

THE SCOVILLE SPLICE LIBRARY · CUISINES

Engineered Thai

Sweet, hot, sour, salt. *Balanced to a number.*

The famous four-taste balance, read at full resolution across the eight axes of the Index — and built, dish by dish, on plants we designed to carry each note exactly. A cuisine of equilibrium, written at last as the composition it always was.

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

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Opening essay · What the balance is made of

Ask any Thai cook what holds a dish together and you will hear the same four words, in some private order of their own: *sweet, sour, salty, hot.* Wan, prew, khem, phet. It is the first thing taught and the last thing mastered — a plate is finished not when a recipe ends but when those four pull even, each one tasting louder for the others standing beside it. We grew up adjacent to that idea without a word for it, cooking at a table where a dish was adjusted by the spoonful and the verdict was a face, not a figure. When we built the Iyengar Flavor Index we found we had been describing the same thing in a different language all along.



Golden hour in the research greenhouse, a pod of designed chili hanging ready. Every dish in this book begins here, in a plant grown to carry one note exactly.

Here is what the balance is actually made of. Two of its four corners the Index scores directly, because they are receptor pathways we can design into a plant. *Sweet* is **IFI-S**, the TAS1R2·TAS1R3 pair that only hears sugar when both of its halves are moved at once. *Hot* is **IFI-H**, capsaicin arriving at TRPV1, the ion channel that also answers to fire and to acid and reports a burn where there is no wound. The other two corners live just outside the eight. *Salt* is sodium carried through ENaC, and *sour* is the proton current of OTOP1 — ionic tastes, added at the table with a spoon and a wedge of lime, not grown into the fruit. The Index leaves them off on purpose. It measures what a plant can be designed to carry, and a plant cannot be designed to be salt.

But watch what happens at the salt corner of a Thai plate. The cook does not reach for salt; she reaches for **nam pla** — fish sauce — and a spoonful of it floods the dish with free glutamate as surely as it floods it with sodium. The Index reads that corner as umami, **IFI-U**, the mGluR1 and TAS1R1·TAS1R3 pathways, the taste of being fed. The sour corner, too, is rarely only acid: green mango and green papaya bring a gripping astringency, **IFI-A**, tannins binding the proline-rich proteins of the saliva until the mouth tightens. And under all of it run the aromatics no one counts among the four — galangal and ginger firing TRPA1 as pungency, Thai basil and mint and lemongrass cooling through TRPM8, the slow fill of a fermented paste pressing on the calcium-sensing receptor as kokumi.

So the famous four are a folk map of a finer country. The real Thai plate is a chord struck across eight axes, and most of what makes it unmistakable lives in the five the old count forgets. This book is that map, drawn at full resolution — every dish read as a chord of axes, and every chord built, where we can, on plants we grew back toward what they were always meant to carry. A recipe that asks for "balance" is a wish. A recipe that asks for IFI-H 600 set against IFI-S 1,400 over a floor of IFI-U 1,800 is an instruction — one that tastes the same in Bangkok and in Montecito, because it is anchored to the receptor and not to a memory.

The formula under every number in this book is the same plain line the whole library rests on:

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

EC_{50} is the concentration at which a stimulus drives its receptor to half of full response — a measure not of how much of a compound a food holds but of how *loudly* that compound speaks. Invert it against a fixed reference, scale by a thousand, and loudness becomes a score a chili and a palm sugar and a cup of iced tea can be read against on one page, each axis normalized to a ceiling of 5,000. We did not learn to measure the balance in order to stop tasting it. We measured it so we could build it on purpose — so that the plate you set down in front of the people you love carries exactly what you meant it to, and so that the plant it came from was grown to hold the most it could.



PART I OF V

The Grammar of Balance

four corners · the ghost axes · heat in three channels · the mathematics of a bite

Chapter 1 · The Four Corners — *the composition problem.*

the folk map · the eight axes · why balance is geometry, not addition

A cook balances by tasting and adjusting — a little more lime, a little more sugar, a splash more fish sauce, until the plate stops asking for anything. What she is doing, without the vocabulary for it, is solving a composition problem: setting several receptor pathways against one another until no single one dominates and all of them are heard. The Index only gives the problem its coordinates. It does not replace the tongue; it tells the tongue where it is standing.

Begin with the folk map, because it is genuinely good science dressed as kitchen lore. Thai cooking names four forces and sometimes a fifth — *khom*, bitter — and insists that a dish is wrong when any one of them is missing or any one runs away with the plate. Translate the four into the receptors they actually move and the map resolves into axes we can measure:

THAI CORNER	ON THE TONGUE	RECEPTOR	ON THE INDEX
Wan — sweet	palm sugar, coconut, ripe fruit	TAS1R2·TAS1R3	IFI-S
Phet — hot	chili, the burn that builds	TRPV1	IFI-H
Khem — salty	fish sauce, soy, shrimp paste	ENaC (+ mGluR1)	*ghost* → IFI-U
Prew — sour	lime, tamarind, green fruit	OTOP1 (+ PRPs)	*ghost* → IFI-A
Khom — bitter	bitter melon, charred edges	TAS2R38	IFI-B

And then the aromatics, which no corner of the folk map holds but which carry the dish's whole identity: galangal, ginger, garlic, and pepper on TRPA1 (**IFI-P**, pungency); Thai basil, mint, kaffir lime, and lemongrass on TRPM8 and the aromatic-cool pathways (**IFI-C**, cool-burn); the long round body of a fermented paste on CaSR (**IFI-K**, kokumi). Eight axes in all. The folk map names four and gestures at a fifth; the dish is playing all eight, and the five it forgets are exactly where its signature lives.



A designed chili in cross-section — the placental tissue, where capsaicin is built, glowing against the wall of the pod. The first corner of the map, and the only one the old count got exactly right.

Now the harder truth, the one that makes this a composition problem and not a shopping list. **Receptors do not add; they interfere.** Add sweetness to a hot sauce and the heat reads lower, though not a single molecule of capsaicin has left the bowl — TAS1R2 firing changes how the central nervous system weighs the TRPV1 signal arriving beside it. Push umami up and a dish will carry more acid before it turns shrill. Lift the salt and sweetness seems to climb with it. Fat does not touch any taste receptor and yet it governs them all, because it decides how fast each lipophilic molecule reaches its target and how long it lingers there. This is why a naïve stack — more of everything — cancels itself into mud, and why a great Thai cook's small, iterative corrections are not fussiness but a search for a point of equilibrium that addition cannot find.

A Thai dish is the everyday proof that balance is geometry. Picture the eight axes as eight directions in a space, and a finished dish as a single arrow — a vector — reaching some particular length in each direction. *Som tam* points hard along heat, sweet, umami, and astringency and barely at all along cool or bitter. *Massaman* leans long on kokumi and sweet and pulls its heat and pungency down to a murmur. *Tom yum* throws most of its length into umami and a bright cool spike of lemongrass and kaffir, with the sour running off the chart entirely because the chart does not have a sour direction. Two dishes with the same four "amounts" of sweet-sour-salt-hot can sit in completely different places in this space, because the aromatics and the body point them elsewhere. That is why "sweet, sour, salty, hot — balanced" is a true description and a useless instruction. The instruction is the vector.

We will spend this book turning wishes into vectors. But the vector is only honest if the ingredients hold their values — if "IFI-H 600" means the same thing in two pods picked a month apart — and that is the part the garden has to solve before the kitchen can. It is the reason every number in this book traces back to a plant we designed to speak its axis cleanly, at a batch-to-batch coefficient of variation at or below **7%**, against the 40-plus percent that an unengineered field throws at a cook who is only trying to make dinner taste the same twice.

Chapter 2 · The Ghost Axes — *sour and salt, measured by their shadows.*

OTOP1 · ENaC · why the Index omits them · how the plate carries them anyway

Two of the four corners the Index does not score, and a book about Thai food cannot pretend they are not there. Sour and salt are not oversights in the Index; they are a boundary drawn with intent. Sweet, umami, bitter, the two kinds of heat, cool, kokumi, astringency — every one of those is a response to a *molecule*, a compound with a shape that fits a receptor, and a molecule is a thing a plant can be engineered to make more or less of. Sour and salt are responses to *ions*. Sourness is protons; saltiness is sodium. You do not design a plant to taste of sodium any more than you design it to taste of table salt. So the Index measures what can be built into the fruit, and leaves at the table what belongs at the table.



Green mango in cross-section — unripe, the flesh dense and pale, carrying the gripping astringency and the tartness that a Thai cook reaches for before the fruit ever turns sweet. Sour's nearest neighbor on the Index is this: the tannin's grip, IFI-A.

Take sour first, because it is the one a Thai dish leans on hardest and most openly. Sourness is transduced by **OTOP1**, a proton-selective ion channel on the sour-sensing taste cells — a channel that simply lets hydrogen ions flow when the extracellular world turns acidic. Lime juice at pH 2.3, tamarind's tartaric and malic acids, the lactic tang of a fermented som tam: all of them are read as the same rising proton current, scaled by how much free acid reaches the cell and how well the food's buffering lets the pH fall at the

surface of the tongue. There is no EC_{50} to invert in the Index's sense, because the stimulus is not a ligand settling into a pocket; it is a bulk change in acidity. We score sour, when we must, by its **titratable acidity** and its pH, and we treat it in this book as the *outside variable* of the composition — the axis added last, by hand, that moves everything else.

And it does move everything else, which is the real reason a Thai cook treats lime as the final adjustment rather than an ingredient. Acid is a powerful cross-modal lever. A squeeze of lime raises the *perceived* saltiness of a dish without a grain of added sodium, so sour and salt prop each other up; it sharpens the edges of sweetness and can make a flat, over-sweet sauce suddenly read as bright; it cuts the heavy coat of coconut fat so the aromatics underneath lift back into view. In our composition language, sour is a term with large coefficients on nearly every other axis — which is precisely why it is powerful and why it is dangerous, and why we add it drop by drop at the end rather than build on it.

Salt is the other ghost, and here the Thai kitchen performs a quiet trick that maps straight onto the Index. The cook seasons not with salt but with **nam pla**, fish sauce — anchovy fermented a year or more under salt until its proteins have been taken apart into free amino acids. A tablespoon of good fish sauce delivers sodium through **ENaC**, the epithelial sodium channel, exactly as salt would. But it delivers something the salt cellar cannot: a flood of free **glutamate**, often above 1,000 milligrams per 100 millilitres, landing on the umami receptors as pure IFI-U. So the Thai "salt corner" is, to the Index, mostly an *umami* corner wearing salt's clothes — which is why a dish seasoned with fish sauce tastes deep and savory and complete where the same dish salted to the same sodium would taste merely seasoned. The shadow that salt throws on the Index is umami, and that shadow is most of the flavor.

There is a second shadow, fainter and just as real. The fermented pastes — *kapi*, shrimp paste; the long-aged fish sauces; the funk at the bottom of a jar of pickled crab — carry not only glutamate but **γ-glutamyl peptides**, short chains that press on **CaSR**, the calcium-sensing receptor, and register as **kokumi**: no taste of their own, but a thickening of continuity and mouthfeel, a sense that the seasoning fills the whole mouth and stays. So salt's full shadow on the Index is IFI-U plus a quiet lift of IFI-K. When we build a vegetarian fish sauce later in this book, this is the brief we are writing to: not "make it taste of fish" but "cast the same two shadows" — glutamate for the umami, γ-glutamyl peptides for the body — using koji, soy, and seaweed in place of the anchovy.

Keep the two ghosts in mind for the rest of the book. On every dish scorecard you will see eight numbers and not ten; sour and salt will be missing from the readout by design. Read their presence in the numbers around them — in a tall IFI-U where the fish sauce went, in a lift of IFI-A where the green fruit and the tamarind brought their grip, in a prose line that tells you where the lime lands. The ghosts are not absent from the plate. They are measured by their shadows.

Chapter 3 · Heat, in Three Channels — *the layered burn.*

TRPV1 · TRPA1 · TRPM8 · why Thai heat has a shape and not just a size

Westerners meeting Thai food for the first time reach for a single word — *spicy* — and a single number, some guess at Scoville units. The dish is doing something far more structured, and a cook who cannot feel the structure cannot reproduce it. Thai heat arrives on three different receptors, on three different clocks, and the character of a dish is set as much by *which* channels fire and *in what order* as by how hard any one of them is driven. The Index gives each channel its own axis, which is how a book can finally say out loud what the tongue has always known: there is more than one kind of burn, and Thai cooking plays all of them.

The first channel is the one everyone means. **TRPV1** is a non-selective cation channel on the trigeminal nerve endings woven through the tongue, and capsaicin is its key. The molecule does not heat the tissue; it lowers the channel's thermal threshold from around 43 °C down toward body temperature, so the nerve fires and the brain reports a fire that is not there. Nothing is burned. The sensation builds over seconds, spreads, and lingers — a slow, deep, cumulative warmth, because capsaicin is lipophilic and clings. This is the heat of the chili itself, scored as **IFI-H**, and in Thai cooking it is most often fresh: the small, loud *phrik kee noo* pounded raw into a som tam, where it registers fast and clean, not the long-cooked, mellowed heat of a stew.



Ginger in cross-section — galangal's close cousin and the readiest image of the second burn. The sharp, bright, fast channel is TRPA1, and these rhizomes are its Thai voice.

The second channel is the one the single-word listeners miss entirely, and it is everywhere in Thai food. **TRPA1** is the sharp, fast, front-of-mouth channel — the bright sting of raw garlic, the clean cut of ginger, the aromatic burn of galangal, the nose-prickle of a mustard green. Its agonists are a rogues' gallery of reactive electrophiles that work by covalently nudging cysteine residues on the channel: **allicin** and the diallyl sulfides of garlic, **gingerols** and

their cooked cousins the shogaols, the **1'-acetoxychavicol acetate** of galangal, the isothiocyanates of the mustard-family greens. Where capsaicin builds and lingers, pungency on TRPA1 flashes and clears — a top note that wakes a dish up and then gets out of the way. Scored as **IFI-P**, it is the difference between a curry paste that merely burns and one that *lifts*, and it is why a Thai cook pounds so much galangal, ginger, and garlic into the mortar before a single chili goes in.

The third channel runs the fire backward. **TRPM8** is the cold receptor — the one menthol fools into reporting a chill that is not there — and a surprising amount of the Thai aromatic kit speaks to it and its neighbors. The cool lift of **Thai basil** and mint, the clean high citral edge of **lemongrass**, the bright oil of **kaffir lime leaf**: these register as coolness and brightness, **IFI-C**, cutting through the heat and the fat and resetting the palate for the next bite. A great tom yum is the clearest demonstration: a broth pushed hard on TRPV1 and on sour, and then lifted — made somehow *refreshing* in the middle of all that fire — by a cold-channel chord of lemongrass, galangal, and kaffir that keeps the whole thing from collapsing into a single hot note.

Put the three clocks together and you have the shape of Thai heat, which no single Scoville number can hold:

CHANNEL	RECEPTOR	THAI VOICE	CLOCK	INDEX AXIS
The deep burn	TRPV1	fresh & dried chili	slow build, long linger	IFI-H
The sharp lift	TRPA1	galangal, ginger, garlic	fast flash, quick clear	IFI-P
The cool edge	TRPM8	Thai basil, lemongrass, kaffir, mint	immediate, cleansing	IFI-C

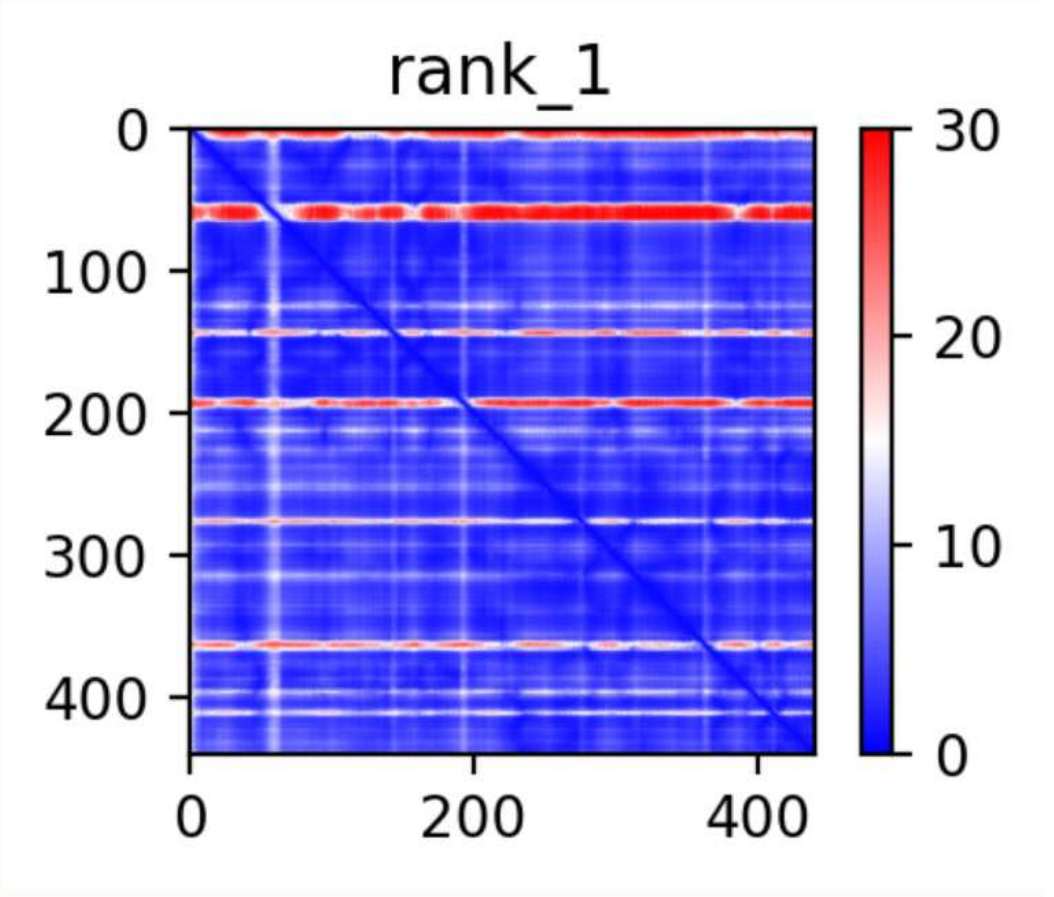
The reason this matters for engineering, and not only for appreciation, is that the three channels can be set on three separate dials. Because capsaicin (TRPV1), the galangal and ginger electrophiles (TRPA1), and the terpene cool-notes (TRPM8) are distinct molecules on distinct receptors, a dish's *burn*, its *lift*, and its *brightness* can be tuned independently — a chili grown to a chosen IFI-H band, an aromatic grown to carry its pungency high, a basil grown to keep its cool oils through the heat of a wok. The folk instruction "make it spicier" collapses three dials into one and usually ruins the balance. The Index pulls them apart again, which is the whole reason a designed pantry can rebuild a Thai dish exactly rather than approximately.

Chapter 4 · The Mathematics of a Balanced Bite — *loudness, coupling, and the vector you are aiming at.*

EC_{50} · cross-modal suppression · the balance vector · flux balance · CV ≤ 7%

We have been using the word *balance* as though everyone agrees on it. Let us make it a quantity. This is the one unavoidably mathematical chapter in the book, and we promise to bring it back to the plate at the end; but a cuisine built on equilibrium deserves to have its equilibrium written down, and the writing-down is what lets the kitchen be exact.

Start with a single axis. The Index score for any stimulus is a ratio of half-activations, **IFI = 1,000 × EC_{50}(reference) ÷ EC_{50}(candidate)**. The reference is fixed per axis — a defined concentration of a defined agonist at a defined receptor — so the only thing that moves the score is the candidate's own EC_{50}, the concentration at which it drives its receptor to half-max. A lower EC_{50} means the molecule speaks louder, so dividing by it makes the score larger; a louder flavor is a bigger number. This is why the Index is a measure of *loudness at the receptor* and not of *amount in the jar*, and why it tracks what you feel. Two chilies with the same milligrams of capsaicinoid per gram can score differently in IFI-H if the balance of capsaicin to dihydrocapsaicin differs, because the two capsaicinoids have different EC_{50}s and sit on the receptor differently — a difference in the *shape* of the burn that a raw Scoville count is blind to.



The predicted-aligned-error map of the Pun1/AT3 acyltransferase — the matrix a protein model returns when it is confident it knows how every part of an enzyme sits against every other. The mathematics under a designed flavor looks like this before it ever looks like a dish.

Now the eight axes at once. Write a dish as a vector — eight numbers, one per axis, **(H, P, C, U, S, B, K, A)** — and a target dish as the vector you are aiming at. The naïve theory of balance says: measure each ingredient's contribution to each axis, add them up, and if the sum matches the target you are done. The naïve theory is wrong, and every cook knows it is wrong, because the axes are *coupled*. The honest model adds a coupling term: the loudness you *perceive* on one axis depends on what is firing on the others. In shorthand, perceived-H is not just the capsaicin's H; it is the capsaicin's H pulled *down* by whatever S and K and fat are present, because sweetness and richness and fat each suppress the central weighting of the TRPV1 signal. The same structure holds across the board:

- **Sweet suppresses heat.** Raise IFI-S and perceived IFI-H falls, though the capsaicin is untouched. This is the mechanism behind every sweet-hot dish and every chili jam: sugar does not remove the fire, it *governs* it.
- **Sour amplifies salt, sharpens sweet, cuts fat.** The ghost axis with the largest coefficients. A lime wedge is a multiplier on three other axes at once.
- **Fat delays and spreads heat and carries aroma.** Coconut fat does not score on any taste axis, yet it sets the clock on IFI-H (capsaicin partitions into it and is released slowly) and the delivery of IFI-C and IFI-P (the terpene and electrophile aromatics are oil-soluble).
- **Umami and kokumi raise the floor.** Lift IFI-U and IFI-K and the whole dish tolerates more of everything else before any single axis turns harsh; savory depth is what lets a Thai dish be loud on four corners without being exhausting.

The practical consequence is that *balance is the vector where the coupled, perceived axes all land where you want them* — not where the raw contributions sum to the target. A Thai cook finds that point by iteration, tasting and nudging, because she is solving the coupled system by hand. The platform finds it by model. Given a target vector and a pantry of ingredients each characterized on all eight axes, a constrained optimization searches the ratios that land the *perceived* vector on target — the same move, done with arithmetic instead of a spoon, and the reason a recipe in this book can specify a balance precisely enough to survive the trip from our kitchen to yours.

That optimization reaches one layer deeper than the recipe, into the plant itself. When no existing cultivar sits where a dish needs it — a chili whose IFI-H is right but whose heat arrives too slowly, a basil whose cool oils collapse under wok heat — we turn to a **genome-scale flux-balance model** of the host organism. Flux-balance analysis treats the plant's metabolism as a network of reactions and asks which distribution of flux maximizes a chosen output — here, the concentration of a target flavor molecule — subject to the stoichiometry of every intermediate step. It tells us which enzyme is the true rate limiter of a pathway before we touch a gene, so that an edit lands on the step that actually governs output and not on an

upstream one that the plant will simply route around. The flavor axis is the objective; the pathway is the constraint; the edit is the answer the model returns.

And none of it is worth anything if the plant will not hold its value. The quiet hero of this entire book is a single statistic: a batch-to-batch **coefficient of variation at or below 7%**, against the 40-plus percent of an ordinary field. CV is the standard deviation divided by the mean — the spread of a measurement relative to its center — and a CV of 7% is the difference between a number you can cook to and a number that is really a hope. "IFI-H 600" is only an instruction if the next harvest also reads 600. Precision is not a luxury here; it is the precondition for the whole idea of a composed dish. Everything else in this book — every target vector, every scored recipe, every promise that the plate tastes the same twice — rests on the plant keeping its word.



PART II OF V

The Engineered Pantry

chilies · the sweet base · the salt-umami engine · aromatics · coconut · the sour line

Chapter 5 · The Chilies — *the heat, laddered for the table.*

IFI-H · TRPV1 · Pun1/AT3 · the Thai heat ladder · double variant S39L+L345G

A Thai kitchen does not use one chili; it uses a vocabulary of them, each on its own rung of heat and each in its proper place. The large, mild *phrik chee fah* — "sky-pointing chili" — gives a curry paste its red body and almost no burn. The small, furious *phrik kee noo* — "mouse-dropping chili," the bird's eye — is the loud one, pounded raw into som tam and nam prik, and its heat lands fast and bright. Dried chilies, toasted until they smell of tobacco and raisins, carry a deeper, rounder warmth into the long-cooked curries. One cuisine, a whole ladder of fire, every rung chosen on purpose.



The pepper, grown for a chosen rung rather than a hoped-for one. The whole Thai ladder lives in one species, read by the Index into a column of numbers a cook can actually aim at.

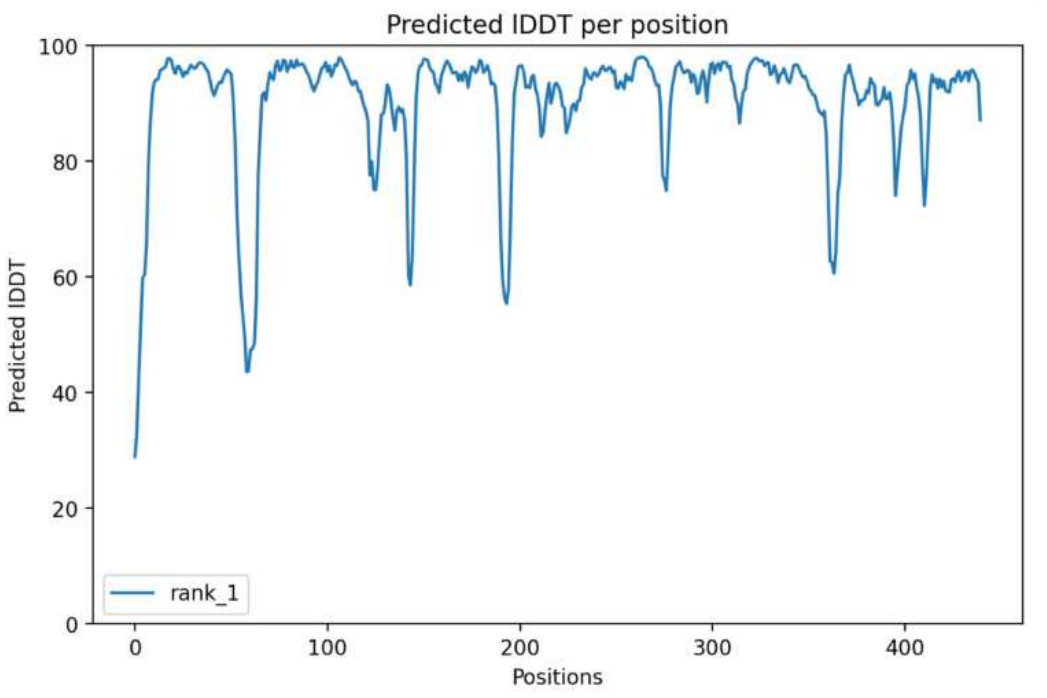
The mechanism is the TRPV1 story from Chapter 3, and it is worth knowing where in the plant the fire is actually made, because that is where we design it. Capsaicin is built in the placenta of the pod — the pale pith the seeds cling to — where **vanillylamine** condenses with an 8-methyl branched-chain fatty acid at the **Pun1/AT3 acyltransferase**, the terminal enzyme of the capsaicinoid pathway. The length and saturation of that acyl chain set the ratio of capsaicin to its cousin dihydrocapsaicin, and that ratio sets the *shape* of the burn — where it lands, how fast it blooms, how cleanly it leaves. A

Thai dish wants a particular shape, usually a fast, bright, clean heat rather than the slow crushing wall of a superhot, and shape is a thing we can tune at the enzyme.

The reason heat can be engineered at all is that its pathway is known step by step. Capsaicin is the marriage of two branches of plant metabolism. The vanillylamine half descends from phenylalanine down the **phenylpropanoid pathway**; the fatty-acid half is built and trimmed from branched-chain amino acids; and the two are joined, at the last step, by the acyltransferase:

STEP	ENZYME	WHAT IT DOES	UNIVERSAL?
1	**PAL**	phenylalanine → cinnamic acid	every vascular plant
2	**C4H**	cinnamic acid → p-coumaric acid	every vascular plant
3	**4CL**	p-coumaric acid → p-coumaroyl-CoA	every vascular plant
4	**HCT**	acyl transfer along the branch	every vascular plant
5	**COMT**	methylation toward vanillin/vanillylamine	every vascular plant
6	**pAMT**	transaminates to vanillylamine	pepper-specific
7	**BCAT / KAS**	build & extend the branched fatty acid	pepper-specific
8	**Pun1 / CS**	condenses the two halves → capsaicin	pepper-specific

Only the last three enzymes are peculiar to peppers; the long upstream spine runs in every vascular plant, which is the deep reason the heat method transfers far beyond the chili — but that is another book's thesis. Here the point is narrower and more useful: because the pathway is mapped enzyme by enzyme, because our flux-balance model predicts the primary control sits upstream at 4CL and HCT/CCoAOMT rather than at the terminal Pun1/AT3 step — Pun1 is the final capsaicin synthase, the enzyme that labels the product, not the one that governs the rate — and because Pun1/AT3 is a protein we can read and model and edit, we can target a chili's heat precisely and make it hold.



The Pun1/AT3 acyltransferase, modeled and colored by pLDDT confidence — the terminal enzyme of the capsaicin pathway, and the protein whose double variant S39L+L345G carries the top of our heat ladder.

At the very top of the ladder sit the proof-of-concept superhots — the ones we designed to show the method's ceiling. An ESM2 650-million-parameter protein language model scored every possible

single-residue substitution in Pun1 by its predicted effect on catalytic efficiency and fold stability; two variants chosen for their combined effect emerged, written in with CRISPR:

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

Those two variants — S39L+L345G — carry our flagship **Phoenix** (SS-0096) to a predicted heat of approximately 2.95 million SHU and a predicted IFI-H of 4,200 at a CV at or below 7%. But a Thai table does not want Phoenix, and this is the crucial point about engineering a cuisine: the same precision that builds the ceiling builds the *middle of the ladder*, where cooking actually lives. The Pepper library carries **1,060 constructs**, and most of the useful ones for this book sit far below the flagships, grown to the modest, bright heat bands a Thai dish is composed in:

RUNG	IFI-H	~SHU FEEL	WHERE IT SITS IN A THAI KITCHEN	SOURCE
Phrik yuak (sweet horn)	40	~0	body and color, no burn	Pepper library
Phrik chee fah (spur)	180	~15K	the red in a curry paste	Pepper library
Phrik kee noo (bird's eye)	600	~75K	the table standard; som tam	Pepper library
Phrik kee noo, hot pick	900	~120K	nam prik, a cook's "proper spicy"	Pepper library
The threat-level top	1,570	866K	Ember · SS-0087, for the fearless	flagship

Read that ladder and the whole promise of an engineered cuisine is visible: not hotter food, but *chosen* food — a burn set to a number and held there, so that "medium" stops being a wish and becomes an instruction a kitchen in two different countries can follow to the same result.

Phrik Nam Pla — the chili fish sauce on every Thai table

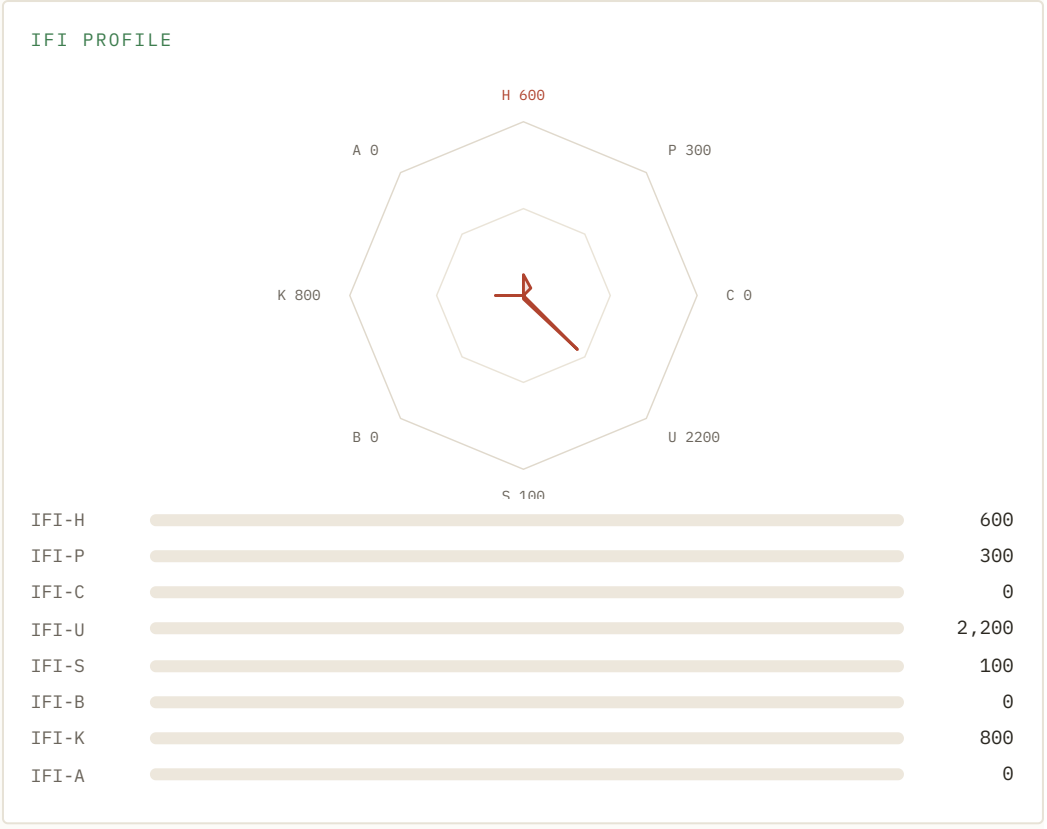
Makes about ¾ cup · 5 minutes · the condiment that finishes everything

There is a small bowl on every Thai table, and it is the single most important thing in this book: fresh chili sliced into fish sauce, with lime and a little garlic. It is seasoning you add at the plate — the last adjustment, the diner's own hand on the balance. We build it on a bird's-eye grown to **IFI-H 600**, loud and clean, and we give the vegetarian cook the nam pla from Chapter 7.

Makes ~¾ cup · 5 minutes
6 Tbsp fish sauce (or vegetarian nam pla, Ch. 7)
8–12 designed bird's-eye chilies (IFI-H 600), thinly sliced
2 cloves designed garlic, minced (optional)
2 Tbsp lime juice, fresh
1 tsp palm sugar syrup (Ch. 6), optional

1. Slice the chilies crosswise into thin rings, seeds and all — the placental pith beside the seeds is where the capsaicin concentrates, so do not scrape it out.
2. Stir everything together in the serving bowl. Let it sit ten minutes so the chili's heat begins to migrate into the sauce.
3. Set it on the table. It goes on rice, on noodles, on anything that wants waking up. It is not cooked and not measured into a dish; it is the diner's dial.

Why it works — This is the composition problem in miniature, handed to the eater. The fish sauce lays a tall IFI-U floor (salt's umami shadow); the fresh chili adds a fast IFI-H spike; the lime — off the Index, a ghost — sharpens all of it and lifts the salt; the optional garlic throws a quick TRPA1 flash of IFI-P. A spoonful of this re-balances any plate it touches, which is exactly why Thai cooks leave the final vector to the diner rather than fixing it in the kitchen.



Toasted Dried-Chili Powder — *phrik pon*

Makes about ½ cup · 15 minutes · the dry heat of the north and the isan table

Where phrik nam pla is bright and wet, this is deep and dry — dried chilies toasted and ground, the warmth that goes into a som tam, a laab, a bowl of noodles. Toasting does real chemistry: it drives off water, concentrates the capsaicinoids, and builds Maillard and pyrazine notes that read as roasted depth.

Makes ~½ cup · 15 minutes
2 cups dried designed chilies (IFI-H 400–600), stems removed
1 tsp kosher salt (optional)

1. Toast the dried chilies in a dry wok over medium-low heat, tossing constantly, until they darken a shade and smell of tobacco and dried fruit — 4 to 6 minutes. Do not let them blacken; burnt capsaicinoid turns acrid and the IFI-B bitterness climbs.
2. Cool completely — they crisp as they cool, which is what lets them grind to powder rather than paste.
3. Grind in a mortar or spice mill to the coarseness you like: flaky for texture on a salad, fine for stirring into a broth. Store airtight, away from light; the heat is at its loudest in the first month.

Why it works — Drying and toasting are a concentration step and a browning step at once. The water leaves, so milligram-for-milligram the capsaicin climbs; the heat of the toast builds roasted aromatics that read as depth without adding a taste axis. We toast at medium-low on purpose: push it too far and you char the capsaicinoids into bitterness, lifting IFI-B exactly where you do not want it.

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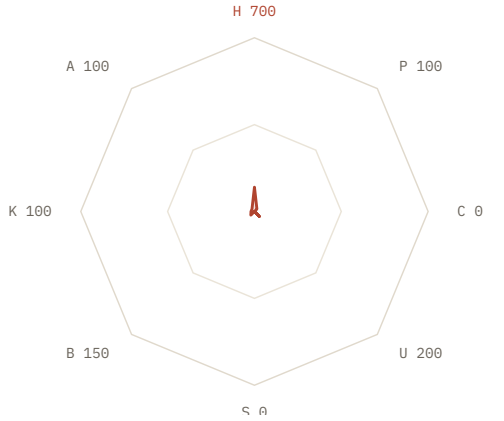

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IFI-P	100
IFI-C	0
IFI-U	200
IFI-S	0
IFI-B	150
IFI-K	100
IFI-A	100

Chapter 6 · The Sweet Base — *wan, without the sugar bill.*

IFI-S · TAS1R2·TAS1R3 · palm sugar · stevia · monk fruit · the suppression lever

Sweetness in Thai cooking is not dessert; it is structure. A spoon of palm sugar in a curry, a caramelized thread of it in a pad thai, a whisper in a dipping sauce — *wan* is the counterweight the other corners lean against, and without it the heat has nothing to push on and the whole plate goes shrill. Understanding sweetness as a *lever on the other axes*, rather than as a flavor people happen to like, is the first step to using it the way a Thai cook does.



Sugarcane, the sweet base at its source. The TAS1R2·TAS1R3 receptor that reads it does not care whether the molecule is sucrose or a high-potency sweetener a hundred times lighter — it cares only that both halves of the lock are turned.

The receptor tells you why. Sweetness is read by **TAS1R2·TAS1R3**, a heterodimer — a lock with two halves that must both be engaged before it opens. Sucrose binds across the pair and turns it; so, far more efficiently, do the high-potency sweeteners, which is why **stevia**'s steviol glycosides and **monk fruit**'s mogrosides register as intensely sweet at a fraction of the mass. On the Index, that efficiency is a high IFI-S: a louder signal per molecule, a lower EC_{50}, a bigger score. The platform's interest in sweetness is precisely this decoupling — the ability to deliver *wan* at full loudness while dropping the sugar load the loudness used to require. We say this carefully and only as an attribute of the molecule, never as a claim about a body: a lighter sweetener is a lighter sweetener, and what a plate does for anyone is their own and their doctor's business, not ours.

The platform's sweet shelf is deep enough to build a Thai dish's whole wan corner without a sugar bowl: **Sugarcane** at 200 constructs for clean sucrose-type body, **Stevia** at 910 for high-potency lift, **Monk Fruit** at 80 for a rounder, fruitier sweetness that hides the faint liquorice edge stevia can carry. In practice we blend them, because a single high-potency sweetener alone reads thin and a little metallic, while a blend tuned against the TAS1R2·TAS1R3 response curve reads like sugar — the roundness of sucrose, the loudness of the glycosides, the suppression of the off-notes.

But the real lesson of this chapter is the *lever*. Recall from Chapter 4 that sweet suppresses perceived heat: raise IFI-S and the TRPV1 signal is weighted down centrally, so the fire reads lower though not a molecule of capsaicin has moved. This is the engine of every balanced hot dish in the book. A nam prik pao (Chapter 15) that would be punishing at its true IFI-H becomes a deep, round, almost addictive warmth once the palm sugar lifts IFI-S into the 1,500s. A green curry holds more chili than it seems to because the coconut sweetness governs the burn. The Thai cook adds sugar to make a dish *less hot* as surely as to make it sweet — and now we can say by how much, and aim it.

Palm Sugar Syrup — the sweet base for the whole book

Makes about 1½ cups · 10 minutes · keeps a month, refrigerated

Palm sugar comes as a dense, fudgy disc that is awkward to measure and slow to dissolve mid-stir-fry. We keep it as a syrup, which is faster to balance with and lets us blend in a measured touch of high-potency sweetener to lift the loudness without climbing the sugar load. This is the *wan* corner, pre-built.

```
Makes ~1½ cups · 10 minutes
1 cup palm sugar, chopped (or designed sugarcane syrup)
½ cup water
pinch of salt
¼ tsp designed stevia extract (IFI-S high), optional, to taste
```

1. Combine palm sugar, water, and salt in a small pot. Warm over medium-low, stirring, until the sugar fully dissolves — do not boil hard; you want a syrup, not a caramel.
2. Off the heat, taste and, if you want more loudness without more body, stir in the stevia a little at a time. The goal is *brighter sweet*, not *more sugar* — stop the moment it reads round and full.
3. Cool and bottle. Use it anywhere a recipe calls for palm sugar; a tablespoon of syrup is roughly a tablespoon of palm sugar.

Why it works — The palm sugar carries the rounded, faintly caramel body that makes Thai sweetness taste like itself; the optional stevia is a loudness lever, raising IFI-S against the TAS1R2·TAS1R3 pair without adding mass. Keeping it as a syrup is not only convenience — a dissolved sweetener distributes and suppresses heat faster and more evenly than a lump stirred in at the end, so your balance lands where you aimed it.

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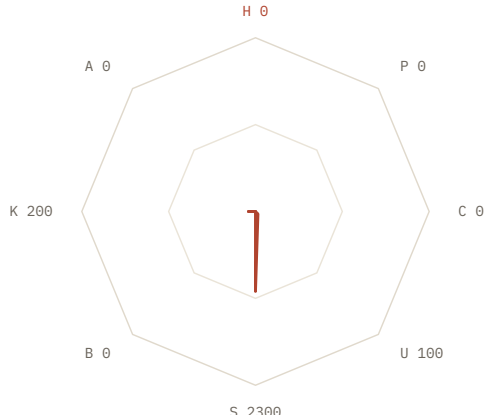

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IFI-P	0
IFI-C	0
IFI-U	100
IFI-S	2,300
IFI-B	0
IFI-K	200
IFI-A	0

Chapter 7 · The Salt-Umami Engine — *fish sauce, shrimp paste, and the vegetarian rebuild.*

IFI-U · IFI-K · mGluR1 · TAS1R1·TAS1R3 · the glutamate–ribonucleotide synergy

If there is a single flavor that *is* Thai food, it is not chili and it is not sweet. It is the deep, salty, savory, slightly funky bass note that fish sauce and shrimp paste lay under everything — the thing that makes a dish taste *finished* and fed. We met it in Chapter 2 as the shadow salt throws on the Index. Here we give it its own chapter, because it is the floor the whole cuisine stands on, and because rebuilding it without the fish is one of the most satisfying pieces of engineering in this book.



Soybean in cross-section — the protein source that, under koji, becomes a vegetarian engine of free glutamate. The whole savory floor of Thai food can be rebuilt from this and a mold.

The savory floor is two receptors working together. **Umami** proper is **glutamate** landing on the **mGluR1** and **TAS1R1·TAS1R3** receptors — a Venus-flytrap pocket that closes around the amino acid and signals *protein, nourishment, food.* Fish sauce is a glutamate delivery system of extraordinary efficiency: a year of fermentation takes anchovy protein apart into free amino acids, and the free glutamate that results lands as pure IFI-U. But the truly Thai trick is the **synergy**, and it is one of the most beautiful pieces of real chemistry in the kitchen. When glutamate is joined by a **5′-ribonucleotide** —

inosinate (IMP) from dried shrimp and dried fish, **guanylate (GMP)** from dried shiitake — the two together do not add; they *multiply*. The ribonucleotide binds a second site on the TAS1R1·TAS1R3 pair and stabilizes the closed, active conformation, dropping glutamate's EC_{50} severalfold. A lower EC_{50} is, by the Index's own formula, a higher IFI-U: the same glutamate, suddenly far louder. The classic measurements put the lift as high as sevenfold or eightfold — which is why a pinch of dried shrimp in a som tam does something no amount of extra fish sauce can.

The second half of the engine is **kokumi**, IFI-K. The long-fermented pastes — *kapi*, shrimp paste; the funk at the bottom of the fish-sauce barrel — carry **γ-glutamyl peptides** that press on **CaSR**, the calcium-sensing receptor, and register not as a taste but as *body*: continuity, thickness, the sense that the savoriness fills the whole mouth and lingers. Umami is the savory *note*; kokumi is the savory *depth*. Together they are the Thai bass line.

Now the rebuild. Our brief, written straight off Chapter 2, is not "make something taste of fish." It is "cast the same two shadows" — a tall IFI-U and a supporting IFI-K — from plants and a mold. The library gives us everything we need: **Soybean** (360 constructs) and **Koji Mold** (80) for the glutamate engine, **Yeast** (240) for glutamate plus γ-glutamyl peptides in one organism, **Shiitake** (80) for the GMP that fires the synergy, **Koji** again for the enzymatic breakdown that turns protein into free amino acids. Koji — *Aspergillus oryzae* — is the quiet genius: its proteases take soy protein apart exactly as the anchovy's own enzymes do, liberating glutamate, while seaweed (kombu, naturally glutamate-rich) and dried shiitake bring the ribonucleotide to light the synergy.

Vegetarian Nam Pla — a fish sauce with no fish

Makes about 2 cups · 30 minutes active, better after a week · the floor of every vegetarian dish in this book

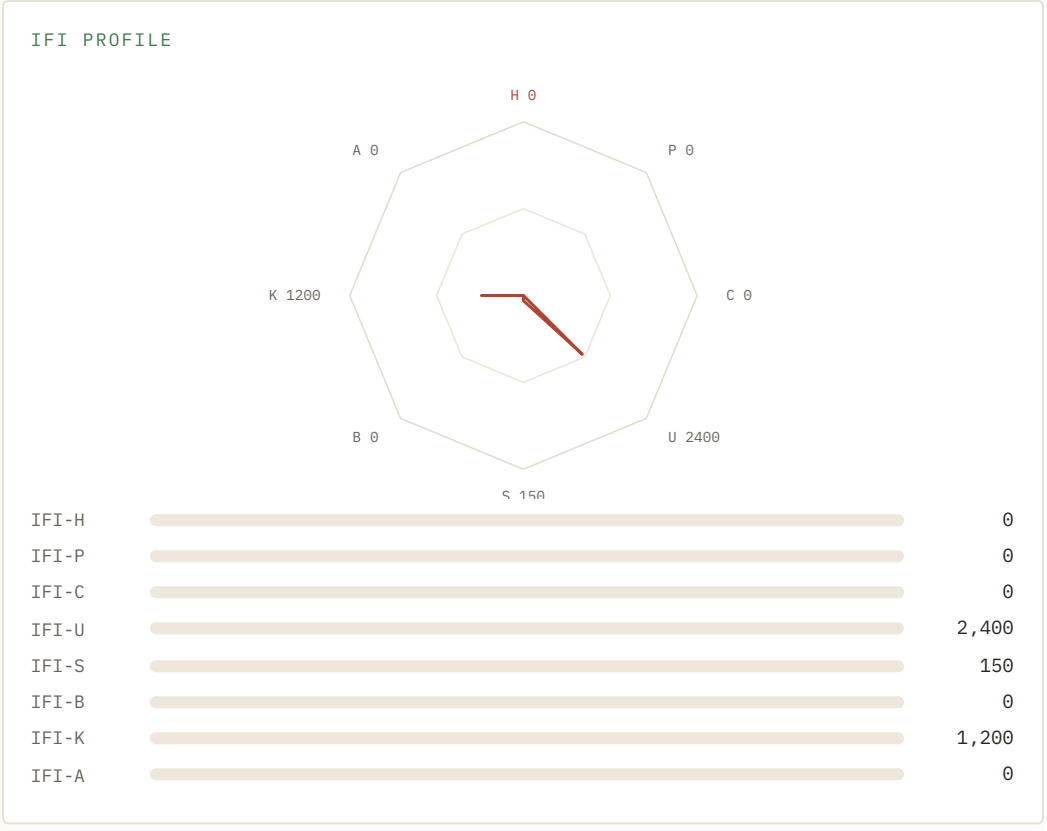
This is not an imitation that apologizes; it is a savory floor built to the same receptor spec as the original. We honor fish sauce fully — it is one of the great ferments of the world — and we also give the plant-first cook a nam pla that casts the same shadows.

```
Makes ~2 cups · 30 min active
2 cups water
1 piece kombu (~10 g), or designed seaweed
6 dried shiitake (designed shiitake, IFI-U + GMP)
3 Tbsp light soy sauce (koji-fermented soybean)
3 Tbsp white miso (koji + soybean)
2 tsp nutritional yeast (designed yeast, IFI-U + IFI-K)
2–3 Tbsp kosher salt, to a clean sting of saltiness
1 tsp palm sugar syrup (Ch. 6)
```

1. Bring the water to just under a simmer with the kombu and dried shiitake. Hold it below the boil for 20 minutes — a hard boil pulls bitter alginates from the kombu and raises IFI-B where you do not want it. Lift out the kombu as the water approaches a simmer.
2. Steep off the heat another 10 minutes, then strain, pressing the shiitake to release their guanylate.

3. Whisk in the soy, miso, yeast, salt, and palm sugar syrup while the liquid is warm. Taste: it should sting with salt, land deep with umami, and carry a faint savory funk. Adjust salt to a clean, bracing edge — this is the *khem* corner, and it should read as seasoning, not as soup.
4. Bottle and refrigerate. It is good at once and better after a week, as the flavors marry.

Why it works — Every piece is a receptor assignment. The soy and miso bring koji-liberated **glutamate** (IFI-U); the kombu brings more; the shiitake bring **guanylate**, the ribonucleotide that fires the synergy and multiplies the glutamate's loudness; the yeast smuggles in both glutamate and the **γ-glutamyl peptides** that lay the IFI-K body; the salt carries the ENaC sodium that was always half the point of fish sauce. Two shadows — umami and kokumi — cast without a single anchovy. It will not taste *identical* to a great aged nam pla, which carries volatile notes of its own; it will stand in the same place on the Index, which is what a dish actually leans on.



Vegetarian Kapi — a shrimp-paste stand-in

Makes about 1 cup · 40 minutes · the funk at the bottom of a curry paste

Shrimp paste is the deep, fermented, almost cheesy funk that gives a Thai curry paste its bottom. Rebuilding it means pushing kokumi and a controlled funkiness higher than the nam pla, with fermented soy and a touch of seaweed doing the work the krill used to.

Makes ~1 cup · 40 min
¾ cup fermented black soybean (koji), rinsed
3 Tbsp red miso (aged, koji + soybean)
2 Tbsp nutritional yeast (designed yeast)
1 Tbsp designed seaweed, ground, or dulse flakes
1 Tbsp light soy sauce
1 tsp kosher salt
1 tsp toasted sesame oil

1. Pound the rinsed fermented soybeans to a coarse paste in a mortar, or pulse in a small processor.
2. Work in the miso, yeast, ground seaweed, soy, salt, and sesame oil until it is a dense, spreadable paste the color of wet earth.
3. Pack into a jar and let it sit at cool room temperature overnight before refrigerating — the funk deepens and rounds. Use it as you would kapi: a teaspoon pounded into a curry paste, never more, or it runs away with the dish.

Why it works — Where nam pla is a *liquid* umami floor, kapi is a *concentrated kokumi bomb* with an umami core and a funk you build deliberately. The aged red miso and fermented soybeans carry both glutamate and a high load of γ-glutamyl peptides; the seaweed adds a marine glutamate that reads, correctly, as "from the water"; the overnight rest lets the fermentation round the edge. It is a seasoning used in drops, which is why its IFI-K reads so tall against its serving size.

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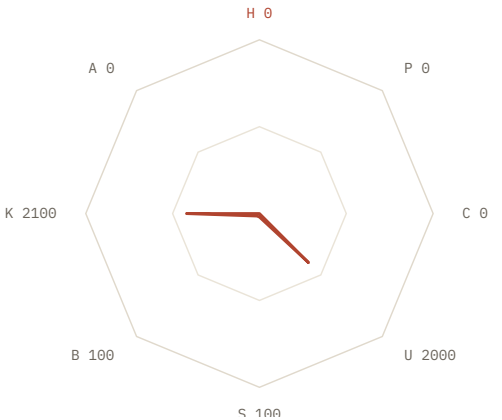


IFI-H	0
IFI-P	0
IFI-C	0
IFI-U	2,000
IFI-S	100
IFI-B	100
IFI-K	2,100
IFI-A	0

Chapter 8 · The Aromatics — *the cold bright soul of the plate.*

IFI-P · IFI-C · TRPA1 · TRPM8 · citral, chavicol, eugenol, citronellal

If fish sauce is the floor and chili the fire, the aromatics are the *identity* — the reason a Thai dish smells, unmistakably, like Thailand before a single bite. Galangal, lemongrass, kaffir lime, Thai basil, holy basil, cilantro, culantro: this is the kit, and no other cuisine pounds and tears and bruises its herbs quite so insistently. Every one of them is a terpene chemistry working on the sharp channel or the cold channel or both, and every one of them is a plant in our library grown to carry its particular oils high and hold them through heat.



Thai basil, the aromatic soul of the stir-fry. Its anise lift is methyl chavicol and linalool working the cool and aromatic channels; holy basil, hotter and clove-sharp, swaps in eugenol and fires the pungent channel instead.

The aromatics split along the two burns we have been tracking. On the **sharp channel, TRPA1** — the fast, bright, pungent lift — sit **galangal**, with its **1′-acetoxychavicol acetate** and galangal acetate, sharper and more medicinal than ginger; **ginger** itself, with its **gingerols**; **garlic**, with its **allicin**; and **holy basil** (*kraphao*), whose **eugenol** gives it its hot, peppery, clove-like bite. On the **cold channel, TRPM8**, and the aromatic-cool pathways beside it, sit **lemongrass**, built on **citral** (a blend of geranial and neral) for its clean lemon-cold lift; **kaffir lime leaf**, carrying **citronellal** for a floral, cooling citrus edge; **Thai basil** (*horapha*), whose **methyl chavicol** and **linalool** give it an anise-sweet coolness; and **mint**, the menthol archetype. Many of them, like galangal, touch both channels at once, which is why a Thai aromatic base is so complex — it is firing the sharp and the cold receptors together.

Here is the full aromatic pantry read as receptor assignments and library depth:

AROMATIC	THAI NAME	GROWN FOR	CHANNEL	KEY MOLECULE
Galangal	*kha*	pungency + cool	TRPA1 / TRPM8	1′-acetoxychavicol acetate
Lemongrass	*takhrai*	cool-bright	TRPM8	citral (geranial + neral)
Kaffir lime leaf	*bai makrut*	cool-floral	TRPM8	citronellal
Thai basil	*horapha*	cool-anise	TRPM8 / aromatic	methyl chavicol, linalool
Holy basil	*kraphao*	pungent-clove	TRPA1	eugenol, methyl eugenol
Ginger	*khing*	pungency	TRPA1	gingerols, shogaols
Garlic	*krathiam*	pungency + kokumi	TRPA1 / CaSR	allicin; γ-glutamyl peptides
Cilantro / root	*phak chi*	green-cool	aromatic	(E)-2-alkenals, decanal
Culantro	*phak chi farang*	green-pungent	aromatic	eryngial

The engineering challenge peculiar to the aromatics is not loudness but *survival*. TRPA1 agonists are volatile and reactive — they are electrophiles, which is how they work — and the cool-channel terpenes are light, quick to evaporate, quick to oxidize. Thrown into a screaming wok or a long-simmered curry, most of a wild herb's aromatic oils are gone in minutes. This is the deep reason Thai technique treats aromatics the way it does: galangal and lemongrass bruised but left in large pieces and added early to a curry so they infuse the oil; Thai basil torn and thrown in at the very last second off the heat so its cool oils survive to the plate; cilantro never cooked at all. We grow these plants to carry their target oils high precisely because so much is lost between the field and the fire — a basil tuned to hold its IFI-C through thirty seconds of wok heat, a lemongrass grown to keep its citral past the simmer. The aromatics are where the garden's work is most fragile and most felt.

Krung Gaeng Base — the pounded aromatic foundation

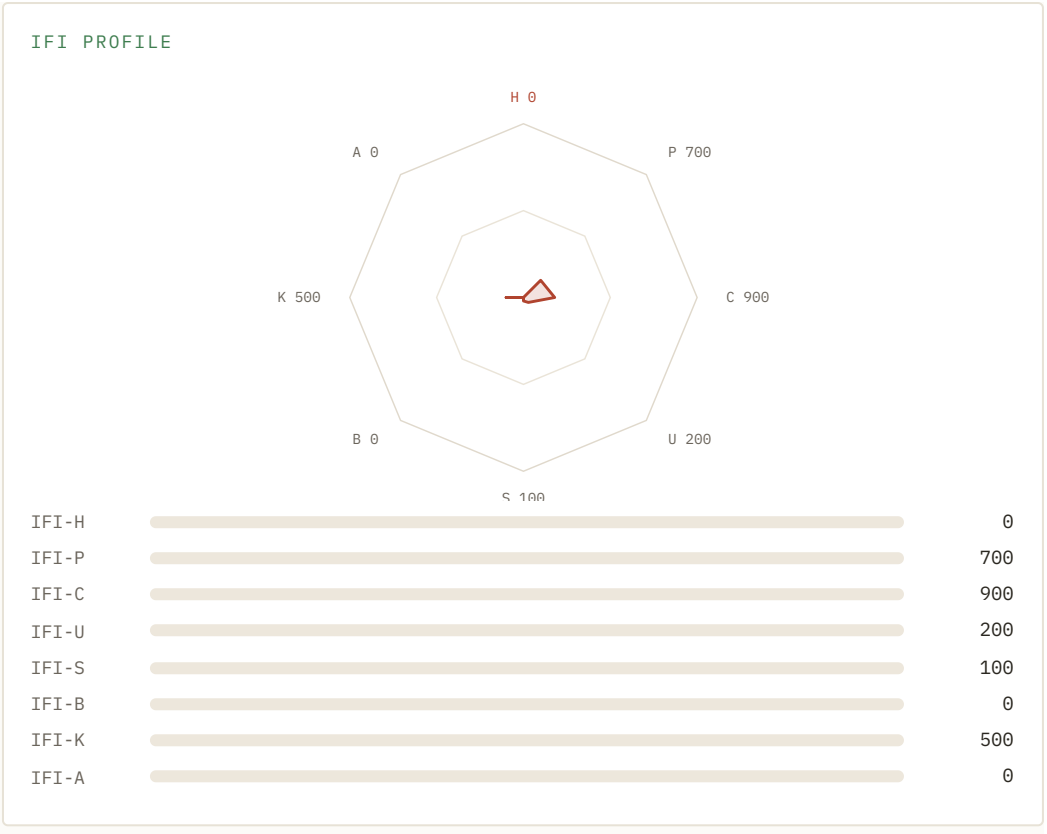
Makes about 1 cup · 25 minutes · the start of every curry and most of the soups

Before a Thai curry is a curry it is this: aromatics pounded in a mortar until they surrender their oils into a fragrant paste. A food processor will do it, but the mortar bruises rather than cuts, which releases more oil and builds a finer paste. This base — without the chili, which we ladder in separately — is the aromatic heart. Pound it fresh; its loudest hour is its first.

```
Makes ~1 cup · 25 min
2 stalks lemongrass, tough outer leaves removed, thinly sliced
1 thumb galangal, peeled and sliced thin
6 kaffir lime leaves, center rib removed, torn
4 cloves designed garlic
3 shallots, quartered
1 Tbsp cilantro root (or lower stems), chopped
1 tsp coriander seed, toasted
1 tsp white peppercorn, toasted
1 tsp kosher salt
```

1. Pound the fibrous aromatics first — lemongrass, galangal, kaffir — with the salt, which acts as an abrasive. Work them to a fine paste before adding anything softer; the fibers are what take the longest to break.
2. Add the garlic, shallots, and cilantro root and pound them in. Then the toasted seeds, ground. Keep pounding until the paste is smooth and intensely fragrant — 10 minutes of real work by hand.
3. Use at once, or press into a jar with a film of oil on top and refrigerate up to a week. It loses its high cool notes fastest, so a fresh pound always reads brightest.

Why it works — This is a two-channel paste with no heat in it yet, which is the point: it lets you set the aromatic character and the burn on separate dials. The lemongrass, galangal, and kaffir lay the IFI-C cool-bright lift; the garlic and the galangal's chavicol throw the IFI-P pungent sharpness; the shallot and garlic bring a kokumi floor. Add chili to taste when the dish calls for it, and the burn climbs independently of everything you built here.



Chapter 9 · Coconut — *the fat that governs the fire.*

the lipid phase · capsaicin's logP · mouthfeel and kokumi · the heat clock

Coconut is the one ingredient in this book that touches no taste receptor at all and governs every one of them. It is fat and water and a little sugar, and it is the medium a great swath of Thai cooking happens *in* — the base of the curries, the richness of the sweets, the thing that makes a punishing amount of chili read as a deep, round, comforting warmth instead of an assault. To understand Thai food you have to understand that coconut is not a flavor you add; it is the *solvent* that decides how every flavor is delivered.



Coconut in cross-section — the white wall of fat and the water at its heart. This is the lipid phase the whole curry lives in, and the reason a Thai curry can carry so much chili and still feel kind.

The physics is worth knowing because it explains a thing every curry cook feels and few can name. Capsaicin is **lipophilic** — it dissolves far better in fat than in water, with an oil-water partition coefficient (logP) around 3.6, meaning it concentrates in the fat phase by thousands to one. Drop chili into a coconut curry and the capsaicin partitions overwhelmingly into the coconut lipid. Two things follow. First, the fat becomes a reservoir that releases the capsaicin to TRPV1 *slowly*, over the length of a bite, so the heat arrives gentler and lasts longer — the fat sets the heat clock, spreading a sharp spike into a long warm curve. Second, when the bite is over, the fat carries capsaicin *off* the receptors far better than water can, which is the real reason a mouthful of coconut curry does not leave the scorched, stranded burn that a water-based hot-and-sour soup can. Coconut does not reduce the chili; it *governs* it, turning a fast bright heat into a slow deep one. This is why a Thai curry can carry an IFI-H that would be brutal in a broth and feel, instead, kind.

Coconut does a second, quieter thing: it delivers **kokumi** and a profound mouthfeel. The medium-chain fats and the trace proteins and the δ-lactones of coconut cream coat the mouth and lengthen everything — not a taste, a texture that reads as richness and continuity, which the Index registers as a lift in IFI-K. A curry made with thin coconut milk and one made with thick coconut cream can hold the same taste molecules and land completely differently, because the cream's fat changes the delivery and the body of every

one of them. The Thai technique of "cracking" the coconut cream — simmering it until the fat separates and the curry paste fries in the released oil — is, in Index terms, a deliberate move to maximize this lipid delivery: the aromatics and the chili infuse directly into the fat phase, where they will be carried best.

Cracked Coconut Curry Base

Makes enough for one curry (serves 4) · 15 minutes · the engine of Part III's curries

This is the move that makes a Thai curry a Thai curry: coconut cream simmered until it breaks, the curry paste fried in its own released oil, the whole aromatic and chili load driven into the fat where it will deliver slow and deep. Master this and the curries in Chapter 12 are assembly.

```
Serves 4 · 15 min
1 cup thick coconut cream (the firm top of a chilled can)
3–4 Tbsp curry paste (Ch. 12) or krung gaeng base + chili (Ch. 8, 5)
1 cup coconut milk (thinner), warm, to let down
1 Tbsp palm sugar syrup (Ch. 6)
2 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
```

1. Simmer the thick coconut cream alone in a wide pan over medium heat, stirring, until it thickens and the clear oil beads out at the edges and the cream "cracks" — 5 to 8 minutes. This is the fat separating; you want it.
2. Add the curry paste to the cracked cream and fry it in the released oil, stirring constantly, until it is deeply fragrant and the oil stains red or green with it — 3 to 5 minutes. This is the step that drives the aromatics and chili into the lipid phase.
3. Let down with the thinner coconut milk to the consistency you want, then season with the palm sugar syrup and the nam pla. Taste for the balance — it should read rich, warm-hot, savory, faintly sweet — then carry on with the curry of your choice.

Why it works — Frying the paste in cracked coconut fat is lipid-phase engineering by hand. The capsaicin and the oil-soluble aromatics dissolve into the coconut fat, which then both *slows* their release to the receptors (the long, kind heat) and *carries* them evenly through every spoonful. The fat also lays the IFI-K body that makes a curry feel complete. The sugar governs the fire from the sweet side; the nam pla lays the umami floor. Every axis in the finished curry is being delivered by this fat.

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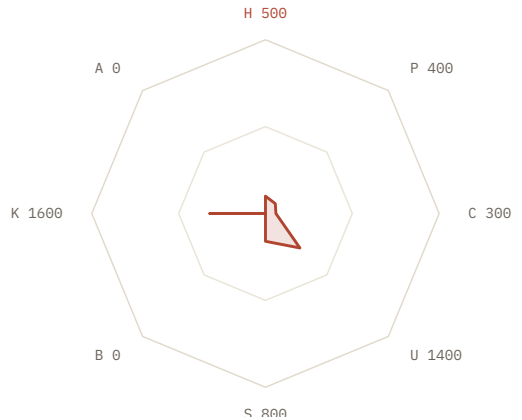

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IFI-P	400
IFI-C	300
IFI-U	1,400
IFI-S	800
IFI-B	0
IFI-K	1,600
IFI-A	0

Chapter 10 · The Sour Line — *tamarind, lime, and the ghost that moves everything.*

OTOP1 · titratable acidity · IFI-A · the end-of-cooking adjustment

We come back to the ghost. Sour is the corner the Index does not score, and it is also the corner a Thai cook adjusts last and trusts most — the final squeeze of lime that tells her the dish is done. This chapter is about using the ghost well: where Thai sourness comes from, how it differs source to source, and why it is always the closing move and never a foundation.



Pineapple in cross-section — one of the sweeter sour notes in the Thai kitchen, its acid softened by sugar and carried into curries and relishes. Sourness has a hundred sources here, each with its own curve of acid and sweetness.

Thai sourness is not one thing. **Lime** (*manao*) is sharp, volatile, and clean — citric acid plus the lime oil's aromatics, a brightness that arrives and leaves fast, which is why it is added off the heat at the end, never cooked. **Tamarind** (*makham*) is deep, round, and slow — tartaric and malic acids with a little sugar and a faint tannic grip, a sourness with body that can be simmered into a dish without disappearing, the backbone of pad thai's sauce and of the sour curries. **Green mango** and **green papaya** bring sourness wrapped in **astringency**: their unripe flesh carries organic acids *and* tannins, so they fire OTOP1 for sour and bind the saliva's proline-rich proteins for IFI-A grip at once. **Fermented** sourness — the lactic tang of a properly aged som tam or a pickle — is different again, a biological acid with a rounder edge. Each source is a different curve of acid against sweetness against astringency, and a cook chooses among them the way a painter chooses a red.

The mechanism, from Chapter 2, is that sour is read by **OTOP1**, a proton channel, so what the tongue registers is bulk acidity reaching the cell — governed by how much free acid the ingredient carries (its **titratable acidity**) and how far the local pH actually falls (its **buffering**). This is why a dish can taste under-sour even at a low pH if it is heavily buffered by protein and salt, and why the final lime goes in at the end: late, uncooked, and un-buffered, it lands with full

force. And it is why we add it *last* — because, as we saw in the mathematics, sour is the axis with the largest coupling coefficients. A squeeze of lime lifts the perceived salt, sharpens the sweet, cuts the coconut fat, and brightens the aromatics all at once. It is the single most powerful adjustment in the Thai kitchen precisely because it moves five other things while barely registering as a flavor of its own.

Astringency, the sour corner's measurable neighbor, *is* on the Index, and it earns a word. **IFI-A** scores the tannin grip — polyphenols cross-linking the proline-rich proteins of the saliva so the mouth tightens and dries. Green papaya, green mango, the skins of certain beans, strong tea: these bring real structure to a dish, a grip that keeps sweetness honest and gives a raw salad its spine. When we want the *sensation* of sourness's structure without stacking pure acid, astringency is the lever — which is exactly what green papaya does in a som tam, bringing grip and freshness that reads as part of the sour corner even though its mechanism is a different receptor entirely.

Tamarind Water — the deep sour base

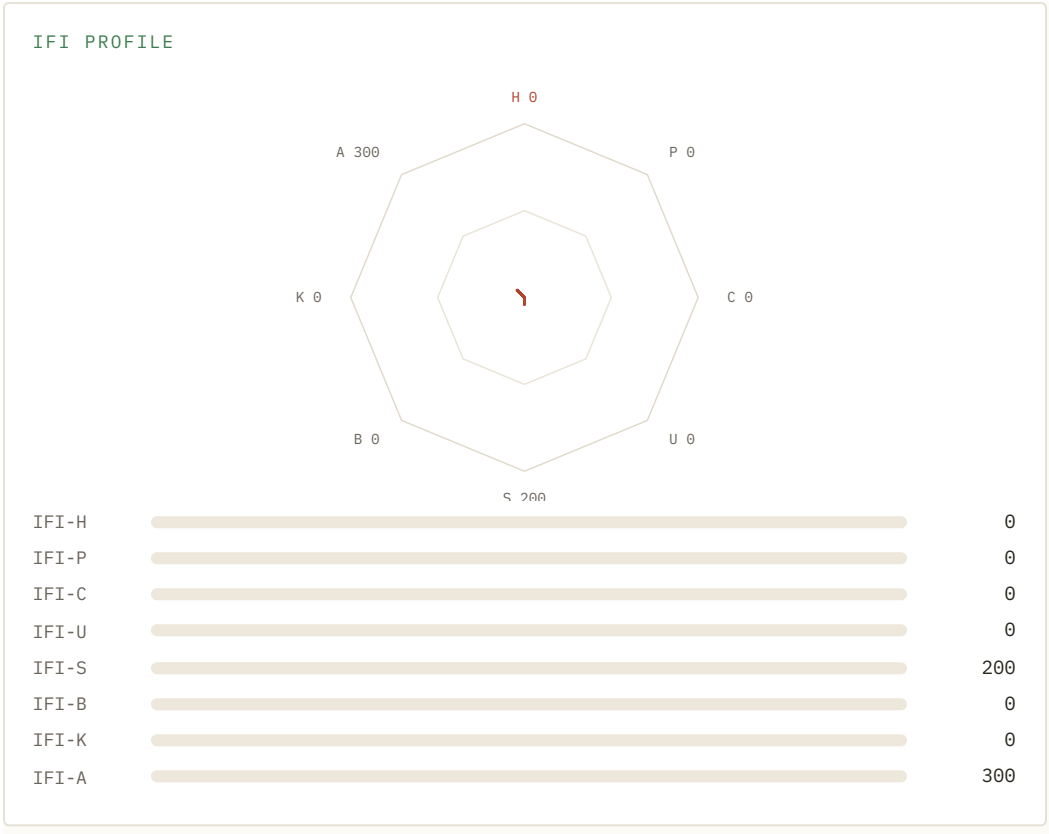
Makes about 1 cup · 15 minutes · the backbone sour of pad thai and the sour curries

Tamarind comes as a sticky block of pulp and seeds; you turn it into a usable sour by soaking and straining. This is the round, deep, cookable acid — the one that goes *into* a dish rather than on top of it.

```
Makes ~1 cup · 15 min
½ cup seedless tamarind pulp
1 cup warm water
```

1. Break the tamarind pulp into the warm water and let it soak 10 minutes, until soft.
2. Work it with your fingers to dissolve the pulp into the water, then push it through a sieve, scraping the underside, until only fiber and any stray seeds remain.
3. The result should be the consistency of thin cream and bracingly sour. Use it where a recipe calls for tamarind; it keeps a week refrigerated, longer frozen in cubes.

Why it works — Tamarind's tartaric and malic acids give a sourness with enough body to survive cooking, unlike lime's volatile citric brightness. It carries a little sugar and a faint tannic grip, so it reads rounder and more structural than a pure acid — which is why it anchors the sour corner of a cooked dish. On the Index it shows as a small IFI-A from its tannins; its sourness itself runs off the chart, the ghost doing its work.



Nam Jim Talay — the bright green seafood dipping sauce

Makes about 1 cup · 10 minutes · the sharp, hot, sour sauce for grilled things

The counterweight to tamarind: a raw, uncooked, electric sauce where lime's sharp sour is the whole point. It is the sauce for grilled fish and seafood, and it is the composition problem at its most naked — four corners and the aromatics, balanced raw in a bowl.

```
Makes ~1 cup · 10 min
¼ cup lime juice, fresh
3 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
2 Tbsp palm sugar syrup (Ch. 6)
8–12 designed bird's-eye chilies (IFI-H 600)
6 cloves designed garlic
2 Tbsp cilantro, chopped
```

1. Pound the chilies and garlic to a rough paste in a mortar — rough, not smooth; you want texture.
2. Stir in the lime, nam pla, and palm sugar syrup. Taste and chase the balance: it should hit sour first, then salt-umami, then sweet, then the heat arriving behind. Adjust by the quarter-teaspoon.
3. Fold in the cilantro at the end. Serve within the hour, raw and loud, with anything from the grill.

Why it works — This is the four corners with nothing to hide behind. The lime is the ghost sour, added raw and un-buffered for full OTOP1 force; the nam pla is the umami floor and the salt; the palm sugar is the governing sweet; the fresh chili is the IFI-H spike and the garlic the IFI-P flash. There is no fat and no long cook to round anything, so the balance has to be exact — which is why a cook tastes and adjusts this one more carefully than almost anything else she makes.

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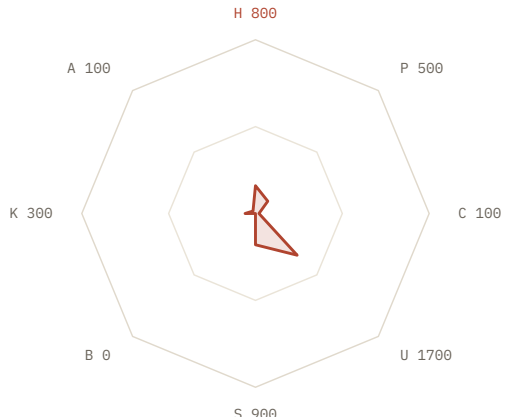

IFI-H	800
IFI-P	500
IFI-C	100
IFI-U	1,700
IFI-S	900
IFI-B	0
IFI-K	300
IFI-A	100



PART III OF V

The Dishes

the raw salads · the curry pastes · the stir-fries · the soups · the dipping sauces

Chapter 11 · Som Tam & the Raw Salads — *the balance you can hear.*

the pounded dish · the synergy on a plate · IFI-A as structure

Nowhere is the Thai balance more naked than in som tam, the green papaya salad, and nowhere is it more audible — literally, the *tok tok tok* of the pestle against the clay mortar is the sound of a dish being composed. Nothing is cooked. Every axis is raw, pounded together to order, tasted and adjusted in the mortar itself, and served the moment it is right. If you want to feel the composition problem in your hands, make a som tam.



Peanut, the roasted crunch and the quiet fat that rounds a som tam's loud raw corners. A handful pounded in at the end changes the whole delivery of the dish.

What makes som tam a masterpiece of balance is that it fires almost every axis at once and keeps them all legible. The green papaya brings IFI-A structure — that tannic grip from the unripe flesh — plus a little of the ghost sour. The chili brings fast raw IFI-H. The palm sugar brings the governing IFI-S. The fish sauce brings the IFI-U floor and the salt. The lime brings the ghost sour that lifts everything. The garlic throws IFI-P. And the two small additions that make a som tam sing — **dried shrimp** and, in the classic, a little fermented crab — bring the **ribonucleotide** that fires the umami synergy from Chapter 7, the IMP that multiplies the fish sauce's glutamate. A pinch of dried shrimp is not a garnish; it is the switch that turns the whole umami floor up severalfold.

Som Tam Thai — green papaya salad

Serves 2 · 15 minutes · the composition problem, pounded to order

The Central Thai version, balanced toward sweet and with peanuts. Taste in the mortar and adjust before you plate — this dish is finished in the pounding, not the recipe.

Serves 2 · 15 min
2 cups green papaya, peeled and shredded
4–8 designed bird's-eye chilies (IFI-H 600)
3 cloves designed garlic
2 Tbsp palm sugar syrup (Ch. 6)
2 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
2–3 Tbsp lime juice, fresh
2 Tbsp dried shrimp (or 1 Tbsp designed shiitake, ground, for the veg synergy)
1 cup long beans, cut in 2-inch lengths
1 cup cherry tomatoes, halved
¼ cup roasted peanuts

1. Pound the garlic and chilies to a rough paste in a large mortar. Add the dried shrimp (or ground shiitake) and pound to break them up — this is the ribonucleotide going in.
2. Add the palm sugar syrup, fish sauce, and lime and stir in the mortar until the sugar dissolves. Taste the dressing now and set the balance: sour-forward, then salt-umami, then sweet, the heat behind.
3. Add the long beans and tomatoes and bruise them lightly with the pestle — not to a pulp, just to open them. Then add the shredded papaya and pound-and-turn with a spoon, lifting from the bottom, until the papaya is dressed and slightly softened but still crisp.
4. Fold in the peanuts and turn once. Plate at once, while the papaya still has its snap.

Why it works — This is the umami synergy made visible. The dried shrimp's IMP (or the shiitake's GMP) lands on the second site of the TAS1R1·TAS1R3 pair and multiplies the fish sauce's glutamate — which is why a som tam tastes so much deeper than its handful of ingredients should. The green papaya's tannins lay IFI-A structure under the raw heat; the lime (ghost sour) lifts the salt and sharpens the sweet; the peanuts' fat rounds the loud raw corners and slows the chili's delivery. Everything is raw, so every axis reads at full force and the balance has to be found by hand, in the mortar, which is exactly why no two cooks' som tam taste the same.

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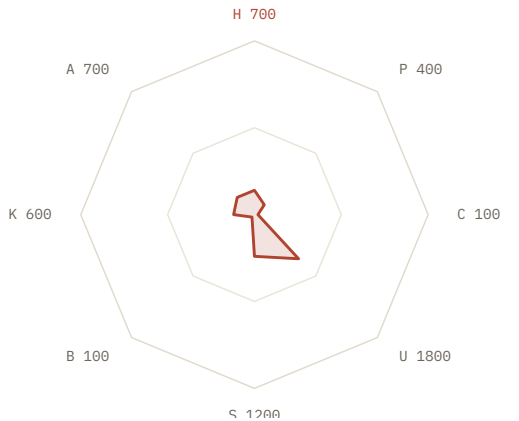

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IFI-P	400
IFI-C	100
IFI-U	1,800
IFI-S	1,200
IFI-B	100
IFI-K	600
IFI-A	700

Yam Woon Sen — glass noodle salad

Serves 2 · 20 minutes · the warm salad, balance over tender noodles

Where som tam is crisp and raw, yam is a family of warm salads over something tender — here glass noodles, which are flavorless on purpose, a neutral carrier that lets the dressing's balance read with nothing to argue with it.

```
Serves 2 · 20 min
3 oz glass (mung bean) noodles, soaked and blanched
3 Tbsp lime juice
2 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
1 Tbsp palm sugar syrup (Ch. 6)
3–5 designed bird's-eye chilies (IFI-H 600), sliced
2 cloves designed garlic, minced
¼ cup shallot, thinly sliced
¼ cup celery or Chinese celery, sliced
2 Tbsp cilantro and mint, torn
2 Tbsp roasted peanuts
```

1. Whisk the lime, nam pla, palm sugar syrup, chilies, and garlic into a dressing. Taste for the four corners.
2. Toss the warm, drained glass noodles with the dressing while they are still warm — they drink it in better warm than cold.
3. Fold in the shallot, celery, herbs, and peanuts. Serve just warm or at room temperature.

Why it works — The neutral glass noodle is a blank carrier, which makes this the clearest tasting lesson in the book: the dressing's vector is all you taste. Lime (ghost sour) leads, the nam pla lays umami and salt, the palm sugar governs, the raw chili spikes the heat, the herbs lift it cool. Because the noodle contributes almost nothing, a mis-set dressing has nowhere to hide — which is why this dish is where Thai cooks are taught to balance.

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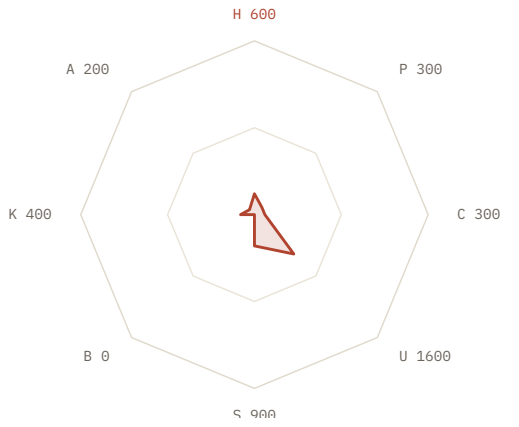


IFI-H	600
IFI-P	300
IFI-C	300
IFI-U	1,600
IFI-S	900
IFI-B	0
IFI-K	400
IFI-A	200

Chapter 12 · The Curry Pastes — *the multi-axis construct in a mortar.*

the paste as a vector · green, red, massaman, panang · the cracked-cream delivery

A Thai curry paste is the most sophisticated single object in this cuisine, and from the Index's point of view it is a *construct* — a dozen ingredients pounded into one, each carrying its axis, assembled to a target vector. Green, red, massaman, panang: these are not recipes so much as *coordinates*, each paste sitting in a different place in axis-space, and a cook who understands them as vectors can build, adjust, and invent them with intent.



Turmeric, the gold at the base of a massaman and the yellow curries — earthy, warm, faintly bitter, and the color of the gentlest curry on the Thai table.

Read the four great pastes as vectors and the whole family snaps into focus:

PASTE	HEAT	AROMATIC CHARACTER	BODY	SITS AT
Green (*gaeng khiao wan*)	high (fresh green chili)	cool-bright: basil, kaffir, lemongrass	medium	high H, high C, medium K
Red (*gaeng phet*)	high (dried red chili)	deep, round	medium	high H, low C, medium K
Panang	medium	nutty, rich	high (peanut)	medium H, high K, high S
Massaman	low	warm spice: cardamom, cinnamon, clove	very high	low H, high P-warm, high K, high S

Massaman is the most revealing, because it is the Thai curry that is barely Thai — a Persian-Muslim inheritance, built on the *warm* spices (cardamom, cinnamon, clove, nutmeg) that the rest of the cuisine mostly leaves alone. In Index terms it is a deliberate move *down* the heat axis and *up* the kokumi and warm-pungency axes: gentle on TRPV1, rich on CaSR, with cinnamon's cinnamaldehyde and clove's eugenol bringing a warm TRPA1 character utterly different from the bright galangal-and-garlic pungency of a green curry. It proves the thesis of this whole book: "a Thai curry" is not one vector but a region, and the paste is how you choose your point in it.

Green Curry Paste — *gaeng khiao wan*

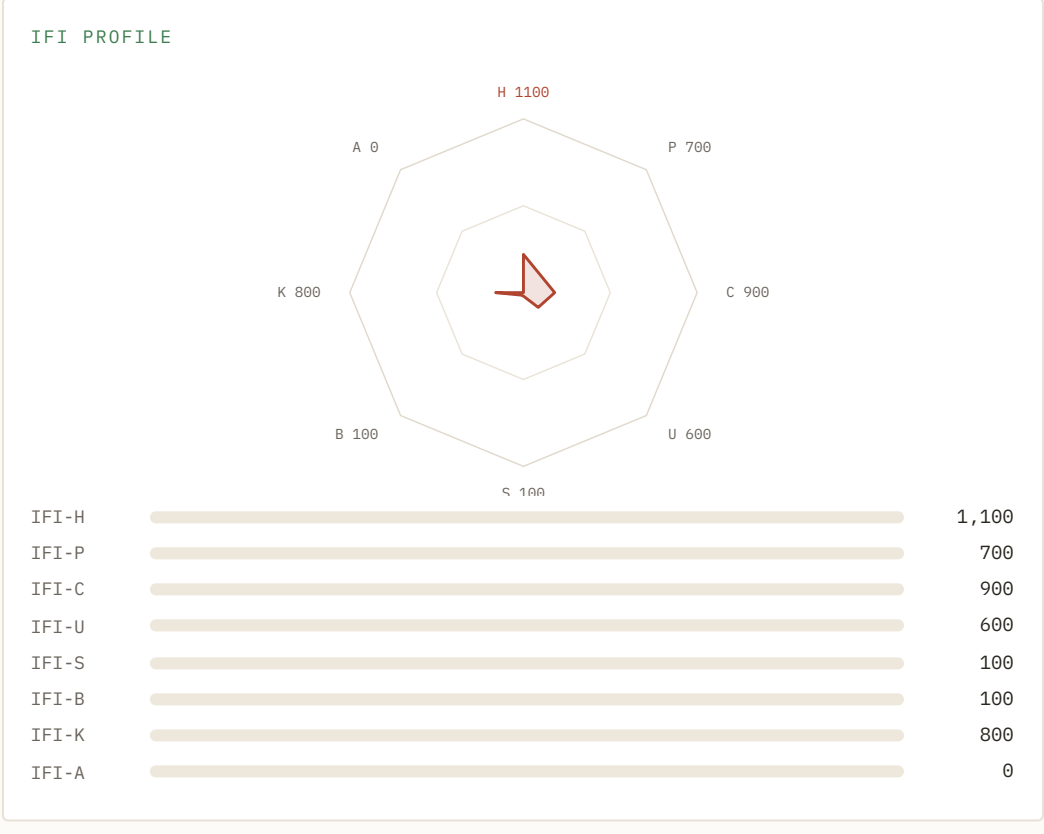
Makes about 1 cup · 30 minutes · the brightest, hottest, most aromatic of the pastes

Green curry gets its color and its fire from fresh green chili, and its soul from a cool-channel aromatic load — basil, kaffir, lemongrass — pounded in raw. This is the krung gaeng base of Chapter 8, pushed green and hot.

```
Makes ~1 cup · 30 min
15–20 designed green bird's-eye chilies (IFI-H 600)
2 stalks lemongrass, sliced thin
1 thumb galangal, sliced
6 kaffir lime leaves, torn
6 cloves designed garlic
3 shallots
1 Tbsp cilantro root, chopped
1 tsp coriander seed, toasted and ground
1 tsp cumin seed, toasted and ground
1 tsp white peppercorn, ground
1 tsp vegetarian kapi (Ch. 7), or shrimp paste
1 tsp kosher salt
handful Thai basil leaves (pounded in last)
```

1. Pound the fibrous aromatics — lemongrass, galangal, kaffir — with the salt to a fine paste first.
2. Add the chilies and pound to a smooth green paste, then the garlic, shallots, and cilantro root.
3. Work in the ground toasted spices and the kapi. Pound in the Thai basil at the very end, just enough to bruise it green through the paste. Use at once or within a few days; the green cool notes fade fastest.

Why it works — The fresh green chili carries both the IFI-H and the green color; the lemongrass, galangal, and kaffir lay the tall IFI-C that makes green curry taste *bright* rather than merely hot; the kapi lays the IFI-K and umami bottom. It is a complete multi-axis construct before it ever meets coconut — a vector you can taste on a fingertip and adjust before you build the curry on it.



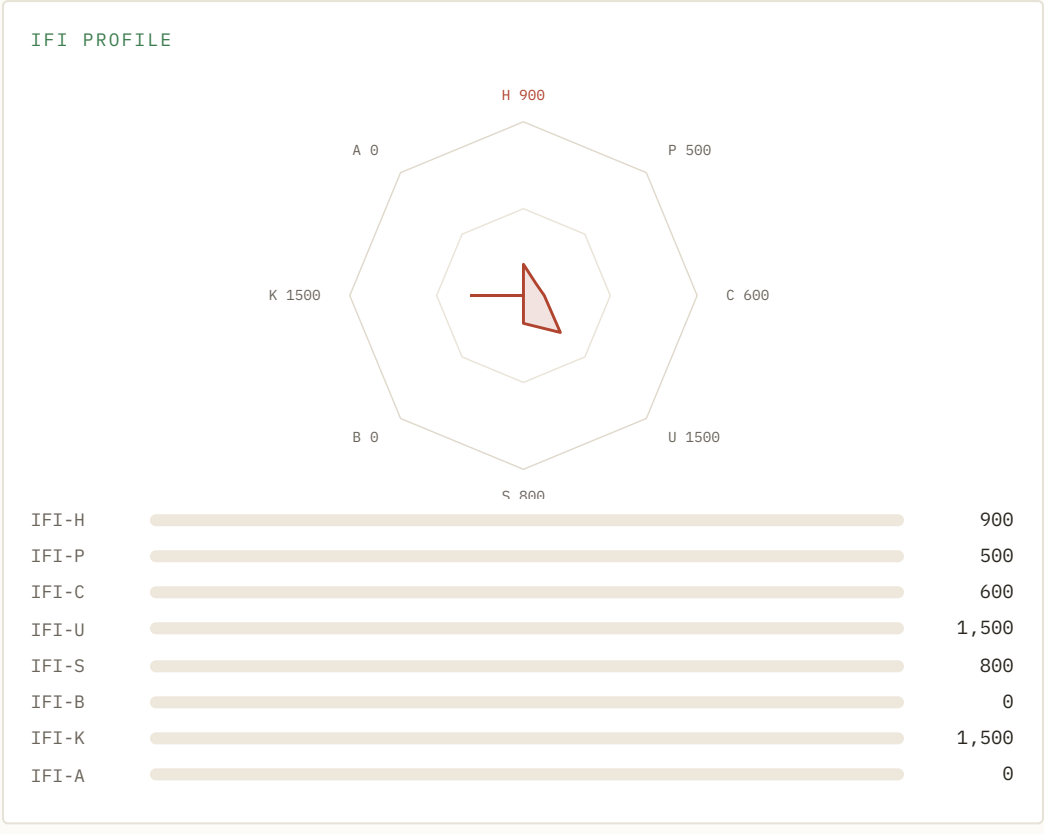
Gaeng Khiao Wan — green curry, built

Serves 4 · 30 minutes · the paste delivered through cracked coconut

```
Serves 4 · 30 min
4 Tbsp green curry paste (above)
1 recipe cracked coconut curry base (Ch. 9)
3 cups vegetables (Thai eggplant, bamboo, long beans) — or protein of
choice
2 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
1 Tbsp palm sugar syrup (Ch. 6)
handful Thai basil
2 kaffir lime leaves, torn
1–2 red spur chilies, slivered, to finish
```

1. Build the cracked coconut base from Chapter 9, frying the green curry paste in the released oil until deeply fragrant.
2. Let down with the thinner coconut milk, bring to a gentle simmer, and add the eggplant and firmer vegetables (or protein). Simmer until just tender — Thai eggplant wants to keep a little bite.
3. Add the long beans and bamboo, season with nam pla and palm sugar, and simmer two minutes more. Off the heat, tear in the Thai basil and kaffir and scatter the red chili slivers for color and a final bright spike.
4. Serve with jasmine rice. Taste before plating: the fire should read round and deep through the coconut, the aromatics bright on top, the sweet governing underneath.

Why it works — Everything we built in Part II arrives here at once. The cracked coconut fat (Ch. 9) slows and spreads the paste's IFI-H into a long kind warmth; the nam pla lays the umami floor; the palm sugar governs the fire from the sweet side; the basil and kaffir torn in off the heat survive to deliver their IFI-C bright top. A green curry is the whole pantry, delivered through fat.



Massaman — the gentle curry

Serves 4 · 45 minutes · low heat, deep body, the warm-spice outlier

Serves 4 · 45 min
4 Tbsp red curry paste (Ch. 12 family) + 1 Tbsp massaman spice blend
1 recipe cracked coconut curry base (Ch. 9)
1 lb potato or sweet potato, in chunks (plus protein of choice if desired)
½ cup roasted peanuts
3 Tbsp tamarind water (Ch. 10)
2 Tbsp palm sugar syrup (Ch. 6)
2 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
massaman blend: 2 cardamom pods, 1 small cinnamon stick, 2 cloves, ¼ nutmeg, 2 bay — toasted, ground

1. Toast and grind the massaman spices. Build the cracked coconut base, frying the red paste and the warm-spice blend together in the released oil.
2. Let down with coconut milk, add the potato (and protein), and simmer gently until everything is tender — 25 to 30 minutes, low and patient. This is a slow curry.
3. Season with tamarind water, palm sugar, and nam pla — massaman wants more sweet and more sour than the fierce curries — and stir in the peanuts. Simmer five minutes more to marry. It should read rich, warm, barely hot, deeply round.

Why it works — Massaman is a deliberate inversion of the green curry's vector: heat pulled down, kokumi and sweet pushed up, the pungency shifted from bright galangal to *warm* cinnamon and clove. The cardamom-cinnamon-clove blend fires TRPA1 in a slow, warm register; the peanuts and coconut stack IFI-K into a deep body; the tamarind's round sour and the extra palm sugar hold the sweet-sour balance a gentle curry needs to keep from going flat. It is proof that "Thai curry" is a region, and this is its far, gentle corner.

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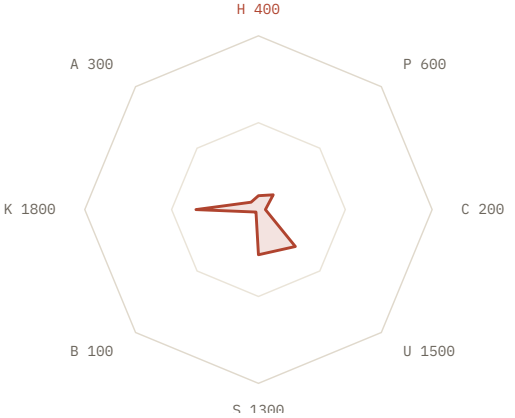


IFI-H	400
IFI-P	600
IFI-C	200
IFI-U	1,500
IFI-S	1,300
IFI-B	100
IFI-K	1,800
IFI-A	300

Chapter 13 · The Stir-Fries — *speed, and the aromatics that survive it.*

wok heat · the last-second herb · pad kra pao · pad thai

The Thai stir-fry is a race against the aromatics' own volatility. A wok runs hot enough to char, and the cool-channel terpenes and the sharp TRPA1 electrophiles that give these dishes their soul are exactly the molecules a screaming wok destroys fastest. So Thai stir-fry technique is, at heart, a sequence of *timing decisions* about when each axis goes in — the garlic early to bloom its pungency into the oil, the sauce to glaze, the herbs thrown in at the very last second off the heat so their cool oils reach the plate alive.



Thai basil again, torn and waiting for the last second of the wok — holy basil for pad kra pao, its eugenol surviving the brief heat to land peppery and hot on the plate.

Pad Kra Pao — holy basil stir-fry

Serves 2 · 10 minutes · the national weeknight dish, fast and loud

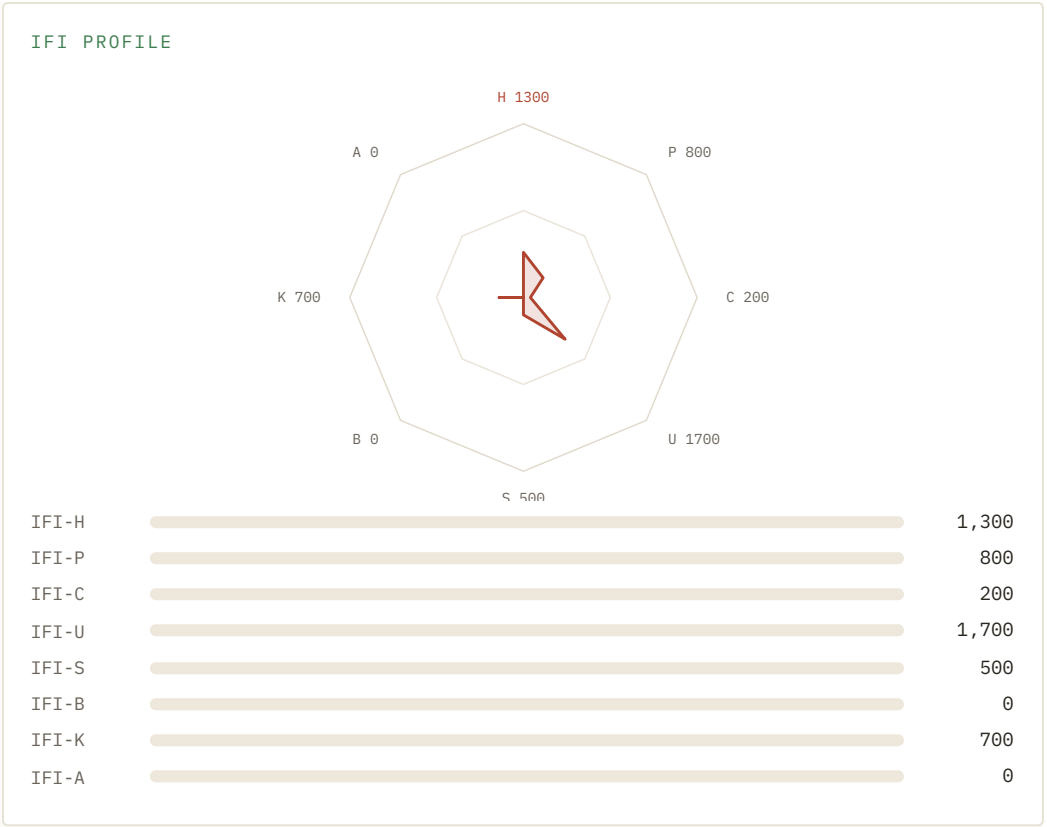
The most-eaten dish in Thailand, and a lesson in TRPA1 timing. Holy basil (*kraphao*) is the whole point — its eugenol gives a hot, clove-peppery bite distinct from the anise coolness of Thai basil — and it goes in at the last possible second so its oils survive. Serve over rice with a fried egg.

```
Serves 2 · 10 min
8 oz protein (minced; or crumbled firm tofu / mushroom for veg)
4 cloves designed garlic, pounded
6–10 designed bird's-eye chilies (IFI-H 600), pounded
2 Tbsp oil
1 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
1 Tbsp light soy sauce
1 tsp dark soy sauce
1 tsp palm sugar syrup (Ch. 6)
2 Tbsp stock or water
2 large handfuls holy basil leaves
```

1. Pound the garlic and chilies together to a rough paste. Heat the oil in a wok until it shimmers.
2. Add the garlic-chili paste and stir just until fragrant — 15 seconds, no more; you want it bloomed, not browned.
3. Add the protein and stir-fry hard over the highest heat until just cooked and beginning to catch, breaking it up. Add the sauces, palm sugar, and splash of stock and toss to glaze.

4. Kill the heat. Throw in the holy basil and fold it through the residual heat until just wilted — five seconds. Plate at once over rice, with a crisp fried egg if you like.

Why it works — This is aromatic timing as receptor management. The garlic blooms its allicin (IFI-P) into the oil early; the fresh chili lands its raw IFI-H through the fast cook; and the holy basil's eugenol — fragile, volatile, a TRPA1 agonist — goes in *off the heat* so it reaches the plate at full loudness instead of cooking away. The dark soy brings color and a trace of molasses sweet; the palm sugar governs the fire. Fast, loud, and built around saving the one ingredient the wok most wants to destroy.



Pad Thai — the sweet-sour noodle

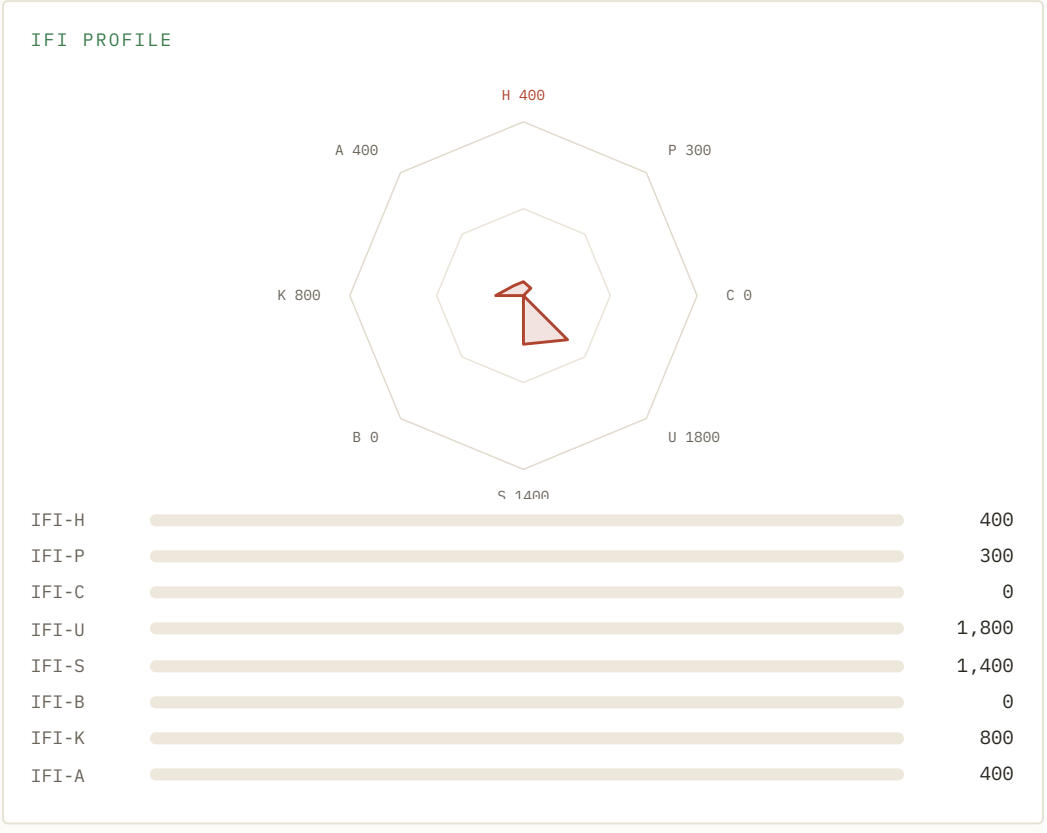
Serves 2 · 25 minutes · the tamarind-forward balance over rice noodles

Pad thai is misunderstood abroad as sweet; made right it is a tight balance of tamarind sour, palm sugar sweet, and fish sauce umami, with the noodle a carrier for the sauce. The sauce *is* the dish — a three-corner balance you can mix ahead and taste as a vector.

Serves 2 · 25 min
6 oz rice noodles, soaked
sauce: 3 Tbsp tamarind water (Ch. 10) + 2 Tbsp palm sugar syrup (Ch. 6) + 2 Tbsp fish sauce/veg nam pla (Ch. 7)
2 Tbsp oil
2 eggs (or omit for vegan)
½ cup firm tofu, cubed
2 cloves designed garlic, minced
1 cup bean sprouts
¼ cup garlic chives, cut
2 Tbsp roasted peanuts, crushed
1 tsp toasted dried-chili powder (Ch. 5)
lime wedges, to serve

1. Mix the sauce and taste it as a vector: it should hit sour, then salt-umami, then sweet, roughly even. Adjust before it ever meets the wok.
2. Fry the tofu and garlic in oil until golden. Push aside, scramble the eggs, then add the drained noodles and the sauce and toss over high heat until the noodles drink the sauce and turn glossy.
3. Add half the bean sprouts, the chives, and half the peanuts; toss once. Plate and top with the rest of the sprouts and peanuts, the chili powder, and a lime wedge to squeeze at the table.

Why it works — Pad thai is the tamarind chapter's thesis on a plate. The tamarind brings a *cookable* round sour that survives the wok (where lime would vanish); the palm sugar governs and sweetens; the nam pla lays the umami-salt floor — three corners premixed and balanced as a vector, then glazed onto a neutral noodle. The table lime is the ghost's final adjustment, added raw by the diner for the bright top the cooked tamarind cannot give. The chili powder lets each eater set their own IFI-H.



Chapter 14 · The Soups — *the sour-hot broth, and the cool that saves it.*

tom yum · tom kha · the aromatic infusion · coconut's governing fat

Thai soups are the cuisine's clearest demonstration that heat has a shape. Tom yum and tom kha are close cousins — the same aromatic chord, galangal and lemongrass and kaffir — and yet they land in completely different places, because one is a clear broth that lets every axis read sharp and the other is a coconut broth that rounds and governs them all. Taste the two side by side and you are tasting the coconut chapter proven.



Coconut, the fat that turns a fierce sour-hot soup into tom kha's round, kind embrace. The same aromatics, delivered through fat instead of water, become a different dish.

Tom Yum — the clear hot-and-sour soup

Serves 4 · 25 minutes · fire and brightness over a clear broth

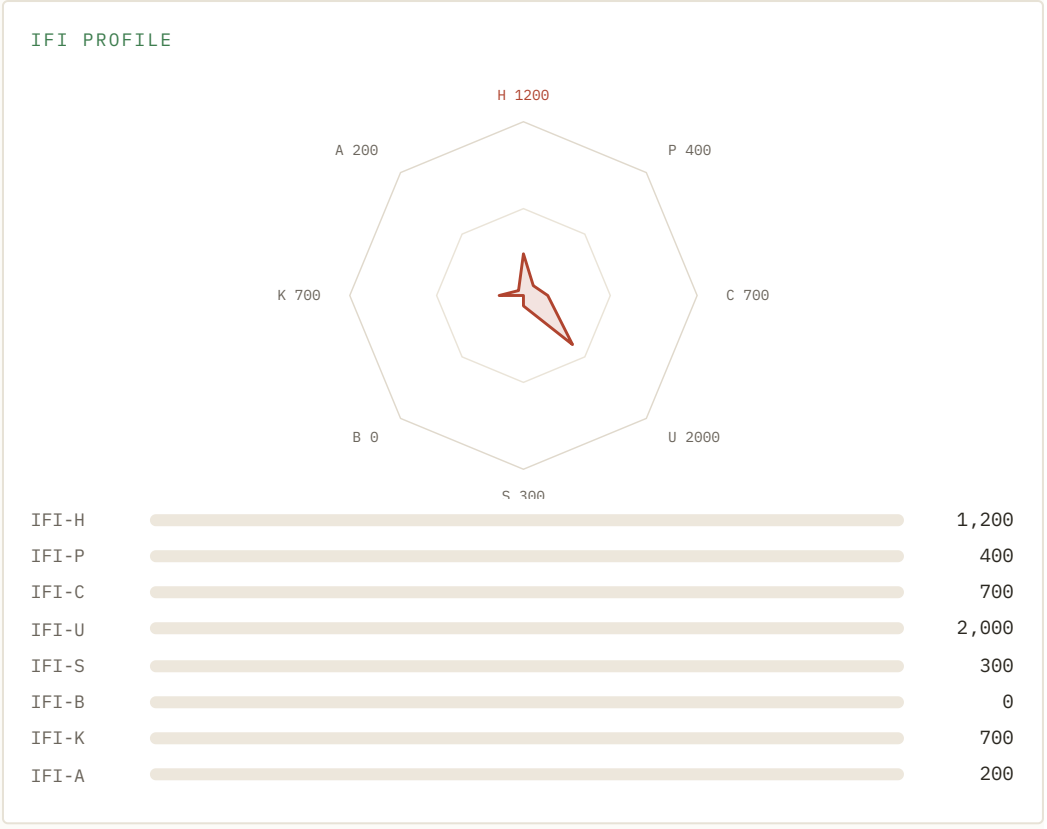
Tom yum is the cuisine at its most electric: a clear broth pushed hard on heat and sour, then lifted — made somehow refreshing in the middle of the fire — by a cool-channel chord of lemongrass, galangal, and kaffir. Nothing rounds it; every axis is sharp.

```
Serves 4 · 25 min
6 cups stock
3 stalks lemongrass, bruised, in 2-inch lengths
1 thumb galangal, sliced
6 kaffir lime leaves, torn
3–4 cilantro roots, bruised
8 oz mushrooms (or shrimp/protein of choice)
2 Tbsp nam prik pao (chili jam, Ch. 15)
3 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
4–8 designed bird's-eye chilies (IFI-H 600), bruised
3–4 Tbsp lime juice (off the heat, at the end)
cilantro, to finish
```

1. Bring the stock to a simmer with the lemongrass, galangal, kaffir, and cilantro roots. Simmer 10 minutes to infuse the aromatics into the broth — these go in whole to be fished out, not eaten.

2. Add the mushrooms (or protein) and cook until just done. Stir in the nam prik pao, which brings a roasted depth and a little IFI-K body, and the nam pla.
3. Add the bruised fresh chilies. Take the pot *off the heat* before the lime goes in — lime's brightness is volatile and dies if simmered. Stir in the lime juice, taste, and chase the balance: it should be sour-hot and bright, salt-deep underneath, with no sweetness to speak of.
4. Finish with cilantro. Serve at once, loud and clear.

Why it works — Tom yum is the clear-broth control in the coconut experiment. With no fat to govern it, the chili's IFI-H reads fast and sharp, the lime's ghost sour lands at full OTOP1 force, and the cool-channel chord of lemongrass-galangal-kaffir (IFI-C) is what keeps all that fire and acid from collapsing into one note — the brightness is structural, not garnish. The nam prik pao lays the only roundness in the bowl. It is a soup held together by its cool high notes, which is why those aromatics go in whole and early to infuse and the lime goes in last and raw.



Tom Kha — the coconut galangal soup

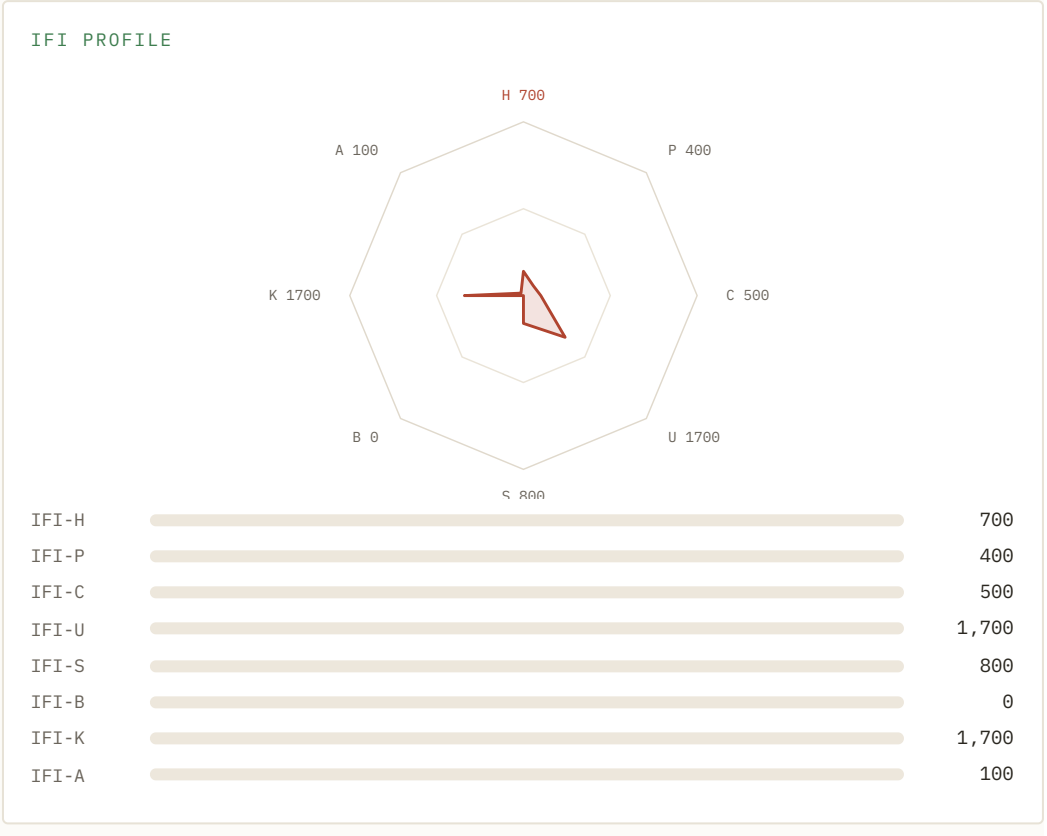
Serves 4 · 25 minutes · the same chord, rounded by fat

Change the broth from water to coconut and the same aromatic chord becomes a different soul: gentler, rounder, the heat governed, the sour softened, the galangal now the lead rather than a bright edge. *Kha* is galangal, and this is its soup.

```
Serves 4 · 25 min
2 cups stock + 3 cups coconut milk + ½ cup coconut cream
3 stalks lemongrass, bruised
1 large thumb galangal, sliced generously (the lead flavor)
6 kaffir lime leaves, torn
8 oz mushrooms (or protein of choice)
3 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
1 Tbsp palm sugar syrup (Ch. 6)
3–4 designed bird's-eye chilies, bruised
3 Tbsp lime juice (off the heat)
cilantro, to finish
```

1. Warm the stock with the lemongrass, galangal, and kaffir and infuse 10 minutes — note the heavier hand of galangal; it leads here.
2. Add the coconut milk and bring to a bare simmer — do not boil hard, or the coconut can split. Add the mushrooms and cook through.
3. Season with nam pla and a little palm sugar (tom kha carries a touch of sweet where tom yum carries none), add the bruised chilies, then finish off the heat with the coconut cream and the lime. Taste: round, gently hot, the galangal singing through the fat.
4. Finish with cilantro and serve.

Why it works — This is the coconut chapter's A/B test. The same aromatics and the same chilies as tom yum, delivered through coconut fat instead of water, land softer on every axis: the capsaicin partitions into the fat and releases slow (IFI-H reads gentler and longer), the lipid lays a tall IFI-K body the clear soup cannot have, and the fat tempers the lime's sour and carries the galangal's aromatics evenly through every spoon. Nothing about the ingredients says "milder"; the *delivery* does. Two soups, one chord, governed by fat or not.



Chapter 15 · The Dipping Sauces & Nam Prik — *the balance, concentrated.*

nam jim jaew · nam prik pao · the condiment as a design object

The dipping sauces and relishes — the *nam jim* and *nam prik* — are where Thai balance is most concentrated and most personal. A nam prik is a meal's center in central and northern Thailand: a pounded chili relish eaten with rice and raw and steamed vegetables, the whole balance held in a single fierce spoonful. To design one is to solve the composition problem at its densest, with no broth or noodle or coconut to dilute a misstep.



A designed pepper at specimen scale — the raw material of a nam prik, where a relish's entire character is set by which chili, dried or fresh, toasted or raw, goes into the mortar.

Nam Jim Jaew — the toasted dipping sauce

Makes about ¾ cup · 10 minutes · the isan sauce for grilled meat and mushrooms

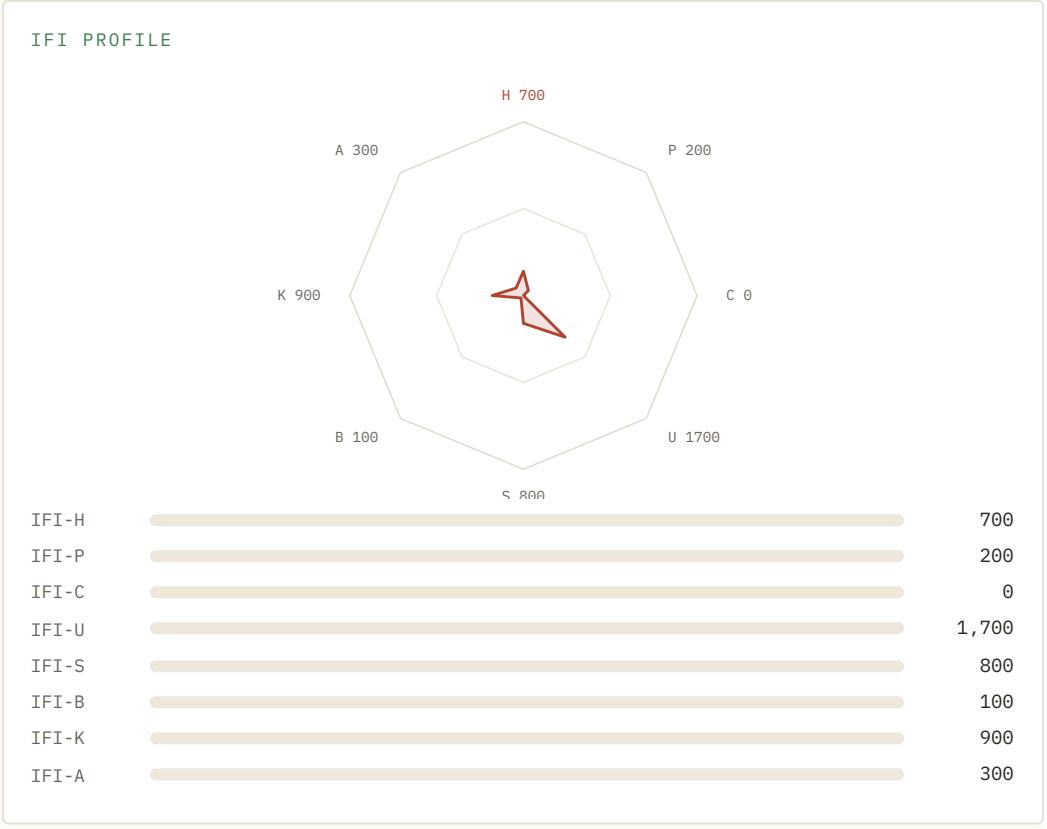
The sauce of the northeast: tamarind and fish sauce and toasted rice powder and dried chili, deep and rust-colored, the one you dip grilled things into. The toasted rice powder (*khao khua*) is the signature — nutty, with a faint texture and a roasted IFI-K depth.

```
Makes ~¾ cup · 10 min
3 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
2 Tbsp tamarind water (Ch. 10)
1 Tbsp palm sugar syrup (Ch. 6)
2 Tbsp lime juice
1 Tbsp toasted dried-chili powder (Ch. 5)
1 Tbsp khao khua (toasted sticky-rice powder)
2 Tbsp shallot, finely sliced
2 Tbsp cilantro and sawtooth herb, chopped
```

1. Make the khao khua: toast raw sticky rice in a dry pan until deep golden and fragrant, then grind to a coarse powder.
2. Stir the nam pla, tamarind, palm sugar, and lime together until the sugar dissolves. Taste the four corners.

3. Stir in the chili powder and khao khua, then the shallot and herbs. Let it sit five minutes for the rice powder to drink in the liquid and thicken it slightly. Serve as a dip.

Why it works — Jaew is a four-corner balance with a roasted spine. The tamarind and lime split the sour between *cookable round* and *raw bright*; the nam pla lays umami and salt; the palm sugar governs; the toasted chili powder brings a deep IFI-H and the khao khua a nutty roasted IFI-K and body that make the sauce cling. It is a condiment built to re-balance whatever it touches — a vector you add to a bite.



Nam Prik Pao — Thai chili jam

Makes about 1½ cups · 40 minutes · the sweet-hot roasted paste under everything

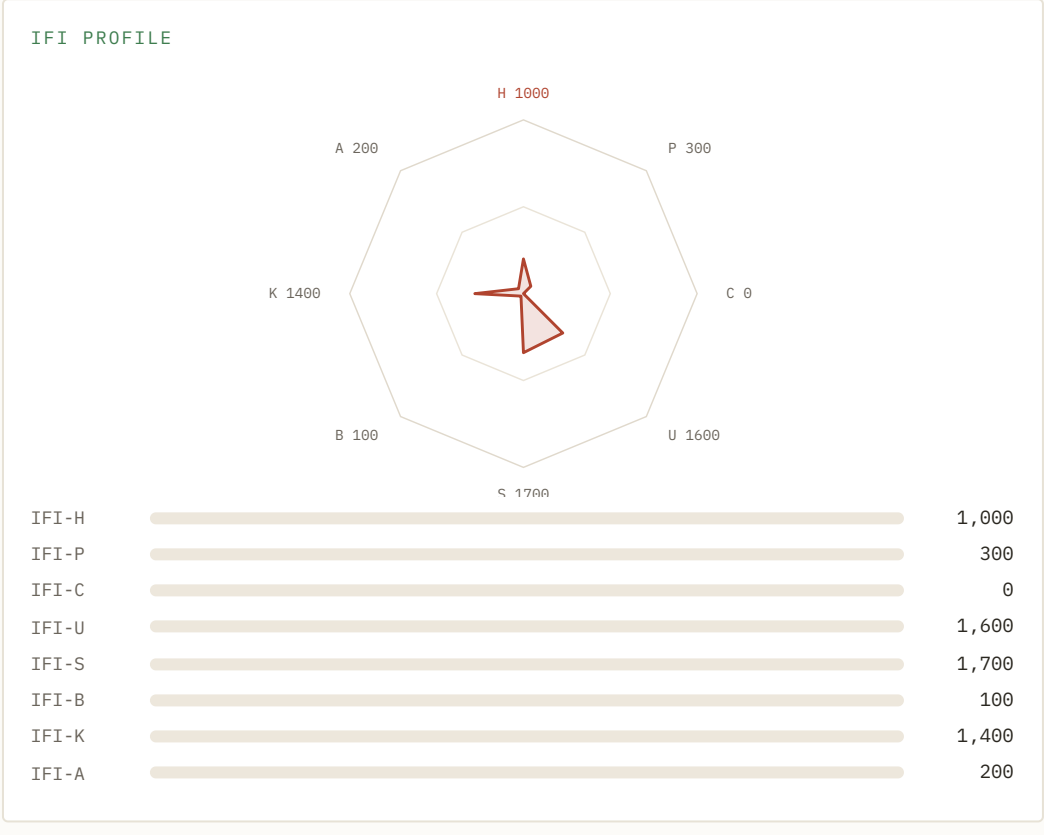
The great workhorse: chilies, shallots, and garlic roasted dark, then pounded with tamarind and palm sugar into a deep, sweet, smoky, umami jam. It goes into tom yum, onto toast, through stir-fries, into dressings. It is the single clearest demonstration in the book of

sweetness *governing* heat — the roasting makes it deep, the palm sugar makes a fierce chili load read as a round, almost addictive warmth.

```
Makes ~1½ cups · 40 min
15 dried designed chilies (IFI-H 400–600), soaked
1 cup shallots, peeled
1 cup designed garlic, peeled
½ cup oil
3 Tbsp tamarind water (Ch. 10)
3 Tbsp palm sugar syrup (Ch. 6)
2 Tbsp fish sauce or vegetarian nam pla (Ch. 7)
1 Tbsp vegetarian kapi (Ch. 7), optional, for depth
```

1. Fry the shallots and garlic separately in the oil over medium heat until deeply golden and sweet, not burnt; lift out. Fry the soaked, dried chilies briefly in the same oil until they darken. Reserve the oil.
2. Pound (or blend) the fried shallots, garlic, and chilies to a paste with the kapi.
3. Return the paste to the pan with the tamarind, palm sugar, nam pla, and enough of the reserved oil to loosen. Simmer, stirring, until it is dark, glossy, and thick — 15 minutes. Taste: it should be sweet-hot and smoky-deep, the fire governed by the sugar. Bottle under a film of oil; it keeps for weeks.

Why it works — This is Chapter 6's lever at full extension. The fierce dried-chili IFI-H would be punishing raw; roasted dark and then governed by a tall IFI-S of palm sugar, it becomes a deep round warmth — the sugar weighting down the central TRPV1 signal so the same capsaicin reads kind. The long frying builds Maillard depth and a roasted IFI-K; the tamarind's round sour keeps the sweet from cloying; the nam pla and kapi lay the umami floor. A chili jam is the composition problem solved and bottled.





PART IV OF V

Sweet, and the Glass

mango sticky rice · the coconut sweets · the cooling drinks of the heat

Chapter 16 · The Sweets — *coconut, sugar, and the one underripe note.*

IFI-S · IFI-K · the 2-acetyl-1-pyrroline connection · sweetness with structure

Thai sweets are built from the same pantry as the savory food — coconut, palm sugar, rice — which is why they taste of the same place. They are rarely only sweet; the best of them carry a counterweight, a salt edge or an underripe grip or a floral bitterness, that keeps the sugar honest. Even here, at the sweet corner, the lesson is balance.



Mango in cross-section, ripe and gold — the fruit at the center of Thailand's most famous sweet, its sugar and faint acid set against salted coconut and sticky rice.

There is a lovely piece of chemistry hiding in a Thai dessert. The aroma that makes good jasmine rice smell like jasmine is a single molecule — **2-acetyl-1-pyrroline** — and it is the *same* molecule that gives **pandan**, the green leaf Thai cooks steep into their sweets, its signature scent. Jasmine rice and pandan smell related because they are: one aroma compound, two plants. When you make mango sticky rice, the rice's own 2-acetyl-1-pyrroline and the pandan you might steep into the coconut sauce are singing the same note. It is the kind of thing the Index makes visible — that two ingredients "go together" because they share a molecule — and the kind of thing a designed pantry can tune, growing a rice or a pandan to carry that note exactly.

Mango Sticky Rice — *khao niao mamuang*

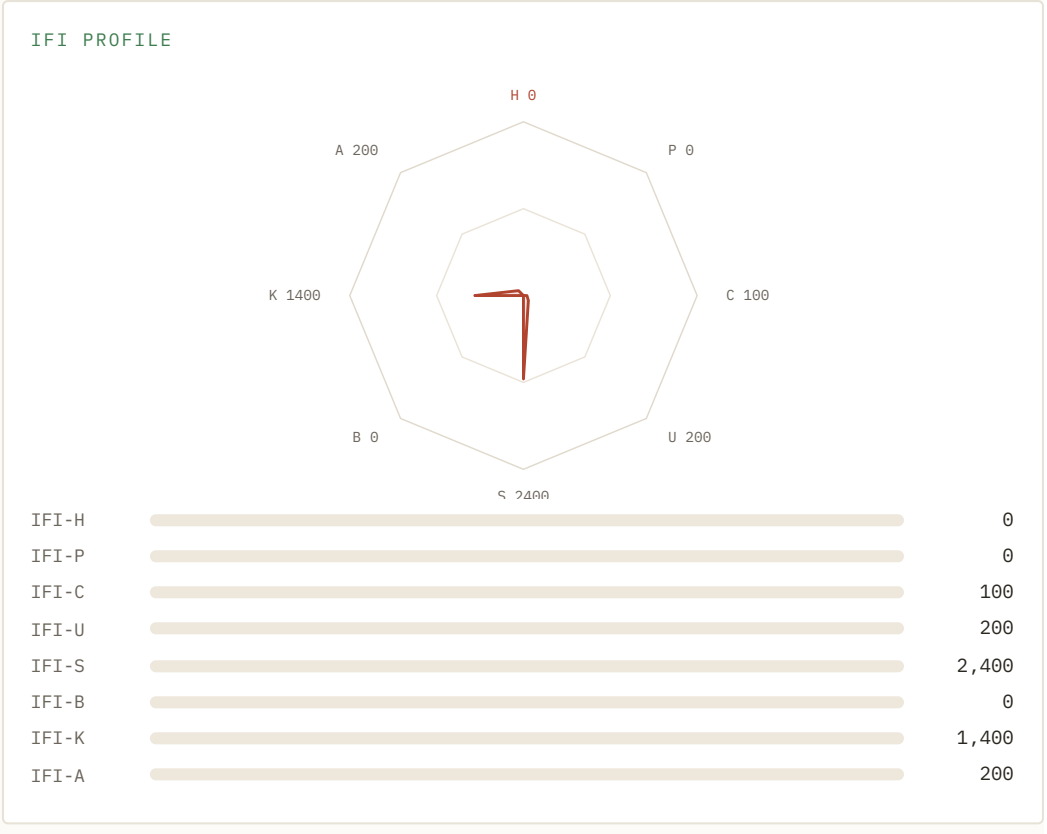
Serves 4 · 45 minutes (plus soaking) · the salted-sweet masterpiece

The dish that proves Thai sweets are about balance, not sugar. Ripe mango, warm coconut sticky rice, and — the secret — a *salted* coconut sauce poured over, so the whole thing lands sweet-salt-rich rather than merely sweet.

Serves 4 · 45 min + soak
1 cup glutinous (sticky) rice, soaked 4 hours
1 cup coconut milk
⅓ cup palm sugar syrup (Ch. 6)
½ tsp salt
2 ripe mangoes, sliced
salted sauce: ½ cup coconut cream + ¼ tsp salt + 1 tsp rice flour
toasted mung beans or sesame, to finish

1. Steam the soaked sticky rice over (not in) water until tender and translucent, 20 to 25 minutes.
2. Warm the coconut milk with the palm sugar syrup and salt until just dissolved — do not boil. Fold the hot rice into it and let it sit, covered, 20 minutes to drink it all in. The rice should be glossy and sweet with a clear salt edge.
3. Make the salted sauce: warm the coconut cream with the salt and rice flour until lightly thickened.
4. Plate the sweet rice with the sliced mango and spoon the salted sauce over the top. Finish with toasted mung beans or sesame for crunch.

Why it works — The genius is the salt. The sweet rice lays a tall IFI-S; the salted coconut sauce poured over brings sodium (ENaC) and coconut's IFI-K body — and the salt, as we saw in the mathematics, *lifts* perceived sweetness while the fat lengthens it, so the dish reads richer and more deeply sweet than sugar alone could make it. The ripe mango brings its own sugar and a faint acid lift; choose one a shade underripe and its trace astringency gives the whole plate a structure that keeps it from cloying. Sweetness with a counterweight, which is the only kind Thai cooking trusts.



Sangkhaya — pandan coconut custard

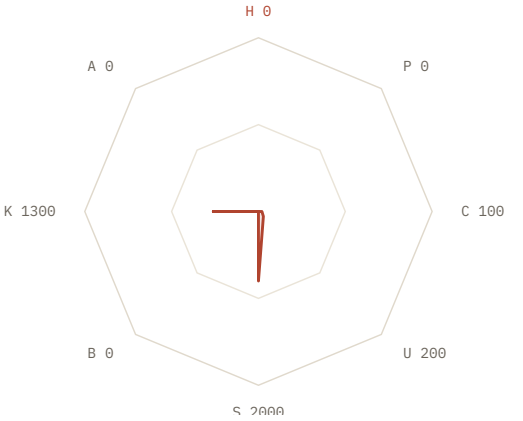
Serves 6 · 40 minutes · the steamed custard scented with the jasmine-rice molecule

Serves 6 · 40 min
4 eggs
¾ cup palm sugar syrup (Ch. 6)
1 cup coconut cream
pinch salt
6 pandan leaves, bruised and steeped (or pandan extract)

1. Steep the bruised pandan leaves in the warm coconut cream for 20 minutes, then strain — this is where the 2-acetyl-1-pyrroline goes in.
2. Whisk the eggs, palm sugar syrup, and salt until smooth, then stir in the pandan coconut cream. Strain again for silk.
3. Steam gently in cups or a shallow dish until just set — 25 to 30 minutes over low steam. Serve warm or cool, with sticky rice or alone.

Why it works — A custard is a texture before it is a flavor, and coconut cream makes it rich without dairy. The pandan carries the same aroma molecule as jasmine rice, so a bowl of sangkhaya and a plate of rice are quietly harmonized; the salt lifts the sweet; the palm sugar brings the caramel-rounded body. Gentle, floral, and balanced even in its sweetness.

IFI PROFILE



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

Chapter 17 · The Glass — *the cooling drinks of a hot country.*

IFI-C · IFI-A · the tannin of Thai tea · the botanical cooler

A cuisine this hot — in both senses — lives or dies by what is in the glass. Thai drinks are built to cool: sweet and icy against the heat of the climate, bright and astringent against the heat of the food. The famous orange *cha yen*, the lime sodas, the steeped-herb coolers — each is a small composition, and each leans on an axis the food mostly saves for last.



Tea, the tannic backbone of Thailand's iced drinks. Its astringency, IFI-A, is the structure a sweet cold drink needs to keep from being merely sugar and ice.

Cha Yen — Thai iced tea, rebuilt

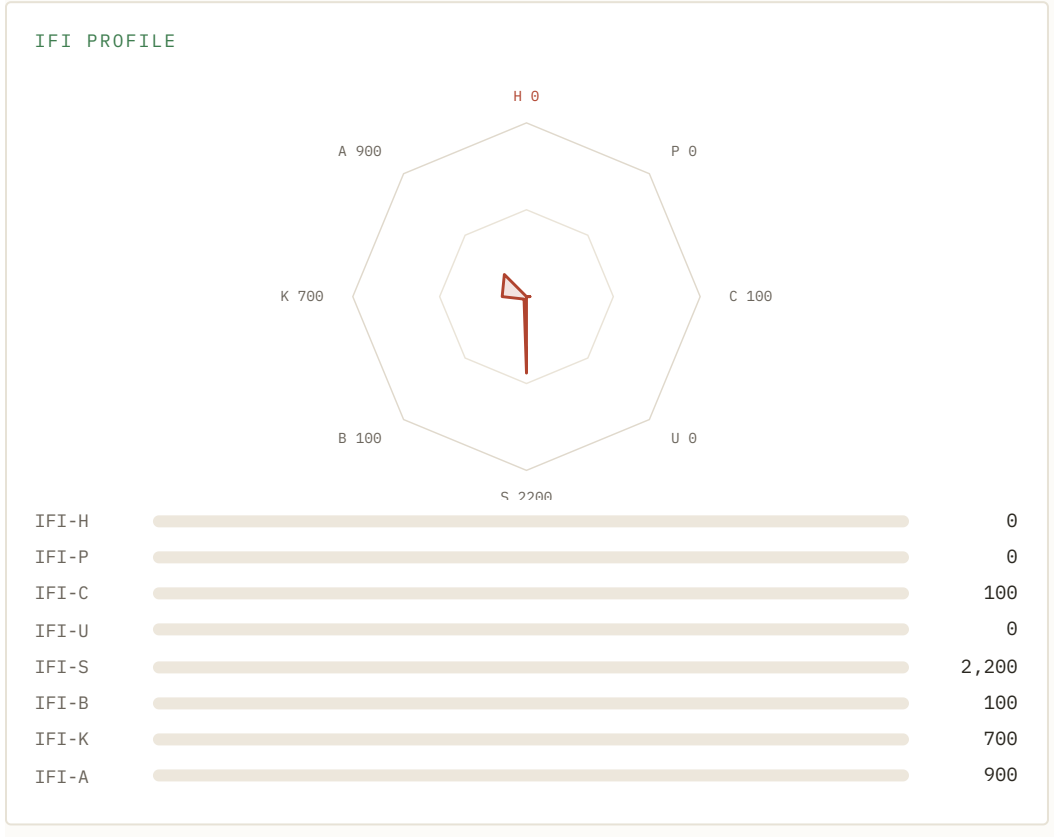
Serves 4 · 15 minutes (plus chilling) · sweet, astringent, orange, and cold

Thai iced tea is strong black tea, heavily sweetened, cut with coconut or condensed milk, over a mountain of ice. What makes it *work* rather than cloy is the tea's tannin — its astringency is the structure the sugar leans on. We build it on a tea grown to carry its IFI-A clean and a palm-sugar sweetness tuned for loudness over load.

```
Serves 4 · 15 min + chill
4 cups water
6 Tbsp strong black tea (designed tea, IFI-A clean)
⅓ cup palm sugar syrup (Ch. 6), to taste
½ cup coconut cream (or evaporated/condensed milk)
pinch salt
ice
```

1. Steep the tea in just-boiled water for 5 minutes — longer than you would for drinking hot, because the astringency *is* the point here. Strain.
2. Stir in the palm sugar syrup and a pinch of salt while warm; cool completely.
3. Pour over tall glasses of ice and float the coconut cream on top, to be stirred in.

Why it works — This is IFI-A doing structural work. Steeped strong, the tea's tannins bind the saliva's proline-rich proteins and bring a grip that keeps the heavy sweetness from sliding into cloying — astringency is the frame a sweet cold drink hangs on. The salt lifts the perceived sweet (so you can use less sugar for the same loudness); the coconut cream's fat rounds the tannin's edge and lays an IFI-K body. Sweet, astringent, and cold, each axis checking the next.



Lemongrass-Pandan Cooler

Serves 4 · 20 minutes (plus chilling) · the steeped-herb cold drink, no caffeine

The non-tea cooler: lemongrass and pandan simmered into a fragrant base, sweetened lightly, served cold. It is the cool channel in a glass — citral and the jasmine-rice molecule, lifting and refreshing against the food's fire.

```
Serves 4 · 20 min + chill
6 cups water
4 stalks lemongrass, bruised and sliced
4 pandan leaves, knotted
3 Tbsp palm sugar syrup (Ch. 6), to taste
2 Tbsp lime juice
ice, and lime wheels to serve
```

1. Simmer the lemongrass and pandan in the water for 15 minutes — the citral and the aroma molecules infuse into the water.
2. Strain, sweeten lightly with palm sugar syrup, and cool. Add the lime off the heat for brightness.
3. Serve over ice with a lime wheel. It should read cool, bright, barely sweet — a palate-reset in a glass.

Why it works — Where the food drives TRPV1 and the sweets drive TAS1R2·TAS1R3, this drives the cool channel: lemongrass's citral is a bright, cooling aromatic that reads as *refreshment*, and the pandan brings its floral jasmine-rice note alongside. The lime (ghost sour) sharpens it; the sweetness is kept deliberately low so the drink cleans the palate rather than coating it. It is the cool-burn chapter's thesis, poured cold.

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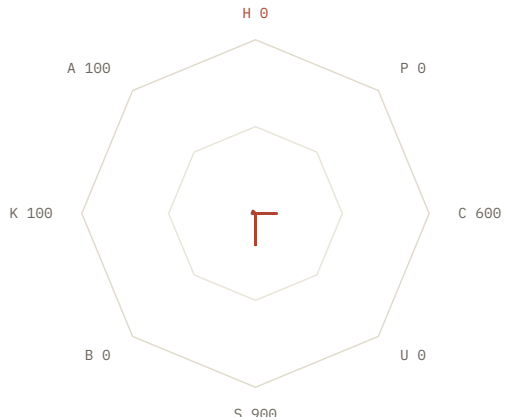

IFI-H	0
IFI-P	0
IFI-C	600
IFI-U	0
IFI-S	900
IFI-B	0
IFI-K	100
IFI-A	100



PART V OF V

Composition

designing a dish from the Index · the vector, reverse-engineered · the table we set

Chapter 18 · Designing a Dish from the Index — *the vector, reverse-engineered.*

the target vector · the pantry as a basis · the coupled solve · a worked example

We have read Thai cooking forward — ingredient to axis to dish. Now read it backward, because that is where an engineered cuisine earns its keep: start from the balance you *want*, written as a vector, and reverse-engineer the plate. This is the method behind every scored recipe in the book, and once you have it, you can compose a Thai dish that has never existed and know, before you cook, roughly where it will land.



Phoenix in the controlled chamber — the flagship that proved a plant could be tuned to a target vector across all eight axes at once. The same discipline, turned down to the gentle bands of a dinner, is how a dish gets designed.

The workflow has four steps, and they are the same whether a model runs them or a cook does.

One: write the target. Decide the dish's character as an eight-axis vector. Say you want a new stir-fry — bright, hot, deeply savory, lightly sweet, and lifted cool, the holy-basil register but greener. You might write: H 1,000, P 700, C 500, U 1,700, S 500, B 0, K 800, A 0. That is a wish turned into coordinates.

Two: lay out the pantry as a basis. Each ingredient is itself a vector — a row in a table of what it contributes per unit on each axis. The designed bird's-eye is almost pure H. The krung gaeng base (Ch. 8) is P and C. The nam pla (Ch. 7) is a tall U with a K shoulder. The palm sugar syrup (Ch. 6) is pure S. Thai basil is C. Garlic is P with a K shoulder. These are your basis vectors; a dish is a combination of them.

Three: solve the coupled system. Not the naïve sum — the *coupled* one from Chapter 4. Because sweet suppresses perceived heat, you add a little more chili than the raw H target implies, knowing the palm sugar will weight it down. Because fat sets the heat clock, you decide whether this dish is governed by coconut (long, kind heat) or clear (fast, sharp heat) and adjust the chili's loudness accordingly. Because the umami floor lets everything else run louder, you set the nam pla first and build the bright corners on top of it. A cook does this by tasting and nudging; the platform does it by constrained optimization against the coupling coefficients; the logic is identical.

Four: check the plant can hold it. The vector is only real if the ingredients keep their values — which is the whole reason the pantry is engineered. A bird's-eye at IFI-H 600 ± 7% means the dish you designed is the dish you get, this week and next. Without that, step one through three are arithmetic over sand.

Here is the worked example, assembled:

INGREDIENT	WHY (AXIS TARGET)	AMOUNT
Designed bird's-eye, IFI-H 600	the H, set a touch high for the sugar to govern	8 chilies
Krung gaeng base (Ch. 8)	the P and C, bright and sharp	2 Tbsp
Vegetarian nam pla (Ch. 7)	the U floor, set first	2 Tbsp
Palm sugar syrup (Ch. 6)	the S, governing the heat	1 Tbsp
Thai basil, last second	the C top note, saved from the wok	2 handfuls
Designed garlic	the P flash and a K shoulder	4 cloves

Cook it like the pad kra pao of Chapter 13 — garlic and base bloomed in hot oil, protein or mushroom seared, sauces to glaze, basil off the heat — and taste it against your target. It will land close, because you built it from the basis; the last adjustments, by spoon and by tongue, are you solving the final coupling by hand. That is the method. The Index does not cook the dish. It tells you where you are aiming and lets you check, honestly, whether you arrived.

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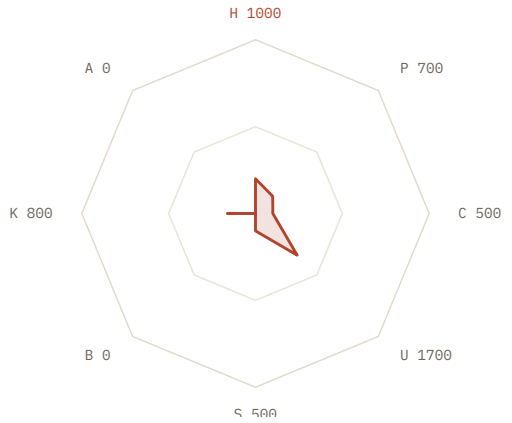

IFI-H	1,000
IFI-P	700
IFI-C	500
IFI-U	1,700
IFI-S	500
IFI-B	0
IFI-K	800
IFI-A	0

This is the quiet revolution under all the lushness. A cuisine famous for a balance that could only be learned by years at a hot stove, taught hand to hand and tongue to tongue, can now also be *written* — not to replace the teaching, but to carry it, so that a dish composed in one kitchen can be rebuilt faithfully in another, and so that the person who never had a grandmother at that stove can still set down a plate that is genuinely, measurably balanced. The numbers are not the opposite of the tradition. They are a way to keep it.

A closing grace · the table we set

the nourishment line · vegetarian-first · the plant, and the people fed

We began at a table, and we end at one. The whole of this book has been an argument that the famous Thai balance is a real, measurable, buildable thing — eight axes, a target vector, a pantry of plants grown to speak each note cleanly. But the reason we built any of it is older and simpler than the Index, and it is the reason we cook at all: to set down food, in front of people we love, that is exactly what we meant it to be, and that is good for the bodies it goes into.



The greenhouse at dusk, the day's work done. Every number in this book began as a plant, and every plant was grown toward the fullest flavor — and the fullest nourishment — it could carry.

Thai cooking is, at its heart, a plant cuisine — a mortar full of herbs and roots and chilies, a wok of vegetables, rice at the center of the table — and we have written it plant-first by instinct and by conviction. The fish sauce and the shrimp paste are honored here as what they are, two of the great ferments of the world, and we have given them their full due; we have also given the plant-first cook a nam pla and a kapi built to cast the same shadows on the Index, so that no one has to choose between the balance and the table they keep. That is not an apology for either way of eating. It is a table wide enough for both.

And under every axis in this book runs a quieter one the Index does not score and we will not oversell: that a plant grown with intention can carry more than flavor. We built this platform first to measure taste, because taste is what you notice; but the same precision that lets us tune a chili to IFI-H 600 lets us grow a plant toward the fullest nourishment it can hold, and we think of those as one act, not two. We make no claim about what any dish will do for any body — that is yours, and your own to tend. We only say what we grow for: flavor you can read, balance you can build, and food grown to give the body the most it can. These are computational designs; Scoville Splice's cultivars and constructs have not been experimentally validated in a laboratory. Season generously. Pound the aromatics fresh. Set the lime on the table. And when the four corners pull even

and the plate stops asking for anything, you will have done, by hand or by number, the oldest and best thing a kitchen does — made something true, and fed someone with it.