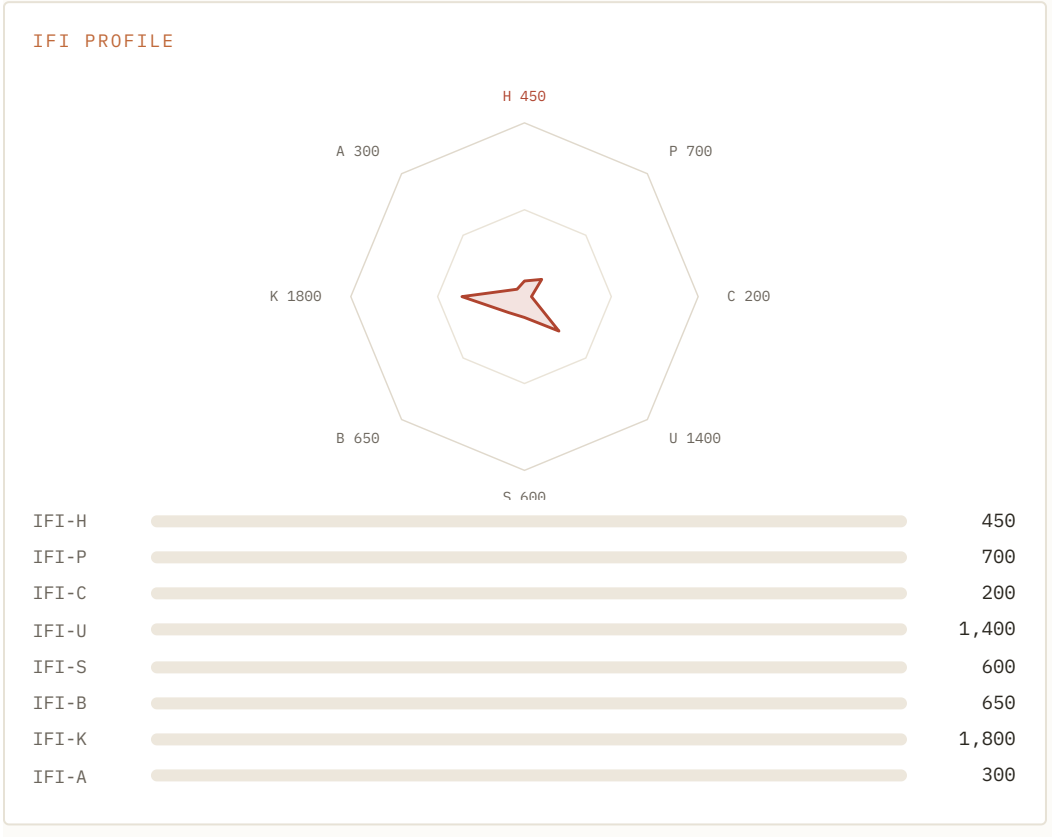
Palak Paneer

Serves 4 · 40 minutes · green and rich, the bitter and the round in balance

```
400 g      spinach, designed where you can get it · blanched
200 g      paneer, cubed
2   tbsp   ghee
1          onion, finely chopped · designed · high-IFI-K
1   tbsp   ginger-garlic, grated · designed
2          green chiles, to IFI-H 450
½   tsp    garam masala (Chapter 4)
60  ml     cream
         salt, and a squeeze of lemon
```

1. Blanch the spinach in boiling water for just 60 seconds, then plunge it into ice water — this fixes its green and, by denaturing the enzymes, limits further bitterness development. Blend it to a coarse or smooth purée, as you like.
2. Lightly brown the paneer cubes in a little of the ghee and set aside; the Maillard edges add savor and keep them from dissolving.
3. In the rest of the ghee, cook the onion to gold, add ginger-garlic and chiles for a minute, then the spinach purée. Simmer 8 minutes to marry — a raw-spinach purée tastes green and sharp; a cooked one tastes round.
4. Fold in the paneer and the garam masala, warm through, then finish off the heat with the cream, salt, and a squeeze of lemon for lift. The cream is not decoration; it is the counterweight to the leaf's astringency.

Why it works — Spinach brings bitterness on the TAS2R receptors and astringency from tannins and oxalic acid gripping the salivary proteins; the dairy answers both, its fat and γ-glutamyl peptides softening the bitter and re-lubricating the mouth against the astringent grip, while adding its own kokumi body on CaSR. The brief blanch sets the color and caps the bitterness; the cream at the end keeps the richness axis in command of the plate.



Kadai Paneer

Serves 4 · 30 minutes · the bolder cousin, built on a coarse coriander-chile masala

Where makhani-style paneer is smooth and sweet, *kadai* paneer — named for the wok-like *kadai* it is cooked in — is drier, coarser, and led by a freshly pounded masala of coriander seed and dried chile. It is a louder dish, and it shows how the same protein canvas takes a completely different position on the eight axes when the masala changes.

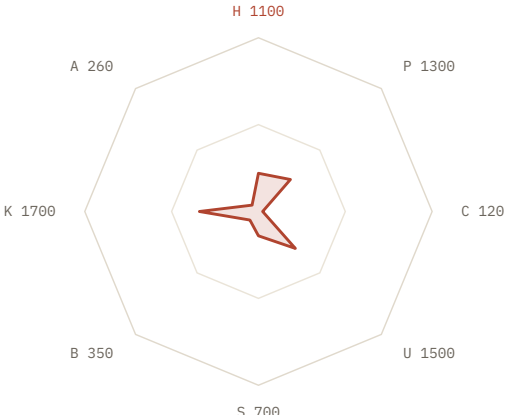
```
2   tbsp   coriander seeds
3          dried red chiles, to IFI-H 1,100
3   tbsp   oil
1          onion, diced · designed
1          green pepper, diced · designed
2          tomatoes, designed · high-IFI-U · chopped
1   tbsp   ginger-garlic, grated · designed
300 g      paneer, in batons
1   tsp    kasuri methi, crushed
         salt, and coriander leaf
```

1. Dry-roast the coriander seeds and dried chiles until fragrant, then crush coarsely — coarse, not powder; the texture is part of the dish. This is your kadai masala.
2. Heat the oil, cook the onion and the green pepper until softened and lightly browned at the edges, add ginger-garlic for a minute, then the tomatoes and most of the kadai masala. Cook down until the fat separates.

3. Fold in the paneer batons, warm through so they take on the masala, and finish with the crushed kasuri methi, salt, the last of the masala for a fresh hit, and coriander leaf. Keep it on the dry side — a kadai clings, it does not pool.

Why it works — The coarsely crushed, freshly roasted coriander-and-chile masala puts a bright, forward pungency and a real heat on the front of the plate, where kadai's identity lives, while the paneer carries dairy kokumi underneath and the restored tomato keeps the umami floor intact. The same canvas as palak paneer, moved across the eight axes by nothing but a change of masala — which is the lesson.

IFI PROFILE

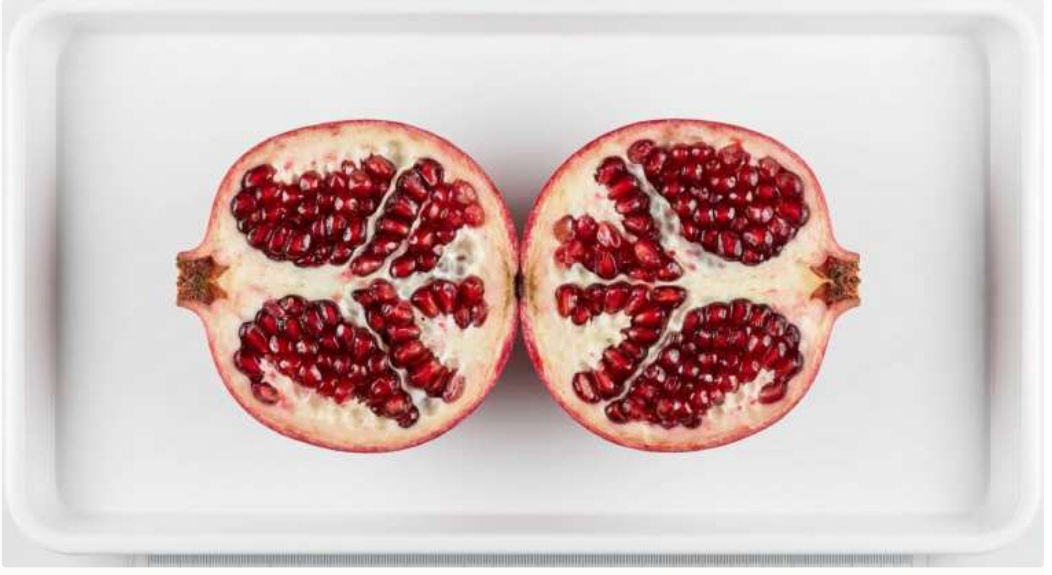


IFI-H	1,100
IFI-P	1,300
IFI-C	120
IFI-U	1,500
IFI-S	700
IFI-B	350
IFI-K	1,700
IFI-A	260

Chapter 10 · The Bean Gravies — *rajma, chana, and the sour that isn't on the chart.*

Beyond the lentils lie the larger pulses — kidney beans for *rajma*, chickpeas for *chana masala* — and with them a different texture, a different heartiness, and a flavor strategy that leans hard on a taste the Index does not score: sourness. A great chana masala is defined as much by its tang as by its spice, and that tang is *amla*, the sour rasa, delivered by amchur or anardana or tamarind or a squeeze of lemon, sitting outside the eight axes on the proton-sensing channels of the tongue. This is the chapter where we honor what the Index cannot measure, because a cook who only chased the eight axes would make a flat chana, and flatness is a failure the receptors we do measure cannot fix.

The chickpea itself is a quiet umami-and-kokumi contributor on the model of the lentil — cooked long, it liberates glutamate and builds γ-glutamyl peptides — but its texture is its glory: the firm, almost meaty bite of a properly cooked chana, which gives the dish a chew that no lentil provides and which, in the mouth, does part of the job texture does in a meat dish. Cook chickpeas with a piece of *badi elaichi* and a tea bag or a few dried amla, as many cooks do, and they darken and deepen; the tannins from the tea even lend a faint astringency — IFI-A by the back door — that frames the sour and the savory. A pot of chana masala is a surprisingly complete reading of the old six-rasa plate: pungent from the masala, bitter from the darker spices, astringent from the tannin, savory from the long-cooked pulse, and sour, loudly and essentially, from the amchur. Only sweet and salt are added by hand, and salt is always added by hand.



Pomegranate — anardana, the dried seed, brings sour and the astringent grip of IFI-A to the bean pot.

The astringency is worth a moment, because it is the subtlest of the eight axes and the bean gravies use it deliberately. *Anardana* — dried pomegranate seed — is a classic souring agent in chana, and the pomegranate is one of our validated hosts: **120 constructs**, tuned squarely on the astringency axis, IFI-A. Astringency, recall, is

not a chemical taste but a mechanical one: tannins and other polyphenols bind and precipitate the proline-rich proteins that lubricate the mouth, and the tongue reads the resulting friction as a dry, puckering grip. In small, deliberate measure it is a structural element — it gives a rich or sour dish a clean, drying finish that keeps it from cloying, the same job tannin does in a glass of wine or a cup of tea. Too much and the mouth revolts. The pomegranate we grow lets a cook reach for a precise, repeatable astringency where before there was only a handful of dried seeds and a hope. It is a small axis, but on a plate meant to hold all the tastes at once, the small axes are the difference between complete and nearly.

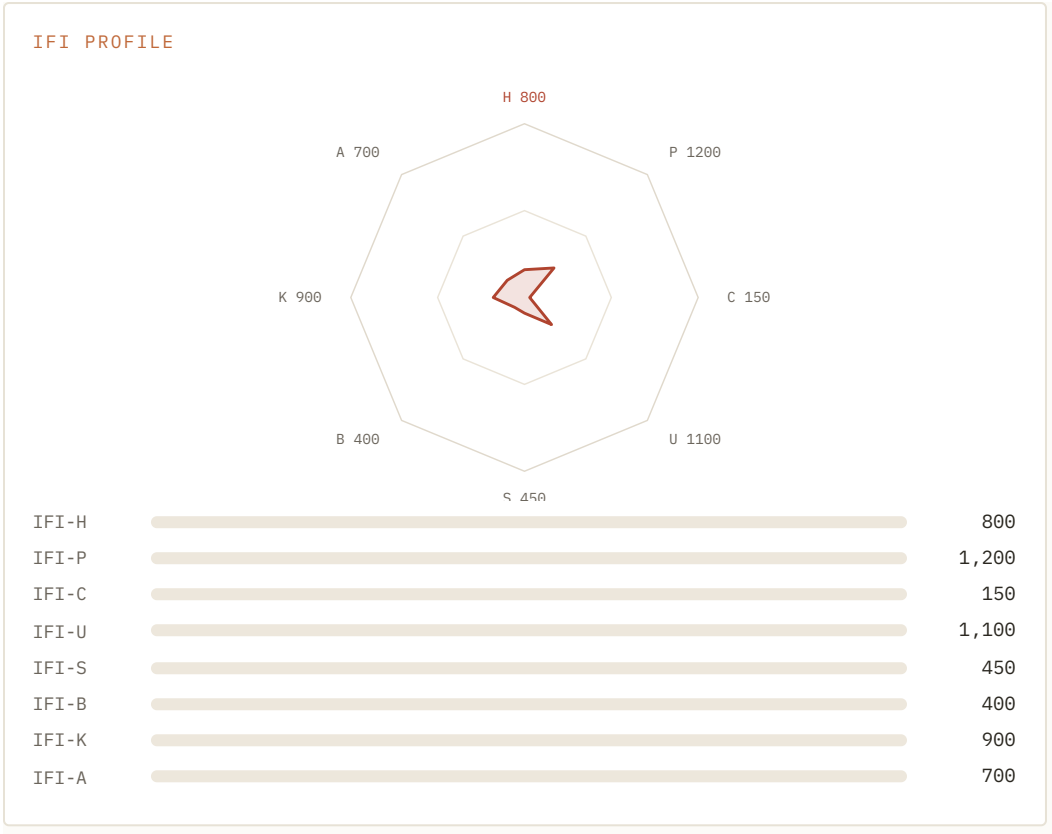
Chana Masala

Serves 4 · 1 hour (plus an overnight soak) · the one with the tang

250	g	dried chickpeas, soaked overnight (or 2 tins, drained)
1		black tea bag (for color and a faint tannin)
2	tbsp	oil
1	tsp	cumin seeds
1	recipe	Bhuna Onion Masala (Chapter 5)
2		tomatoes, designed · high-IFI-U · chopped
2	tsp	chana masala blend (or garam masala, Chapter 4)
1	tsp	amchur, or 2 tbsp anardana (dried pomegranate), ground
1		green chile, to IFI-H 800
		salt, ginger slivers and coriander leaf to finish

1. Simmer the soaked chickpeas with the tea bag and a little salt until completely tender but still holding their shape, 45–60 minutes. Fish out the tea bag. Keep the dark cooking water.
2. Heat the oil, crackle the cumin, warm the bhuna base, add the tomatoes and cook down until the fat separates. Stir in the chana masala blend and the green chile.
3. Add the chickpeas with a ladle of their cooking water and simmer 15 minutes, mashing a few against the side to thicken the gravy, until it clings. Stir in the amchur or ground anardana — this is the tang, and the dish is not itself without it.
4. Finish with salt, raw ginger slivers for a fresh pungent lift, and coriander leaf. Taste for sour; it should prickle the sides of the tongue.

Why it works — The long-cooked chickpea brings umami and a kokumi body on the model of the lentil, with a firm, satisfying chew that does the work of texture; the amchur or anardana supplies the essential sour rasa the Index leaves to the cook's hand, while the tannin from the tea and the pomegranate adds a measured astringency that gives the rich, tangy gravy a clean, drying finish. Raw ginger at the end lands a fresh TRPA1 pungency over the cooked depth.



The kidney bean carries one more lesson, and it is a safety lesson a book that serves home cooks owes its readers plainly. Raw and undercooked red kidney beans contain **phytohaemagglutinin**, a lectin that is genuinely toxic in quantity — a handful of raw or barely-simmered beans can make a person sharply ill — and it is destroyed only by a hard boil, not a gentle one. The rule is exact: soak the beans, discard the soak water, then boil them *vigorously* for at least ten minutes before dropping to a simmer. A slow cooker left on low never reaches the temperature that denatures the lectin, and is the classic way people make themselves sick on an otherwise wholesome pot. This is not folklore; it is food science, and it is why rajma is always started with a rolling boil. We note it because the nourishment this book cares about begins with not harming anyone, and because the fix costs nothing but ten honest minutes.

Rajma

Serves 4 · 1 hour (plus an overnight soak) · the Punjabi Sunday, kidney beans in a deep gravy

```
250 g      red kidney beans, soaked overnight
2   tbsp   ghee or oil
1   recipe  Bhuna Onion Masala (Chapter 5)
2          tomatoes, designed · high-IFI-U · puréed
1   tsp    kashmiri chile · to IFI-H 600
1   tsp    garam masala (Chapter 4)
1   tsp    dried mango (amchur), or a squeeze of lemon
         salt, ginger slivers and coriander leaf to finish
```

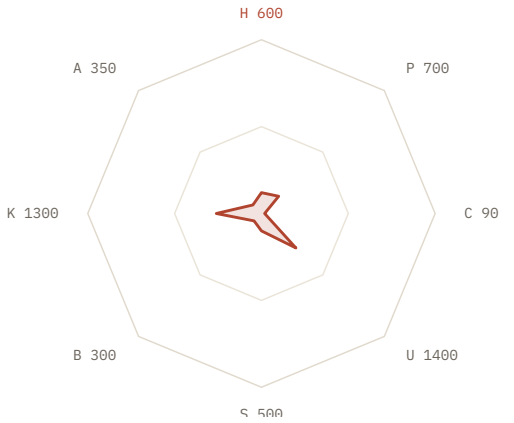
1. Drain the soaked beans, cover with fresh water, and bring to a hard, rolling boil for 10 full minutes — this destroys the kidney bean's lectin and is not negotiable. Then lower to a simmer and cook until completely tender and a few beans begin to break, about 45 minutes. Keep the starchy cooking liquid.
2. Warm the bhuna base with the ghee, add the tomato purée and the chile, and cook down until the fat separates.
3. Add the beans with a few ladles of their cooking water and simmer 20 minutes, mashing some against the side so the gravy thickens to a silky, clinging body. Stir in the garam masala and the

amchur or lemon.

4. Finish with salt, raw ginger slivers, and coriander leaf. Serve over rice — *rajma-chawal* — the dish that is Sunday lunch for half of north India.

Why it works — The long-cooked kidney bean brings umami and a kokumi body on the pulse principle of Chapter 7, with the broken beans' released starch giving the gravy its coating weight; the restored tomato adds glutamate for synergy, the amchur supplies the sour the Index leaves to the cook's hand, and the measured chile holds the heat at a comfortable home default. The hard initial boil is the safety step that makes the whole pot sound.

IFI PROFILE



IFI-H	600
IFI-P	700
IFI-C	90
IFI-U	1,400
IFI-S	500
IFI-B	300
IFI-K	1,300
IFI-A	350

Chapter 11 · Biryani — *the one-pot composition, and the aroma that isn't a taste.*

Biryani is the cuisine's grand composition — fragrant long-grain rice layered with a spiced vegetable or protein masala and steamed sealed until the whole becomes one thing — and it is the dish that most forcefully reminds us of the Index's honest limit: that a great deal of what we love in food is *aroma*, not taste, and aroma is a different sense with a different map. You can score a biryani on the eight axes, and we will, but the thing that makes a biryani a biryani — the perfume that rises when the lid comes off — lives almost entirely in the nose. We score what we can and we revere the rest, and biryani is where that discipline is most tested.

The rice itself carries the headline aroma, and it is one molecule: **2-acetyl-1-pyrroline**, the compound responsible for the characteristic scent of basmati rice (and, not coincidentally, of pandan leaf and of fresh bread crust). It is extraordinarily potent — detectable at parts per billion — and it is why basmati, aged and long-grained, is non-negotiable for a proper biryani. This is pure retronasal aroma; 2-acetyl-1-pyrroline has essentially no taste on the eight axes. It is also a reminder of the frontier: rice sits on our roadmap as the concept we call *Dynasty*, in the furthest tier of the Beyond-Peppers program, a grass genome that would take ten to twelve edits to bring into the platform — long-horizon work, named honestly as a concept and not a product. Today we cook biryani with the best aged basmati we can find and tune everything around it.



Basmati rice — the aroma of biryani is 2-acetyl-1-pyrroline, a scent, not a taste.

The layering is a lesson in composition over time. A biryani is built in strata — par-cooked rice over a wet, intensely spiced masala over a scatter of fried onion, saffron milk, and whole spices — and then sealed and steamed (*dum*) so that moisture and aroma migrate upward through the rice as it finishes. The whole spices steeping in the steam — green cardamom, cloves, cinnamon, bay, star anise,

mace — perfume the rice without ever being tasted directly; they are aromatic infusers, not seasonings. The saffron brings its own trio: **safranal** for aroma, **picrocrocin** for a faint bitter edge, **crocin** for the gold color that stains the rice in streaks. The fried onion (*birista*) brings Maillard sweetness and kokumi. And the masala at the bottom carries the dish's actual taste coordinates — the heat, the savory, the pungency — up into the rice as steam. Reading a biryani on the Index means reading mostly that bottom layer, and understanding that the top note, the thing that makes a table go quiet when the lid lifts, is a smell the Index was never built to hold.

The rice chemistry deserves its own moment, because biryani lives or dies on the grain. Aged basmati is prized for two measurable reasons: a year or more of storage lowers the grain's moisture and raises its proportion of **amylose**, the straight-chain starch, relative to the branched amylopectin — and high-amylose rice cooks to firm, separate, non-sticky grains that stay distinct in a layered pot rather than collapsing to a mass. Starch granules gelatinize — absorb water and swell irreversibly — across roughly 60–75 °C; the par-boil takes the grain only to about 70% done, to the very edge of gelatinization, so that the core stays firm and the final steaming finishes it without tipping into mush. This is why a biryani cook drains the rice early and fast. Cook it through in the water and the *dum* has nothing left to do but overcook it.

The *dum* itself is a small thermodynamic machine. Sealed under a tight lid — traditionally a rope of flour-paste dough that bakes shut — the pot traps the steam rising off the wet masala at the bottom, and that steam carries both heat and volatile aroma *upward* through the rice, finishing the grain and perfuming it in one motion. The fried onion, *birista*, contributes Maillard sweetness and kokumi with a faint bitterness from its deep browning; the saffron's three compounds divide the labor cleanly — safranal for the aroma, picrocrocin for a faint bitter edge that keeps the sweetness honest, crocin for the gold that bleeds into the rice in streaks. A biryani is, in the end, a gentle distillation performed on dinner: the flavors of the base coaxed upward as steam and condensed into every grain.

Vegetable Dum Biryani

Serves 6 · 1½ hours · the composition, layered and sealed

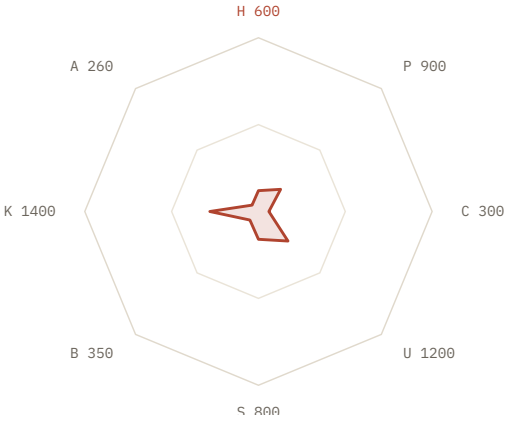
```
500 g      aged basmati rice, soaked 30 minutes
          mixed vegetables: carrot, bean, potato, cauliflower, peas
1   recipe  Bhuna Onion Masala (Chapter 5), made wet and bold
200 g      yogurt
2   tsp    biryani masala (or garam masala, Chapter 4)
2          green chiles, to IFI-H 600
          large pinch saffron, steeped in 3 tbsp warm milk
2          onions, thinly sliced and fried to deep gold (birista)
          whole spices: 4 green cardamom, 4 clove, 1 cinnamon, 2 bay
          mint and coriander leaf, ghee, salt
```

1. Boil a large pot of salted water with a few whole spices. Add the drained rice and cook until just 70% done — still firm at the core, because it will finish in the steam. Drain at once.
2. Cook the vegetables into the wet bhuna base with the yogurt, biryani masala, and green chiles until nearly tender and thickly coated. Season assertively; this layer must flavor the whole pot.

3. Layer in a heavy pot: masala on the bottom, then the par-cooked rice, then the saffron milk drizzled in streaks, the fried onion, the herbs, and dots of ghee. Repeat if your pot is deep.
4. Seal the lid tight (a flour-paste seal, *dum*, is traditional and worth it) and steam on the lowest heat, 20–25 minutes. Rest 10 minutes sealed. Open at the table, and let the room fall quiet.

Why it works — The dish is a controlled migration of aroma and moisture through par-cooked rice: the whole spices and saffron perfume the grains retronasally while the bottom masala sends its measured heat, pungency, and savory up as steam. The basmati's 2-acetyl-1-pyrroline and the saffron's safranal are the headline, and they are scents the Index cannot score — which is the honest reason the scorecard below, accurate as it is, is only part of the truth of the plate.

IFI PROFILE



IFI-H	600
IFI-P	900
IFI-C	300
IFI-U	1,200
IFI-S	800
IFI-B	350
IFI-K	1,400
IFI-A	260

Chapter 12 · The Cold Side — *chutney, raita, and the cooling channel.*

A hot plate needs a cold answer, and the Indian table always provides one: a bright green chutney, a sweet-sour tamarind one, a cooling bowl of yogurt raita. These are not afterthoughts. They are the structural counterweight that makes a spiced meal sustainable mouthful after mouthful, and they operate on an axis the main dishes mostly leave alone — IFI-C, the cooling channel, TRPM8 — alongside the sour and sweet and dairy-kokumi the Index reads at its edges. The cold side is where the eighth axis finally comes forward, and where the cuisine's balance reveals itself as a deliberate thermal composition: fire on one side of the plate, frost on the other.

Cooling is a true sensation with a true receptor. **TRPM8** is the cold-sensing ion channel on the trigeminal nerve, the counterpart to capsaicin's TRPV1, and it is activated both by actual low temperature and by certain molecules that fool it — chiefly **menthol**, from mint. Menthol does to cold what capsaicin does to heat: it lowers the channel's activation threshold so the mouth reports a coolness that is not thermally there. A mint chutney is not cold because of its temperature; it is cold because its menthol is opening TRPM8. This is why mint and coriander chutney feels like relief against a chile's burn even at room temperature — the two sensations are being read by two opposite channels, TRPV1 reporting fire and TRPM8 reporting frost, and the mind experiences their simultaneity as balance. The cooling plants are their own deep library in our program — peppermint alone carries 2,360 constructs across the five-gene menthol pathway — and while a chutney uses ordinary mint, the axis it plays on is one we have characterized to the molecule.



A cultivar at dew — the cooling channel, TRPM8, is the mirror of the fire; a plate needs both.

The other cold players work differently. The tamarind-date chutney is a study in the two rasas the Index does not score — a deep, sticky sweetness (*madhura*, which the Index *does* read, as IFI-S) wrapped around a sharp tartaric-acid sourness (*amla*, off the chart) — with a faint astringency from the date skins and tamarind pulp giving it a clean finish. The raita is pure dairy strategy: yogurt's fat and γ-glutamyl peptides deliver kokumi and, crucially, *physically* soothe a

capsaicin burn, because capsaicin is fat-soluble and the dairy fat dissolves and carries it off the receptor — the reason a lassi quenches a chile where water only spreads it. The cold side, read as a system, is a four-receptor insurance policy against the heat of the main plate: TRPM8 cooling, dairy fat clearing TRPV1, sour resetting the palate, sweet rounding it off. The cuisine built this balance by feel. The Index shows it was right to.

There is a further subtlety the cuisine exploits without naming. Menthol does not only open TRPM8; it also acts on the trigeminal sense of nasal airflow, which is why a minty chutney reads as not merely cool but *clarifying*, opening the breath as it cools the tongue. And because the cold channel TRPM8 and the heat channel TRPV1 feed into overlapping trigeminal pathways, the brain processes fire and frost together — present both at once, a hot dish and a cool chutney in the same mouthful, and the experience is not cancellation but a vivid, legible contrast, each sharpening the perception of the other. The cold side is not merely relief from the heat; it is what makes the heat *readable*. A fiery plate without its cooling counterpoint is a monologue. With it, it becomes a conversation between two channels, and the mouth follows the exchange.

Mint-Coriander Chutney

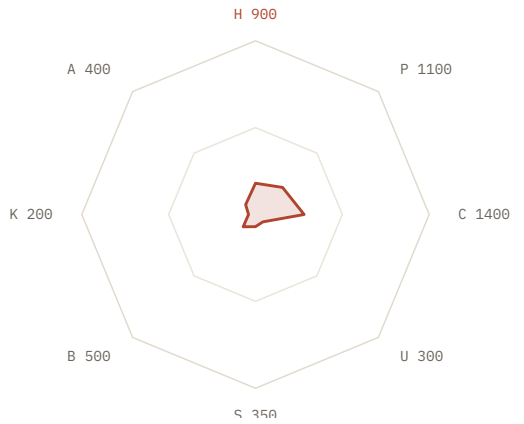
Makes a bowl · 10 minutes · the green one, the cooling one

1	cup	mint leaves
2	cups	coriander leaf and tender stem
2		green chiles, to IFI-H 900
1	inch	ginger · designed
1	tbsp	lemon juice
½	tsp	salt · a pinch of sugar
2	tbsp	yogurt (optional, for a creamy version)

1. Blend everything with a splash of cold water to a bright, smooth green. Keep it cold and use it the day you make it — the green and the volatile mint aroma fade fast once cut.
2. Taste for balance: it should be sharp with chile, cool with mint, bright with lemon, all at once.

Why it works — The mint's menthol opens TRPM8, the cold channel, delivering a true cooling sensation that reads against the main plate's TRPV1 heat as relief; the green chile keeps a forward pungency so the chutney has lift of its own, and the lemon's sour and the optional yogurt's kokumi round it. It is the coolest-reading recipe in the book, and the only one where IFI-C leads.

IFI PROFILE



IFI-H	900
IFI-P	1,100
IFI-C	1,400
IFI-U	300
IFI-S	350
IFI-B	500
IFI-K	200
IFI-A	400

Tamarind-Date Chutney

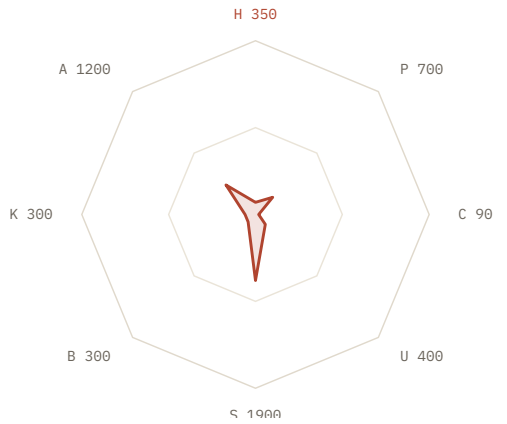
Makes a jar · 25 minutes · sweet, sour, and a clean dry finish

100 g		seedless tamarind
100 g		dates, pitted
1	tbsp	jaggery, to taste
½	tsp	roasted cumin, ground
¼	tsp	chile · to IFI-H 350
¼	tsp	dried ginger (sonth) · black salt

1. Simmer the tamarind and dates in water until very soft, 15 minutes. Blend smooth and pass through a sieve.
2. Return to the pan with the jaggery and spices and simmer to a pourable, glossy syrup. It thickens as it cools; keep it looser than you think.

Why it works — This is sweetness (IFI-S, on the TAS1R2·R3 receptor) wrapped around a sharp tartaric-acid sourness that lives off the Index on the proton channels, with a faint astringency from the date and tamarind giving it a clean, drying close so the sweetness never cloys. It is the sweet-sour pole of the cold side, the foil to the green chutney's cool.

IFI PROFILE



IFI-H	350
IFI-P	700
IFI-C	90
IFI-U	400
IFI-S	1,900
IFI-B	300
IFI-K	300
IFI-A	1,200

Cucumber Raita

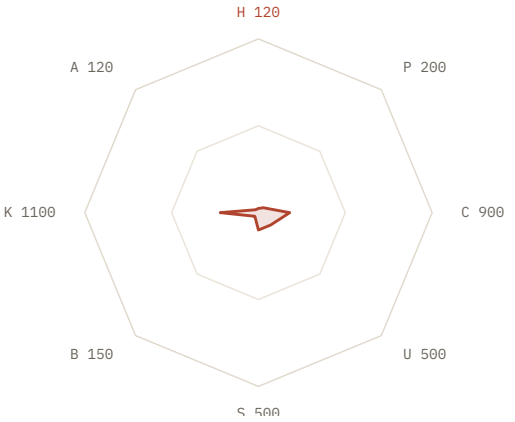
Makes a bowl · 5 minutes · the fire extinguisher

250 g	thick yogurt, whisked smooth
½	cucumber, grated and squeezed dry
¼ tsp	roasted cumin, ground
	pinch of chile, mint, salt

1. Fold everything together, keep it cold, and serve it beside anything hot. The grated cucumber adds its own faint cool and crunch.

Why it works — Yogurt's fat physically dissolves and clears fat-soluble capsaicin off TRPV1 — the mechanism by which dairy, and not water, actually relieves a chile burn — while its γ-glutamyl peptides deliver a soft kokumi body and the cucumber adds a cool, watery lift. It is the plate's insurance, and it is why the hottest meals are always served with a bowl of something white.

IFI PROFILE



IFI-H	120
IFI-P	200
IFI-C	900
IFI-U	500
IFI-S	500
IFI-B	150
IFI-K	1,100
IFI-A	120



PART IV OF V

Heat, Ferment & Region

The pickle · the south · the regional heat map

Chapter 13 · Achaar — *the pickle, where heat and ferment meet.*

If the cold side is the cuisine's relief, the pickle — *achaar* — is its exclamation point: a tiny, intense, preserved spoonful of vegetable or fruit suspended in spiced oil, so concentrated that a smear of it seasons a whole plate of plain rice and dal. Achaar is where Indian cooking reaches its highest intensities on several axes at once, where fermentation meets fire, and where our designed mustard and our extreme chiles do their most dramatic work. It is also a masterclass in food preservation as a flavor technology, which is what a pickle has always secretly been.

Start with the medium, because in a North Indian achaar the medium is itself the headline: **mustard oil** (*kachi ghani*, cold-pressed), which carries a pungency most cuisines never meet. Raw mustard oil is loaded with the same allyl isothiocyanate chemistry as mustard seed — the glucosinolate-and-myrosinase system firing AITC onto TRPA1 — and it brings a sharp, sinus-clearing bite that defines the northern pickle. The oil is usually heated to smoking and cooled before use, which tames the harshest edge while keeping the pungency; it then acts as both flavor and preservative, sealing the vegetable away from oxygen under a pungent, antimicrobial blanket. Our designed **Black Mustard** host — **2,790 constructs** — is tuned for exactly this intensity, and a pickle is where its high, clean IFI-P is most gloriously at home: the sharpest legal expression of the pungency axis on an Indian table.



A superhot cultivar — in a pickle, a single edited pod does the work of a fistful of commodity chile.

Then the preservation, which is real microbiology. A traditional pickle is often a lacto-fermentation: the salt draws water from the vegetable and selects for salt-tolerant *Lactobacillus* and related lactic-acid bacteria, which ferment the vegetable's sugars to lactic acid, dropping the pH below the point where spoilage organisms can live. The sourness of a fermented pickle is *amla* manufactured by microbes — tartaric and malic from the fruit, lactic from the ferment — and it sits, as ever, off the Index on the proton channels, while doing the essential work of preservation. The chile and mustard oil add their own antimicrobial muscle. A jar of achaar left in the sun for

weeks is a small, deliberate, ancient fermentation vessel, and the cook who makes it is running a controlled microbial process whether she names it or not. This is the same principle that runs under koji, under kimchi, under every ferment in the library: life, directed toward flavor and preservation at once.

And this is the one place in everyday Indian cooking where the extreme end of the heat ladder earns its keep. You would never cook a weeknight sabzi with a superhot. But a pickle is preserved and eaten in tiny amounts over months, and a single pod of an edited chile — *Firestorm* at IFI-H 3,490, say, or a sliver of *Solara* at 3,980 — steeping in the oil of a whole jar distributes its fire across a hundred small servings, each one a measured prick of heat rather than an assault. The ≤7% CV matters more here than anywhere: in a jar meant to last a year, you want the last spoonful to burn exactly as the first did. A pickle is the chilihead's playground and the quartermaster's dream, and it is where this cuisine and our extreme library finally shake hands.

The pickle shelf is a whole grammar of its own, and its dialects are worth knowing. A **brine pickle** — lime or green chile in salt and its own juice — leans hardest on the lacto-fermentation, the *Lactobacillus* turning sugar to acid under salt until the jar is sour and self-preserving. An **oil pickle** — mango, mixed vegetable, the northern style — relies on the mustard-oil seal and the spice's antimicrobial muscle more than on acid, which is why its heat and pungency run so high. The spice blend that defines a North Indian *achaar masala* is remarkably stable across kitchens: fenugreek for its bitter-savory depth and its sotolon aroma, fennel for a sweet anise lift, nigella (*kalonji*) for an oregano-like sharpness, mustard for the AITC pungency, turmeric for color, and chile for heat. Each of these is also, quietly, a preservative — part of the reason the pickle keeps for a year on a shelf without refrigeration.

Underneath it all is water activity, the single variable that governs whether a jar spoils. Salt and sun-curing pull free water out of the vegetable and bind what remains, dropping the water activity below the roughly 0.85 threshold most spoilage organisms need to grow. The traditional weeks in the sun are not for warmth or romance; they are a slow dehydration that concentrates flavor and starves the microbes that would ruin the jar, while the salt-tolerant lactic bacteria the cook *wants* carry on acidifying. A pickle is preservation science that predates the science by millennia — a cook managing water activity, pH, and selective fermentation with nothing but salt, oil, spice, and sunlight.

Quick Mango Achaar

Makes a jar · 30 minutes plus 3 days to mature · the pickle, in a hurry

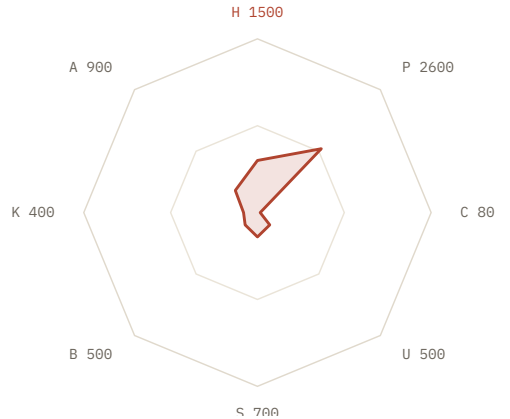
A true aam ka achaar matures for weeks in the sun; this is an honest quick version that captures the architecture — sour mango, pungent mustard oil, bright spice, measured fire — in days rather than months.

2	large	unripe green mangoes, diced small with skin
3	tbsp	salt
4	tbsp	mustard oil, heated to smoking and cooled
2	tbsp	black mustard seeds, designed · coarsely cracked
1	tbsp	fennel seeds
1	tsp	fenugreek seeds
1	tsp	nigella seeds (kalonji)
1	tsp	turmeric
2	tsp	chile powder, or 1 sliver of an edited pod · to IFI-H 1,500

1. Toss the diced mango with the salt and leave in a bowl for 2–3 hours; it will release liquid. Drain it and pat the pieces dry — this is a fast stand-in for the days of sun-drying a traditional pickle uses to pull water and concentrate.
2. Dry-roast the fennel and fenugreek, cool, and crack them coarsely with the mustard seeds. Toss the mango with all the spices and turmeric.
3. Pack into a clean, dry jar and pour the cooled mustard oil over to cover completely — the oil must seal the surface. Press down so no mango stands proud of the oil.
4. Leave at warm room temperature, shaken once a day, for at least 3 days before eating; it deepens for weeks. Always serve with a dry spoon. A little goes a very long way.

Why it works — The salt draws water from the mango and sets up a mild lacto-fermentation that manufactures the sour, preserving tang off the Index, while the smoking-and-cooling of the mustard oil keeps its AITC pungency but softens its raw harshness. The oil then seals the mango from oxygen under an antimicrobial, intensely pungent blanket. The chile is held to a measured heat because a pickle is eaten by the spoonful over months — this is intensity designed to be rationed.

IFI PROFILE



IFI-H	1,500
IFI-P	2,600
IFI-C	80
IFI-U	500
IFI-S	700
IFI-B	500
IFI-K	400
IFI-A	900

Chapter 14 · The South — *coconut, curry leaf, tamarind, and the overnight batter.*

Cross the Vindhyas and the grammar of the cuisine changes. The fat of choice becomes coconut oil and coconut flesh; the souring agent becomes tamarind rather than yogurt or amchur; the tempering gains curry leaf and urad dal and whole dried chile as a constant; and rice, not wheat, is the undisputed staple — not only boiled but *fermented*, ground with lentils into batters that rise overnight into dosa and idli. South Indian food is a distinct flavor system built on the same eight axes, and it brings two things the north uses less: coconut's particular richness, and the living chemistry of the overnight ferment. Both reward reading on the Index.

Coconut is a kokumi and texture story. Its flesh and its first-press milk are high in fat, and that fat does the familiar work — coating the mouth, carrying aroma, lengthening the finish on CaSR — but coconut also brings a gentle natural sweetness and a smooth, almost creamy body that makes it the south's answer to dairy in countless dishes. A coconut chutney, ground fresh with green chile and tempered with mustard and curry leaf, is a complete small composition: kokumi and sweetness from the coconut, pungency from the tempering, heat from the chile, all balanced in a spoonful. Where the north reaches for cream, the south reaches for coconut, and the Index reads both as plays on the richness axis by different means.



Coconut in cross-section — the south's answer to dairy, fat and sweetness and body in one.

The ferment is the deeper science, and it is quietly spectacular. A dosa batter is nothing but rice and urad dal, soaked, ground, and left overnight in a warm place — and in that time it transforms completely. Wild *Leuconostoc mesenteroides* and other lactic-acid bacteria, present on the lentil, ferment the batter's sugars, producing lactic and acetic acids that lower the pH and give the finished dosa its characteristic gentle tang (*amla*, off the Index, microbial in origin). Crucially, the same bacteria produce **carbon dioxide**, which leavens the batter — this is why idlis are soft and spongy and dosas lace and

crisp, with no yeast and no baking soda, only the living gas of fermentation. The ferment also does nutritional work the tradition arrived at by taste: it begins breaking down the phytates and complex carbohydrates of the grain and pulse, which is part of why fermented rice-and-lentil foods sit so lightly. We note this as food chemistry, not as a claim — the bacteria do what bacteria do, and the cook who leaves a batter out overnight is cultivating them as deliberately as any brewer. It is the same principle as the pickle, as koji, as every ferment: life, directed toward flavor.

Sambar

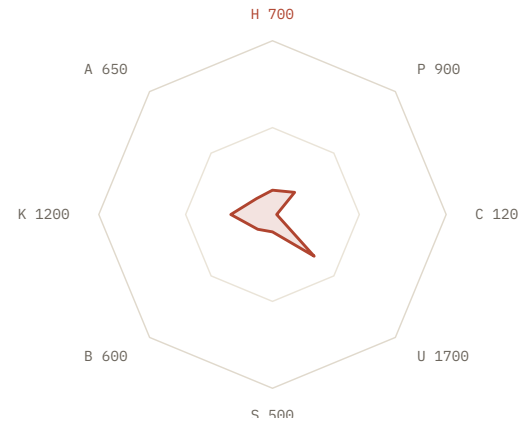
Serves 6 · 1 hour · the tamarind-and-lentil stew that anchors the southern plate

```
150 g      toor dal (split pigeon peas), rinsed
          mixed vegetables: drumstick, pumpkin, carrot, okra, shallot
1   tbsp   tamarind, soaked and strained to a thin pulp
2   tbsp   sambar powder (a roasted blend of coriander, chile, lentils,
fenugreek)
½   tsp    turmeric
          salt

— for the tadka —
2   tbsp   coconut or sesame oil
1   tsp    black mustard seeds, designed
1   tsp    urad dal
2          dried red chiles, to IFI-H 500
1   pinch  asafoetida · 15 curry leaves
```

1. Cook the toor dal with the turmeric until completely soft and collapsed, 30 minutes; mash it smooth. This is the umami-and-kokumi base, on the lentil principle of Chapter 7.
2. Separately cook the vegetables until tender. Combine with the mashed dal, the tamarind pulp, the sambar powder, and salt, and simmer 15 minutes so the sour, the spice, and the savory marry.
3. Make the tadka: heat the oil, pop the mustard, fry the urad dal to gold, then the chiles, hing, and curry leaves until crisp. Pour it over the sambar and cover immediately to trap the aroma.

Why it works — The toor dal brings the long-cooked pulse's umami and kokumi, the tamarind brings the defining sour the Index leaves to the cook, and the sambar powder layers pungency and a measured heat over the top; the tadka finishes it with a sharp TRPA1 lift and the nutty note of fried urad dal. It is the southern lentil stew as a balanced reading of the old rasa plate, sour and savory in the lead.

IFI PROFILE



IFI-H		700
IFI-P		900
IFI-C		120
IFI-U		1,700
IFI-S		500
IFI-B		600
IFI-K		1,200
IFI-A		650

Coconut Chutney

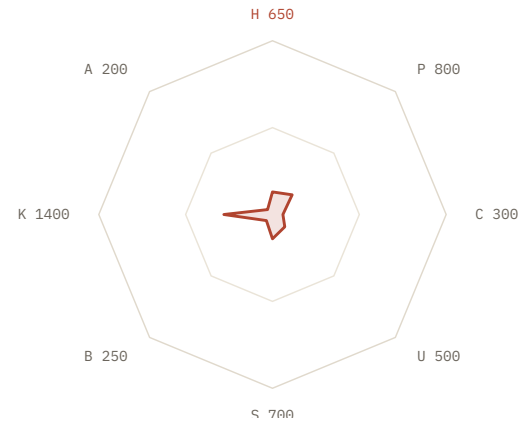
Makes a bowl · 10 minutes · the white one, beside every dosa

```
1    cup     fresh grated coconut
2    tbsp    roasted chana dal (for body)
1            green chile, to IFI-H 650
1    inch    ginger · designed · small clove garlic
          salt, a little tamarind or lemon

— for the tadka —
1    tbsp    coconut oil
½    tsp     black mustard seeds, designed
1            dried chile · 8 curry leaves · pinch hing
```

1. Blend the coconut, chana dal, green chile, ginger, garlic, salt, and souring agent with a little water to a soft, scoopable paste.
2. Temper: pop the mustard in the oil, add the dried chile, curry leaves, and hing, and pour the tadka over the chutney.

Why it works — Coconut's fat delivers a smooth kokumi body and a gentle sweetness — the south's dairy-free richness — while the green chile and the mustard-seed tadka add heat and a sharp pungency, and the souring agent lifts it. A whole small composition in a spoonful, built on the richness axis by way of the coconut.

IFI PROFILE



IFI-H		650
IFI-P		800
IFI-C		300
IFI-U		500
IFI-S		700
IFI-B		250
IFI-K		1,400
IFI-A		200

Rasam

Serves 4 · 30 minutes · the thin, hot, sour pepper-broth that ends a southern meal

If sambar is the south's lentil stew, rasam is its spiced consommé — a thin, intensely flavored tamarind-and-pepper broth, drunk from a cup or poured over rice, traditionally served to clear the palate and settle the stomach at a meal's close. It is also the dish where black pepper, not chile, carries the heat, which makes it a small lesson in a second route to TRPV1.

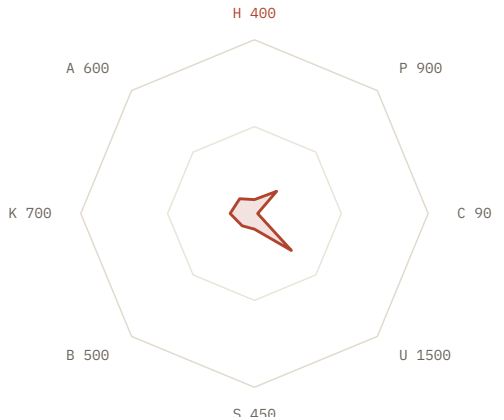
```
1   tbsp   tamarind, soaked and strained to a thin pulp
2          tomatoes, designed · high-IFI-U · chopped
2   tsp    rasam powder (coriander, cumin, pepper, chile, toor dal,
roasted)
1   tsp    black peppercorns, coarsely cracked · to a pungent IFI-H ~400
1   pinch  turmeric · salt · a little jaggery
         a few tbsp cooked toor dal, optional, for body

— for the tadka —
1   tbsp   ghee · 1 tsp black mustard seeds, designed
1          dried chile · 10 curry leaves · pinch hing
         crushed garlic (optional), coriander leaf to finish
```

1. Simmer the tamarind pulp, chopped tomato, rasam powder, cracked pepper, turmeric, salt, and jaggery with about 600 ml water (and the optional dal for body) for 15 minutes — do not boil hard; rasam is coaxed, not raged. It should stay thin, cloudy, and fragrant.
2. Make the tadka: pop the mustard in the ghee, add the dried chile, curry leaves, hing, and garlic, and pour it in. Cover at once to trap the aroma. Finish with coriander leaf.

Why it works — Black pepper's **piperine** is the engine here, a TRPV1 agonist that delivers a warm, rounded heat distinct from capsaicin's sharper bite, with its own pungency alongside; the tamarind carries the essential sour off the Index, and the restored tomato's glutamate

gives the thin broth a savory depth it would otherwise lack. Rasam proves the heat axis has more than one key — capsaicin is the loudest, but piperine plays it too.

IFI PROFILE



IFI-H	400
IFI-P	900
IFI-C	90
IFI-U	1,500
IFI-S	450
IFI-B	500
IFI-K	700
IFI-A	600

Chapter 15 · The Regional Heat Map — *Kashmir to Andhra, and the Portuguese accident.*

To cook this cuisine to the number is to discover that "Indian heat" is a dozen different arguments about what a chile is *for*, and that each region answers differently. The Index lets us finally draw the map, because once heat is IFI-H and not "medium," the regional styles separate into clean, distinct positions on the axis — and reveal that the great regional cuisines disagree not just about how much heat, but about what *job* the heat is doing. This chapter is a short atlas of that disagreement, and it ends with the one dish where a foreign vinegar rewrote an Indian chile.

In the far north, in **Kashmir**, the chile is barely a heat at all. The Kashmiri chile is prized for its deep, clear red — a color from its carotenoids and anthocyanins — and for a gentle warmth, perhaps IFI-H 60–150, that colors a rogan josh or a yakhni without ever dominating it. Here heat is a pigment and a whisper. Move to **Punjab** and the home default rises to a comfortable IFI-H 500–750, present and pleasurable, the warmth under a dal makhani or a chana. Go west to **Goa**, and something foreign enters: the Portuguese brought the chile to India in the sixteenth century in the first place, and in Goa they also brought vinegar, and the collision produced *vindaloo* — a fiercely hot, sharply sour dish whose very name is a Konkani rendering of the Portuguese *carne de vinha d'alhos*, "meat in wine-garlic marinade." Vindaloo is an Index outlier: high heat (IFI-H 1,800+) crossed with a loud sour that lives off the chart, a dish defined by the tension between TRPV1 fire and proton-channel acid. And in the south-east, in **Andhra** and **Telangana**, the heat simply goes further than almost anywhere — Guntur chiles driving everyday dishes past IFI-H 1,500, a regional palate calibrated to intensities that would stop a northern cook cold. One cuisine, one chile species, and a heat axis that runs across more than an order of magnitude depending on which kitchen you stand in.

REGION	EVERYDAY IFI-H	THE CHILE'S JOB	SIGNATURE
Kashmir	60–150	Color and gentle warmth	Rogan josh, yakhni
Punjab / north	500–750	Comfortable, present warmth	Dal makhani, chana
Bengal	300–600	Restraint; mustard leads	Shorshe, mustard-forward
Gujarat	200–500	Sweet-leaning, gentle	Sweet-savory balance
Goa	1,500–1,900	Heat crossed with sour	Vindaloo
Andhra / Telangana	1,500–2,200	Heat as the point	Guntur-forward, gongura

This is the clearest practical argument in the whole book for a number. A recipe that says "add chile to taste" is useless across this map — one cook's "to taste" is twenty times another's. A recipe that

says IFI-H 600 travels: it means the same warmth in Srinagar and in Hyderabad, adjustable by a knob the cook actually controls because the chile that delivers it is reproducible to ≤7%. The regional styles are not erased by this; they are *liberated* by it, because a cook in one tradition can now reach precisely into another's palette without years of calibration. The map stops being a mystery you must be born into and becomes a set of coordinates you can visit.

Two deeper facts sit under this map, one historical and one physiological. Historically, none of it is as old as it feels: the chile is a New World plant, unknown in India until Portuguese traders brought it from the Americas in the sixteenth century, and the entire towering edifice of Indian heat — the Guntur fields, the vindaloo, the pickle that strips paint — was built in roughly five hundred years on a fruit that, in the long life of this cuisine, arrived only yesterday. Before the chile, the pungent corner of the plate was carried by black pepper, long pepper, ginger, and mustard, and those still hold the line in dishes like rasam. The chile did not replace them; it gave heat and pungency a far louder voice, and the regions took up that voice at wildly different volumes.

Physiologically, the regional differences are partly written into the receptor itself. TRPV1 **desensitizes** with repeated exposure: eat capsaicin habitually and the channel's response dampens, its threshold drifts upward, and the same dose reads as milder than it would to an unaccustomed mouth. This is real receptor pharmacology, not bravado — an Andhra palate calibrated to IFI-H 1,800 is not imagining its tolerance; its TRPV1 population has genuinely adapted. It is also why the Index anchors to the receptor's *half-maximal activation* under a standard condition rather than to anyone's lived sensation: the number is fixed even as the mouth that reads it moves. A cook can trust IFI-H 600 to be the same stimulus everywhere; whether a given eater finds it gentle or fierce depends on the history of their own channels.

Vindaloo Paste

Makes enough for a hot pot for 4 · 20 minutes · the Portuguese accident, laddered

A paste, not a finished dish, because vindaloo is a marinade-and-braise and the paste is its engine. This is where we cook near the top of the comfortable ladder on purpose — hot and sour and garlicky — and where you can dial the heat to a number instead of a dare.

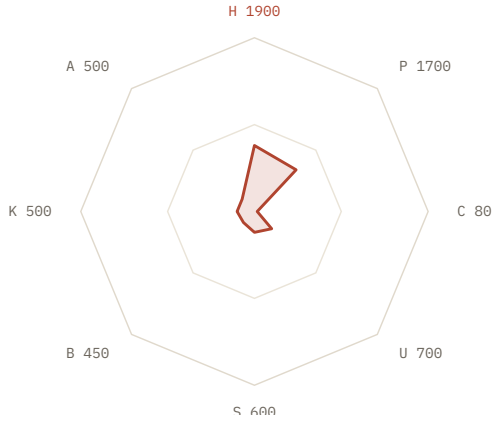
```
8          dried red chiles (Kashmiri for color + a hotter one for heat) ·
to IFI-H 1,800
1   tsp    cumin seeds
1   tsp    black peppercorns
4          cloves · 1 in cinnamon · ½ tsp turmeric
10         garlic cloves · designed · high-IFI-K
2   inch   ginger · designed
3   tbsp   palm or cider vinegar
1   tsp    sugar · salt
```

1. Soak the dried chiles in hot water until soft, 15 minutes. Drain.
2. Dry-roast the cumin, pepper, cloves, and cinnamon, and grind to a powder.

3. Blend the soaked chiles, the ground spices, turmeric, garlic, ginger, vinegar, sugar, and salt to a smooth, dark-red paste. Use it to marinate and then braise vegetables, potato, or paneer — traditionally meat, which this cuisine cooks with equal respect and which the same paste serves without a single change.

Why it works — The chile brings a committed TRPV1 heat, laddered here to a number rather than left to chance, while the vinegar supplies the sharp sour — off the Index, on the proton channels — that is vindaloo's defining second note and, not incidentally, a preservative that lets the dish keep. The garlic, high on kokumi and pungency, gives it a savory-sharp foundation. It is the hottest-leaning composition in the main cuisine, and the one that most clearly shows heat and sour working as partners.

IFI PROFILE



IFI-H	1,900
IFI-P	1,700
IFI-C	80
IFI-U	700
IFI-S	600
IFI-B	450
IFI-K	500
IFI-A	500



PART V OF V

Design & Nourishment

The simmer sauce · the molecular kitchen · the full plate

Chapter 16 · Designing a Simmer Sauce — *the spec in the jar.*

Most people will never grind their own garam masala, and that is not a failure of anyone's — it is the reason the jarred simmer sauce exists, and the reason this book has a chapter for the brands who make them. A simmer sauce is a finished base in a jar: open it, add your vegetables or protein, simmer, and eat. Done well, it carries a genuine kitchen's flavor to a weeknight that has no time to build one. Done badly, it is thin, over-salted, over-sweetened, and flat — a makhani with the tomato bred out of it and sugar and cream papering over the hole. This chapter is how to design one to the number, because a simmer sauce is the single clearest commercial case for everything the Index makes possible: it is a flavor you must hit exactly, repeatedly, at scale, on a label that must not lie.

Begin by specifying the target as a point on the eight axes, not as a recipe. A tikka-masala simmer sauce — the category's best-seller — has a known, lovable shape: high umami, high kokumi, a real but moderate sweetness, a gentle heat, and only a whisper of the other axes. Written as a spec, that is roughly IFI-U 2,400, IFI-K 2,000, IFI-S 1,500, IFI-H 700, everything else low. That target is the contract. Every ingredient decision then serves it, and — this is the discipline a jar demands — every batch must hit it within tolerance, because a customer who loved the jar last month will reject the one that drifts. Our **≤7% coefficient of variation** is the number that makes a branded simmer sauce honest: when the tomato is grown to a specified IFI-U and the chile to a specified IFI-H, the sauce formulator inherits that precision and can hold the jar to its own label batch after batch. A commodity-tomato sauce cannot promise this; its umami wanders with the harvest, and the formulator patches the wander with salt and sugar, which is why so many jars taste of exactly those two crutches.



A microscope stage in the QC lab — a simmer sauce is a flavor you must hit to ≤7%, batch after batch.

Here is the design logic, step by step, for a formulator holding the spec:

AXIS	TARGET	LEVER	SOURCE
Umami (U)	2,400	grow the glutamate back	designed tomato · IFI-U restored
Kokumi (K)	2,000	γ-glutamyl load + dairy	browned onion · cream · designed garlic
Sweetness (S)	1,500	from the tomato, not sugar	ripe designed tomato · minimal added sugar
Heat (H)	700	a specified chile	laddered cultivar · ≤7% CV
Pungency (P)	600	late-added masala	garam masala, protected from the cook

The commercial payoff of growing the umami back is not only flavor; it is *label*. A sauce that reaches its savory depth from a tomato's own restored glutamate does not need added monosodium glutamate, and it does not need the salt-and-sugar load that props up a thin base — which lets a brand make a cleaner declaration on the panel. We are careful here, because this is where a flavor claim can slide into a health claim, and we do not cross that line: the honest statements are about *composition* — "no added MSG," "no added sugar," an ingredient list a shopper can read — not about what the food will do to a body. Naturally occurring glutamate from a tomato is not added MSG, and saying so is true; implying the sauce is therefore healthful is a different sentence, and not one we write. The nourishment this library cares about is a reason to grow the plant well, never a line on a jar.

Two compliance notes a brand must carry, because a book that serves simmer-sauce makers owes them the unglamorous truths. **Allergens:** mustard is a declared allergen in the EU, the UK, and Canada; dairy (the cream and paneer), tree nuts (the cashew in a korma or makhani), and soy all require declaration where present — an Indian sauce is an allergen-dense category and the label must be exhaustive. **Bioengineering disclosure:** because our hosts are engineered, a sauce built on them falls under the US National Bioengineered Food Disclosure Standard and its counterparts abroad; the right posture is plain disclosure, because the engineering is the point and the story — a tomato grown back to the flavor shipping took from it — is one worth telling on the label rather than hiding. Precision, transparency, and a flavor you can repeat: that is the whole offer of designing to the Index, and the simmer-sauce aisle is where it most obviously pays.

Tikka Masala — the simmer-sauce spec

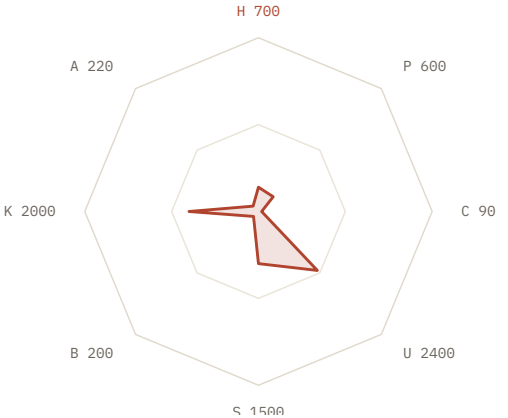
Makes ~1 L of base · 45 minutes · a formula written as a target, not a wish

```
3   tbsp   ghee or oil
2   recipes Bhuna Onion Masala (Chapter 5), scaled
800 g      tomatoes, designed · high-IFI-U · to carry the umami and
sweetness
15         cashews, soaked and blended (body + sweetness, not sugar)
2   tsp    garam masala (Chapter 4), added late
1   tsp    kashmiri chile · to a specified IFI-H 700
150 ml     cream (or cashew cream)
1   tbsp   kasuri methi · salt to spec
```

1. Build the base deep — bhuna the onion fully, cook the designed tomato and cashew down until the fat separates and the umami and sweetness concentrate from the fruit itself.
2. Blend smooth and pass through a sieve for a jar-worthy silk. Return to low heat, add the specified chile for the heat target, and taste against the spec — adjust toward IFI-U 2,400 and IFI-S 1,500 by reduction, not by reaching for sugar.
3. Finish off the heat with the cream and the late garam masala and kasuri methi, so the pungency and aroma survive into the jar. Cool and pack.

Why it works — Every move serves the target: the restored tomato delivers umami and sweetness from its own chemistry so the sauce reaches its lovable shape without the salt-and-sugar crutch; the browned onion and dairy hold the kokumi target on CaSR; the specified chile hits the heat to ≤7% so every jar burns the same. It is a flavor written as coordinates and built to be repeated — the commercial heart of designing to the Index.

IFI PROFILE

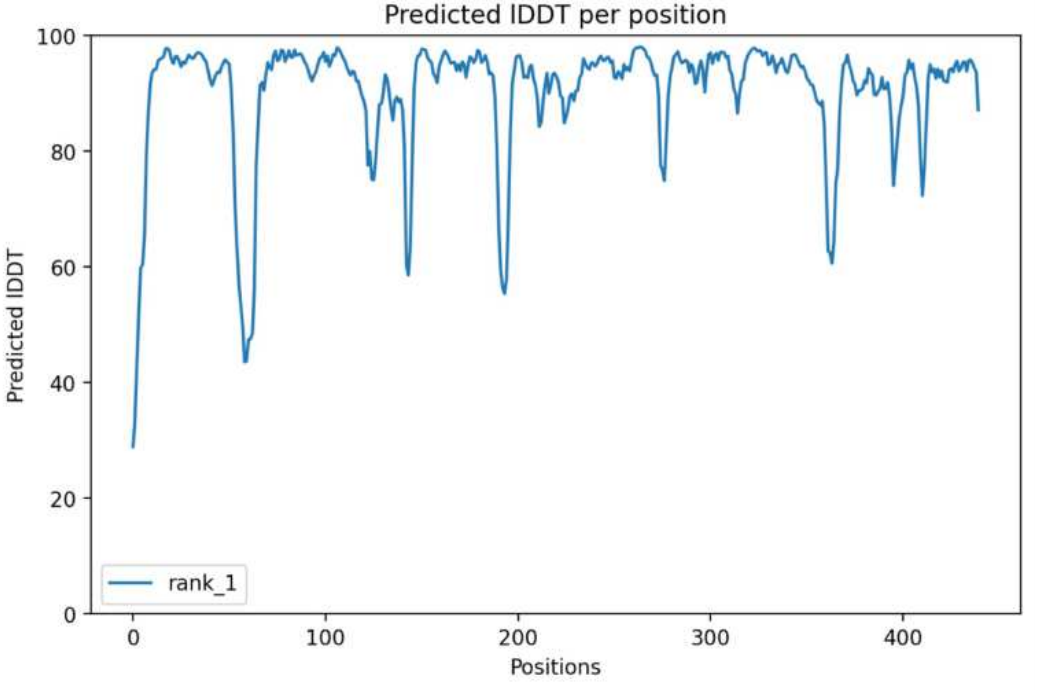


IFI-H	700
IFI-P	600
IFI-C	90
IFI-U	2,400
IFI-S	1,500
IFI-B	200
IFI-K	2,000
IFI-A	220

Chapter 17 · The Molecular Kitchen — *how a spice gets designed.*

This is the chapter that earns the word *engineered* on the cover, and it belongs at the end of a cookbook on purpose, because everything before it was the eating and this is the growing — the long, unglamorous, deeply reverent work that lets a tomato arrive at IFI-U 2,600 and a mustard seed at a clean, high IFI-P. We will stay concrete, name the enzymes and the intermediates, and show the method on the molecule this whole library began with — capsaicin — because the pepper is where we proved the approach, and every spice organism after it is a variation on this score.

Start with the pathway, because flavor is a pathway before it is a taste. Capsaicin is the condensation of two halves built by two converging routes. The aromatic half comes down the **phenylpropanoid branch**, the universal route present in every vascular plant: phenylalanine is deaminated by **PAL** (phenylalanine ammonia-lyase) to cinnamic acid; **C4H** (cinnamate 4-hydroxylase) hydroxylates it to *p*-coumaric acid; **4CL** (4-coumaroyl-CoA ligase) activates it to coumaroyl-CoA; **HCT** and the hydroxylases carry it onward; **COMT** (caffeic acid O-methyltransferase) methylates it toward the vanilloid; and from there the pepper-specific enzyme **pAMT** (putative aminotransferase) transaminates vanillin to **vanillylamine**. The other half — the branched-chain fatty acid — is built from a branched amino acid by **BCAT** (branched-chain aminotransferase) and extended by a **KAS** (ketoacyl-ACP synthase) to an 8-methyl-branched acyl-CoA. Then the committed step: **Pun1 / CS** — capsaicin synthase, an acyltransferase also called AT3 — condenses vanillylamine with the branched acyl-CoA to make capsaicin itself. Five enzymes of that chain are shared by every plant; only the four terminal ones — pAMT, Pun1/CS, KAS, BCAT — are the pepper's own. That single fact is the thesis of the entire platform: the hard machinery is universal, and only a short terminal cassette is bespoke, which is why the method that designs a pepper can, in principle, design a great many plants.

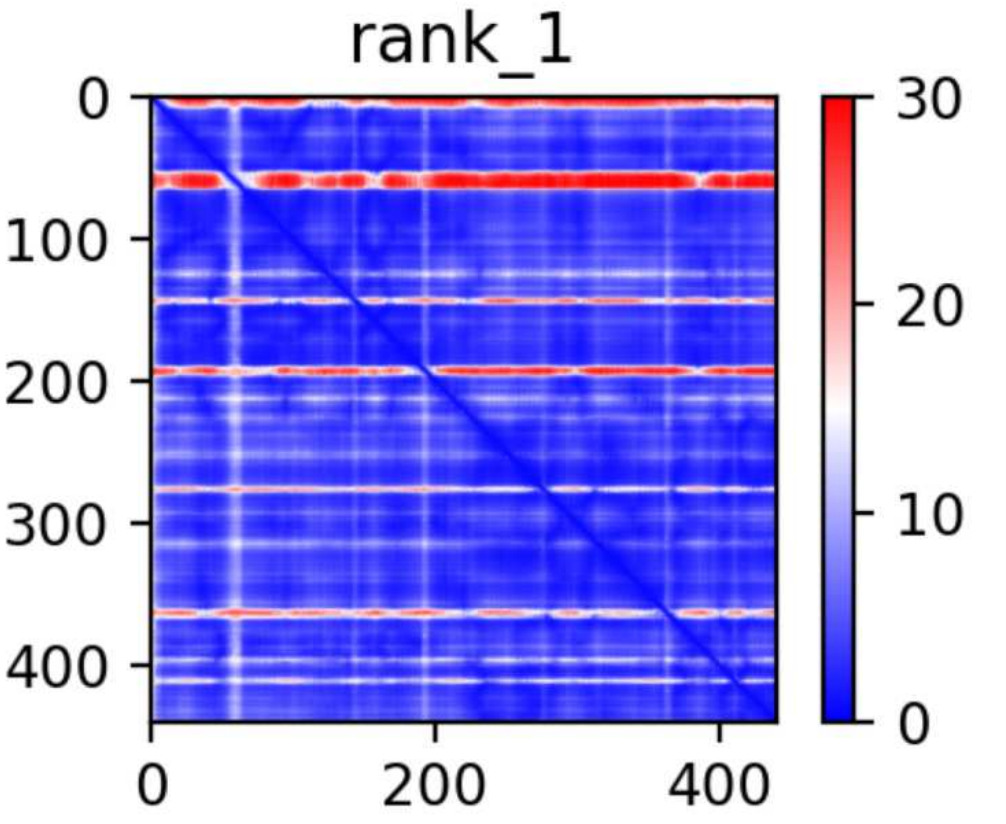


The Pun1 / AT3 capsaicin synthase, colored by model confidence — the active-site cleft is where the design happens.

Now the design, because knowing the pathway is not the same as improving it. Every prior breeding program chased heat by selecting a phenotype — taste the pod, keep the hot plant's seed — and hoping the genotype followed. We inverted it. We took the Pun1 / AT3 enzyme, the terminal capsaicin synthase, and scored every possible single-residue substitution in it with an **ESM2 protein language model** — a 650-million-parameter network that has read enough protein sequence to estimate how a given mutation will affect an enzyme's fold stability and catalytic plausibility — ranking each by predicted effect on catalytic efficiency times fold stability. A genome-scale **flux-balance analysis** predicted that flux control sits upstream in the phenylpropanoid pathway at 4CL and HCT, not at the Pun1 step itself; Pun1 labels the product, it does not govern the rate. The ESM2 optimization targets Pun1 for reliability and consistency — a more stable enzyme locks in whatever precursor flux the upstream pathway delivers, trading the wild-type's ±42% scatter for a ≤7% coefficient of variation. Only the top candidates, scored in silico across millions of possibilities, were written into the plant with **CRISPR**. Two Pun1 substitutions, never before combined in any pepper that ever grew, emerged from the in silico scoring:

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

Together, those two Pun1 substitutions (S39L · L345G) improve catalytic efficiency and consistency to to **2,937,948 SHU** — the Phoenix figure — at a batch coefficient of variation of **≤7%**, against roughly 42% in a wild-type crop. Read the ΔΔG column as the structural story: each negative number is a stabilization, a fold made more favorable, which is why the enzyme both works harder and fails less often. The predicted aligned error map and the per-residue confidence of the model told us which regions we could touch safely and which held the fold together; we edited into the confident, functional regions and left the scaffold alone.



The predicted aligned error map — the model's own statement of where the structure is certain, and where to cut.

What does this have to do with an Indian kitchen? Everything, because the same method made the plants in the recipes. The designed tomato's restored umami runs through its native **GAD / GDH1** glutamate machinery, tuned by the same score-then-edit logic. The designed mustard's clean, high pungency is a tuning of its glucosinolate-and-myrosinase system for a reproducible AITC burst. The garlic and onion carry elevated γ-glutamyl peptide loads for kokumi; the pomegranate carries a specified astringency. Here is the book's cast of hosts, with their real libraries, so a reader can see which plants on these plates were grown on purpose:

HOST	CONSTRUCTS	PRIMARY AXES	ROLE IN THIS BOOK
Pepper	1,060	all	the heat, laddered
Tomato	2,040	S · U · F · M	umami grown back; the gravies
Black Mustard	2,790	P · M	the tadka; the pickle
Garlic	560	K · P	the trinity; kokumi base
Soybean	360	U · K	the pulse principle
Ginger	120	P	the tadka; fresh pungency
Pomegranate	120	A	anardana; the bean gravies
Potato	80	B	the sabzi; bitter control
Cinnamon	40	P	garam masala
Onion	40	K	the trinity; the base

Across the whole platform that is part of roughly **19,000 engineered constructs**, about **1,000** live and purchasable today, across **42** host organisms and **8** sensory axes, held to that **≤7%** CV, with **3** patents filed and **21** peer-reviewed papers published open-access. We put the numbers down plainly because a number is a form of respect, and because the point of all of it is not the cleverness. The point is the plate. We learned to read capsaicin so that one day we could grow a tomato back to the taste a century of shipping took from it, and hand it to a cook who only ever wanted the gravy to taste like

her grandmother's. The molecular kitchen exists to serve the other kitchen, the one with the steel plate and the ring of small bowls. It was always going to come back here.

Chapter 18 · The Full Plate — *the thali, and all eight at once.*

We end where we began, at the thali — the steel plate with the wall of rice and the ring of small bowls — because the thali is the thesis of this book made edible. It is a composition designed, over two thousand years and without a single instrument, to hold every taste at once: the six rasas the tradition named, and the three great axes it never had words for. Assembled well, a thali is the only everyday meal on earth that deliberately lights up all eight axes of the Index in a single sitting, and doing it on purpose — reading the plate as a composition and scoring the whole — is the final skill this book can offer.

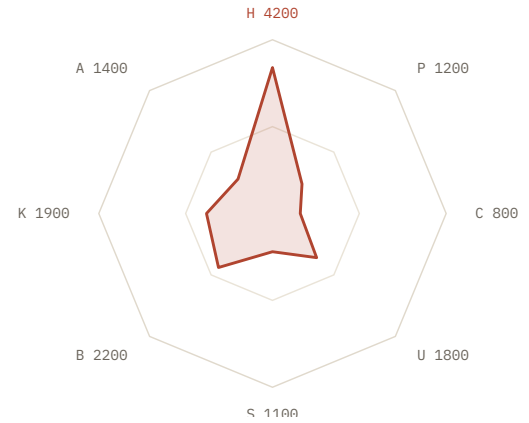
Watch the axes fill as the bowls go down. A **dal**, deep with kokumi from patience and umami from the pulse, finished with a sharp **tadka** of pungency and warm heat: there go IFI-K, IFI-U, IFI-P, IFI-H. A **sabzi**, dry and smoky and faintly bitter from its turmeric and char: IFI-B and a lift of savory. A tangle of **greens with paneer**, bitter and astringent from the leaf, rounded by dairy kokumi: IFI-B, IFI-A, IFI-K again. A spoon of **chana**, loud with the sour that lives off the chart and a measured astringency from its anardana: *amla* by hand, IFI-A on the chart. A **pickle**, tiny and pungent and fierce, IFI-P and IFI-H at their most concentrated. A cool **chutney** or **raita**, menthol opening TRPM8, dairy fat clearing the burn: IFI-C, at last, the eighth axis, the frost against all that fire. A sweet at the edge, *madhura*, IFI-S. And the rice at the center, its aroma — 2-acetyl-1-pyrroline, a scent and not a taste — tying the whole plate together through the nose. Eight axes, plus the two rasas on the ion channels and the whole country of aroma, all on one plate, balanced so that no bowl wins.



Phoenix — the one cultivar that registers on all eight axes at once; the plate does it with many bowls, but the principle is the same.

This is why, of all the books in this library, the Indian one is where the full spectrum feels least like a laboratory ambition and most like a Tuesday. Our flagship superhot, **Phoenix**, is the proof-of-concept that a *single plant* can be engineered to express all eight axes at once — here is its profile, the only organism in the catalog that does it alone:

IFI PROFILE

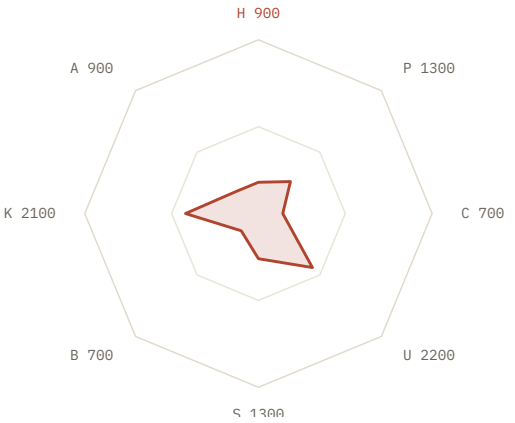


IFI-H	4,200
IFI-P	1,200
IFI-C	800
IFI-U	1,800
IFI-S	1,100
IFI-B	2,200
IFI-K	1,900
IFI-A	1,400

But the thali has been doing the same thing with a dozen plants and a thousand years of practice, and that juxtaposition is the whole meaning of this book. The frontier of our science — an eight-axis plant — is a technological echo of an ancient cultural intuition: that completeness is the goal, that a meal should hold every taste, that the body is best fed by a plate that leaves nothing out. We built an instrument to measure what this cuisine already knew, and the instrument keeps pointing back at the plate.

Here, then, is the composed thali, scored as a whole — not a recipe but an assembly, the sum of the dishes in this book, read on all eight axes at once:

IFI PROFILE



IFI-H	900
IFI-P	1,300
IFI-C	700
IFI-U	2,200
IFI-S	1,300
IFI-B	700
IFI-K	2,100
IFI-A	900

A reading with no zeros. Every axis lit, none screaming, the fire answered by the frost and the richness carried by patience and the bitter given its small, essential place. That balance is what the old six-rasa plate was reaching for, and it is what the eight-axis Index can now confirm it reached.

The order and structure of the plate are themselves a design, not a decoration. A thali is eaten in no fixed sequence precisely so that the diner composes each mouthful — a little rice, a dab of this, a drop of that — building and rebuilding the balance bite by bite, which is why the small bowls are small and many rather than large and few. The spread is also a satiety strategy, though the tradition would not have used the word: a meal that lights up every axis, that gives the mouth heat and cool and sour and sweet and savory and the dry grip of astringency all at once, satisfies more completely and more lastingly than a monotonous one, because fullness is as much a matter of sensory completeness as of quantity. We state this as a fact about how satisfaction is built, not as a claim about any outcome — the plate was designed to feel complete, and it does, and that is reason enough to build it well.

We will end the way this cuisine ends a meal, quietly and with intention. The nourishment that runs under this whole library is not a claim we make about any dish; it is a reason we grow the plants the way we do — a tomato grown to carry the most it can of what a tomato is, a lentil cooked until it gives the body everything it holds, a plate built to leave nothing out. We cook this food to feed people, which is the oldest reason there is, and the Index did not replace that reason. It only let us see, in numbers, what our family had been doing by feel at a steel plate for longer than any of us can remember. This is the kitchen the Index is named for. We are glad you came to the table. — *the family*

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