



The Science of Accurate Calorie Tracking

A Technical Whitepaper — March 2026

THE BOTTOM LINE

UK nutrition labels may legally vary by $\pm 20\%$ from declared values. That is a regulatory ceiling, not a description of reality. Eatamate users scan barcodes and, where needed, weigh ingredients on a kitchen scale, eliminating two of the three traditional sources of caloric error entirely. The only remaining source of error is the natural variation in caloric density per gram of food — the subject of this paper.

Eatamate achieves greater than 93% weekly caloric accuracy at 2σ across all household sizes and diet profiles in Scenarios A and B. This is a conservative floor: single-user households reach 95.28% (Scenario B balanced). The figure is delivered retrospectively — on last week's data, when users actually review their progress — not at the moment of logging.

Section 10 extends this framework to micronutrients. The same gram-level ingredient precision that delivers $\geq 93\%$ caloric accuracy enables weekly micronutrient screening with propagated 95% confidence intervals — classifying each of 24 tracked nutrients as confirmed above RDA, intake unclear, or confirmed below RDA (all at 95% CI). No other commercially available nutrition tracker does this.

The mechanism: three calibration weighings per meal type, then zero weighing thereafter. Sub-2-second logging. Physics-based reconciliation that guarantees mass conservation across the week. Greater than 93% accuracy delivered automatically, before the user opens the app on Monday morning.

0.1 A Primer on Uncertainty: CV, σ , 2σ , and the Gaussian Distribution

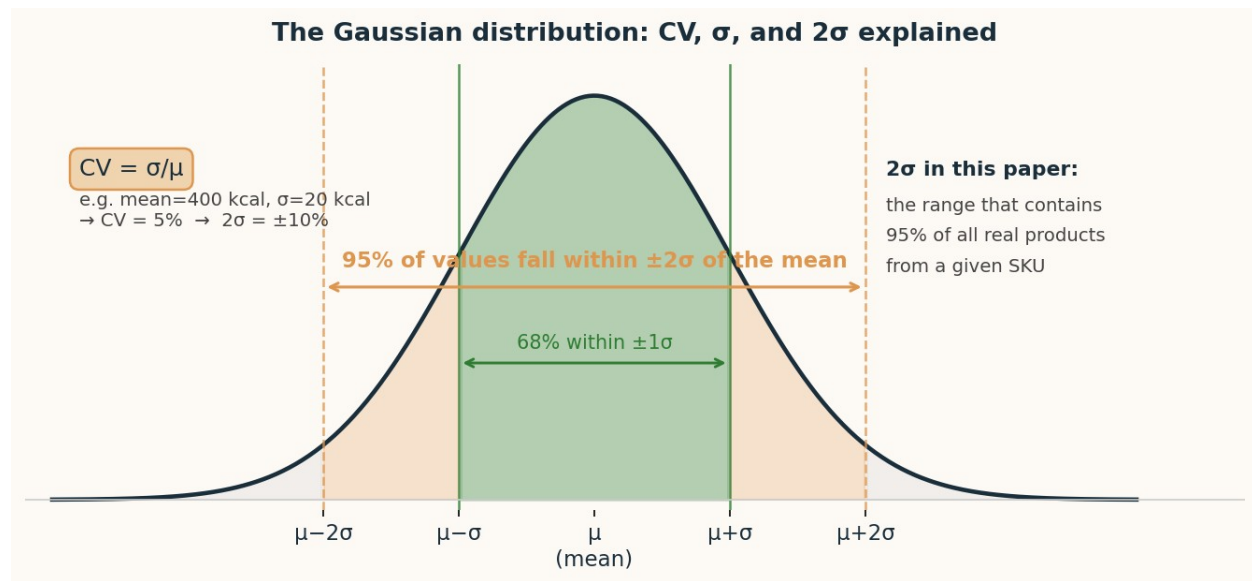
Every food item contains a slightly different amount of energy per gram — even within the same product. A bag of white rice from the same brand will have slightly more or less starch depending on the harvest, drying conditions, and storage. This natural variation is the fundamental source of caloric uncertainty that this paper quantifies. To do that rigorously, we need three statistical concepts: the Gaussian distribution, standard deviation (σ), and coefficient of variation (CV).

A Gaussian (or normal) distribution is the bell-shaped curve that describes how most measured quantities vary around a central value. If you weighed the caloric content of 1,000 packets of the same chicken breast SKU, most would cluster near the declared value, with progressively fewer packets deviating further away in either direction. That bell-shaped cluster is the Gaussian distribution.

The mean (μ) is the centre of the bell — the average caloric value. The standard deviation (σ) measures the width of the bell: a small σ means values cluster tightly around the mean; a large

σ means they spread widely. The key property of the Gaussian is that exactly 68% of all values fall within $\pm 1\sigma$ of the mean, and 95% fall within $\pm 2\sigma$. When this paper quotes a 2σ figure for a food, it means: 95 out of 100 real-world packets of that product will have a caloric content within that range of the declared label value.

The coefficient of variation (CV) expresses σ as a percentage of the mean: $CV = \sigma/\mu$. This makes uncertainty comparable across foods with very different caloric densities. A CV of 10% means $\sigma = 10\%$ of the mean, so $\pm 2\sigma = \pm 20\%$. All percentage uncertainty figures in this paper are 2σ CVs — the range containing 95% of real products.



Example: white rice has a mean of 360 kcal/100g and a barcoded 2σ of $\pm 10\%$. That means 95% of bags of the same rice SKU contain between 324 and 396 kcal/100g. The other 5% fall outside this range — but the $\pm 10\%$ figure captures the vast majority of real-world variation.

0.2 A Primer on Quadrature Summation: Why Independent Errors Grow as \sqrt{n}

When a weekly diet contains many different foods, each with its own caloric uncertainty, the question is: how do those individual errors combine into a total weekly error? The answer depends critically on whether the errors are independent of each other.

If all errors moved in the same direction — every food simultaneously running higher than its label — the weekly error would be the simple linear sum of all individual errors. This is the worst possible case, and it almost never happens in reality.

In reality, different foods vary independently. A bag of rice that happens to be slightly denser than average has no influence on whether a chicken breast is fatter or leaner than average. These are biologically and physically unrelated products. When errors are independent, something important happens: on average, the high errors and low errors partially cancel each other out.

The mathematical rule that captures this is quadrature summation (also called root-sum-of-squares). If n independent error sources each have magnitude σ , the combined error is not $n \times \sigma$ but $\sqrt{n} \times \sigma$. For 7 independent food groups each with 2σ error of 100 kcal, the linear sum would be 700 kcal — but the quadrature sum is only $\sqrt{7} \times 100 \approx 265$ kcal. The cancellation effect is substantial.

Quadrature summation: why independent errors grow as \sqrt{n} , not n



The intuition: imagine 7 friends each independently flipping a coin and moving one step forward (heads) or backward (tails). After all 7 flips, the group doesn't end up 7 steps from the start — it ends up roughly $\sqrt{7} \approx 2.6$ steps away on average, because the forward and backward steps partially cancel. Caloric errors across independent food groups work exactly the same way.

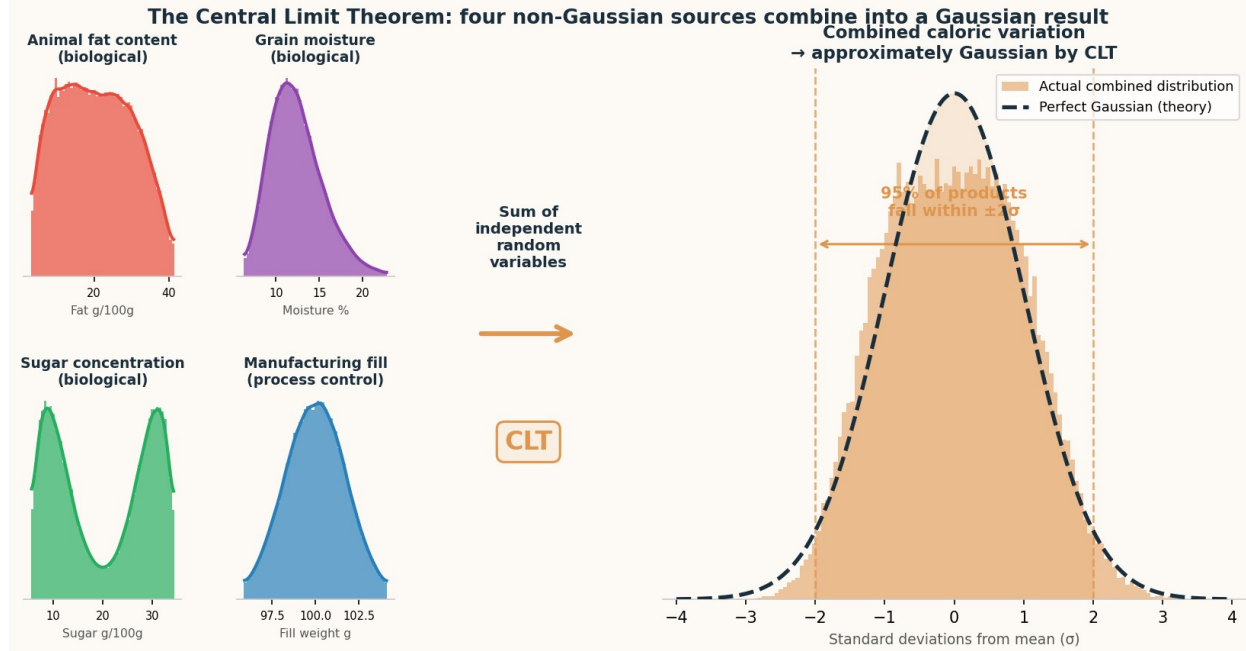
This paper uses quadrature across independent food groups (meat vs dairy vs grains, for example), and linear addition within the same food item consumed all week from the same batch — because a single batch of rice that runs high will run high every day, so those errors do not cancel.

0.3 Why Caloric Variation Is Gaussian: The Central Limit Theorem

The Gaussian distribution is used throughout this paper to describe caloric uncertainty in foods. But there is a question worth addressing directly: why should caloric variation be Gaussian at all? The individual sources of variation — fat deposition in an animal, moisture content in a grain, sugar concentration in a fruit — each follow their own irregular, non-Gaussian distributions. So why does the end result behave as a bell curve?

The answer is one of the most powerful results in statistics: the Central Limit Theorem (CLT). It states that when several independent random variables are added together, their sum will be approximately normally distributed — regardless of the shape of the individual distributions — provided there are enough sources and none dominates completely. In practice, as few as three or four independent sources is often sufficient for the approximation to be excellent.

For a food item, the caloric content per 100g is not a single measurement. It is effectively a weighted sum of contributions: fat content (9 kcal/g), protein content (4 kcal/g), carbohydrate content (4 kcal/g), and moisture (0 kcal/g, but it displaces the others). Each of these components varies independently and with its own distribution shape — yet their combined contribution to calories converges toward a Gaussian by the CLT. This is the mathematical foundation for using $\pm 2\sigma$ and CV figures throughout this paper.



The diagram above illustrates this concretely. Animal fat content follows a skewed, bimodal distribution shaped by breed and feed. Grain moisture follows a log-normal distribution driven by drying conditions. Sugar concentration in fresh produce shows a broad spread reflecting ripeness variation. Manufacturing fill weight follows a tightly truncated distribution controlled by machinery tolerances. None of these is Gaussian. Yet when their standardised contributions are summed — as they are in the caloric total per 100g — the result is strikingly bell-shaped, closely matching the theoretical Gaussian curve.

Biological sources of variation arise before the product reaches the factory. For meat and fish, the primary drivers are breed and genetics, feed composition, age and weight at slaughter, season, and in fatty fish the timing within the annual fat cycle. A farmed salmon in autumn carries substantially more fat than the same fish in spring. For plants, the drivers are soil composition, sunlight hours, rainfall, temperature during ripening, and harvest timing. A banana picked at peak ripeness contains more sugar than one harvested early for transport. These sources operate over days, seasons, and years. They are independent of each other and of anything that happens during processing, and they produce the raw biological variance that is the starting point for the ‘old 2σ ’ figures in Section 5.3.

Manufacturing and supply chain variation arises during processing and acts as a filter on the biological variation that entered the factory. Mechanical fat trimming removes a controlled proportion of surface fat from meat, reducing variance from the raw animal. Moisture standardisation during grain drying or cereal extrusion constrains moisture content within specification limits. Emulsification and homogenisation in products like peanut butter and sauces blend ingredients to uniformity, collapsing batch-to-batch variation. Industrial blending across multiple ingredient batches further averages out biological differences. Each manufacturing step introduces its own process variation — from tolerances in machinery, temperature fluctuations, and batch blending ratios — but simultaneously reduces the biological variation inherited from raw ingredients. This is why a branded crisp has a within-SKU 2σ of $\pm 3\%$ despite the potato it originated from having far wider biological variance.

A third layer — label compliance — constrains the combined output of both biological and manufacturing variation to a legally bounded range ($\pm 20\%$ under UK Regulation 1169/2011). For products where the combined biological and manufacturing CV would exceed this bound,

the manufacturer must tighten their process controls or reformulate, or risk a non-compliant label. The legal ceiling is therefore a binding constraint on real-world variance for all products on UK supermarket shelves, as discussed in Section 2.

The result of all three layers is that the caloric content of a compliant barcoded supermarket product — the sum of many independent biological and manufacturing random variables, filtered by process control and legal compliance — is well described by a Gaussian distribution. The $\pm 2\sigma$ figures used throughout this paper are therefore both statistically principled and practically grounded.

1. Three Sources of Error — Eatomate Eliminates Two

Every calorie tracker faces three independent sources of error. Their magnitudes differ by an order of magnitude, and knowing which ones dominate is the key to building an accurate system.

Error source	Typical magnitude	Traditional apps	Eatomate
Portion weight uncertainty	$\pm 20\text{--}30\%$ CV	Estimated by eye or cup measure	<p>✓ Eliminated 95% of inputs: barcoded items use exact net weight from label; volumes are converted using well-characterised densities (oils, milk, juices: $<1\%$ error). Solid barcoded items are always weighed.</p> <p>5% of inputs: loose produce and non-barcoded items — kitchen scale at setup, physics-based reconciliation thereafter.</p>
Product identity uncertainty	$\pm 15\text{--}25\%$ CV	User searches text database manually	<p>✓ Eliminated — barcode scan locks the SKU</p>
Caloric density per gram	$\pm 2\text{--}25\%$ CV (this paper)	Assumed = label value, no uncertainty shown	<p>⚠ Residual — irreducible biological fact, quantified and shown</p>

A note on product identity: the $\pm 50\%$ figure sometimes cited for ‘generic salmon’ is a product identity error — the spread between wild and farmed types when the wrong entry is selected. Barcode scanning eliminates this. It is not a caloric density error and does not appear in the per-food tables in this paper.

2. The Label as Anchor: What Barcode Scanning Guarantees

When a user scans a barcode, three things are locked simultaneously: the product species or type, the manufacturer’s production specification, and the declared nutritional values on that specific label. The relevant question then becomes: how far does the actual product deviate from its own declared label?

For UK products, this is legally bounded. Under Regulation 1169/2011 (as retained in UK law), a nutrition label is compliant as long as the actual energy value falls within $\pm 20\%$ of the declared

value. This is the hard outer ceiling for any product on a UK supermarket shelf. In practice, within-SKU biological variation is substantially tighter:

Manufactured items (crisps, cereal, protein bars, sauces, sugar): 1–8% 2σ

Dairy and plant staples (milk, rice, lentils, oats): 6–12% 2σ

Lean meat and fish (chicken breast, farmed salmon): 12–14% 2σ

Fatty cuts (beef steak, lamb shoulder): raw biological variance exceeds the cap, so the label compliance requirement is binding at $\pm 18\%$ 2σ

The supermarket supply chain as quality control

ONS retail data puts UK supermarket share of food spend at ~96%. Virtually all meat, fish, dairy, and packaged goods are pre-labelled with barcodes. Major retailers enforce supplier contracts that include fat specification, grading, and trimming standards — because their nutrition labels must be defensible under FSA surveillance. A Sainsbury’s own-label chicken breast has lower within-SKU caloric variance than a random chicken breast from an uncontrolled source precisely because of this supply chain discipline.

3. Loose Produce: USDA Matching Is Equivalent to Barcode Scanning

Fresh fruit and vegetables sold loose are logged by weight against a matched USDA reference entry. This introduces no additional uncertainty relative to barcoded produce: supermarket nutrition labels for fresh produce are derived from the same USDA/CoFID reference databases, not from batch testing of individual crops. The biological variance is identical in both cases.

Quantitatively, fresh produce contributes less than 0.9% to weekly 2σ across all diet profiles. Even doubling produce variance to account for worst-case USDA matching imprecision moves overall weekly accuracy by less than 0.27 percentage points.

4. The Correlation Model: How Errors Stack Within a Week

Not all caloric errors within a week are independent. The same bag of rice consumed across seven dinners carries the same batch-level caloric offset every time. Eatomate models this explicitly using a two-tier correlation structure.

Food group	Correlation model	Rationale
Grains, legumes, dairy, fats, manufactured	Linear within group	Same batch all week — correlated error
Meat, fish & eggs	Quadrature within group	Multiple packs, biologically independent
Fresh produce	Quadrature (all items)	Each piece biologically independent

Across all groups	Always quadrature	Different food categories are independent
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Linear addition is the conservative assumption: the full batch error is persistent across every serving from that batch. The across-group quadrature is the key compression mechanism — an above-average rice batch and a below-average chicken batch partially cancel in the weekly total.

5. Food-by-Food Uncertainty (Barcoded, Weighed, 2σ)

All figures below assume barcode-scanned, kitchen-scale-weighed ingredients from UK supermarkets, or USDA-matched loose produce. In Section 5.3 (Meat & Fish), an ‘old 2σ’ column shows raw biological population variance alongside the ‘barcoded 2σ’ figure — this comparison is shown only where the label compliance correction is material. For manufactured, dairy, and fresh produce categories, only the barcoded 2σ figure is shown.

5.1 Manufactured & Processed — the accuracy anchors

Product	Mean kcal	Barcoded 2σ	Reason
White sugar / 100g	400	±1%	Pure sucrose
Olive / vegetable oil / 100g	884–900	±1%	Pure fat
Crisps (branded) / 100g	530	±3%	Controlled frying process
Protein bar / powder / 100g	380–400	±3%	Manufactured, batch-tested
Breakfast cereal / 100g	375	±4%	Extruded, tight moisture spec
Peanut butter / 100g	600	±4%	Homogenised emulsion
Tomato ketchup / sauces	80–100	±5–8%	Brix-controlled formulation
Fruit juice (100%) / 100ml	45	±5%	Brix-controlled blend
Butter / 100g	740	±5%	Pure fat; standardised milk fat content by regulation

5.2 Dairy, Grains, Legumes & Eggs

Product	Mean kcal	Barcoded 2σ	Primary driver
Skimmed milk / 100ml	35	±6%	Protein (seasonal)
Semi-skimmed milk / 100ml	50	±8%	Fat standardisation
Greek yoghurt / 100g	120	±10%	Fat content by type
Cheddar cheese / 100g	410	±10%	Ageing, milk fat spec
White rice, dry / 100g	360–383	±10%	Moisture content (USDA: 360; UK CoFID: 383 — pantry profiles use CoFID)
Rolled oats / pasta, dry / 100g	355–380	±10%	Moisture content
Lentils / dal, dry / 100g	350	±10%	Moisture content
Chickpeas, dry / 100g	364	±12%	Fat content + moisture

Tinned pulses / 100g	81–90	±5%	Manufactured — tight
Eggs, whole (by weight) / 100g	143	±12%	Yolk-to-white ratio

5.3 Meat & Fish (Barcoded Supermarket Products)

The critical correction from population studies: raw biological variance for meat often exceeds the ±20% legal label tolerance. For a compliant barcoded supermarket product, the effective 2σ is bounded by that legal cap, because a product with 32% caloric variance cannot have a compliant label unless the manufacturer controls inputs to stay within tolerance.

Product	Mean kcal/100g	Old 2σ	Barcoded 2σ	Correction
Tofu firm	76	±12%	±8%	Manufactured product
Chicken breast	108	±18%	±14%	Own-label spec + label compliance
Salmon, farmed (barcoded)	208	±16%	±14%	Farm spec + label compliance
Cod / haddock	80	±15%	±14%	Lean fish, moisture-driven
Beef mince 5–20% fat	133–250	±20–22%	±12%	DEXA fat analysis in production
Beef steak / lamb / pork loin	140–240	±24–32%	±18%	Legal label cap is binding

5.4 Fresh Produce (USDA-Matched)

Product	Mean kcal/100g	2σ	Absolute ±2σ per 200g serving
Broccoli / spinach / carrot	23–41	±20%	±9–16 kcal
Apple / orange	47–52	±17%	±16–18 kcal
Banana	95	±18%	±34 kcal
Avocado	160	±25%	±80 kcal — fat varies with ripeness

6. Master Reference: All Foods at a Glance

Consolidated within-brand 2σ for every food in this paper. All figures assume barcode scanning and kitchen-scale weighing. Traffic light: green ≤14%, amber 15–20%, red >20%.

Food	Mean kcal	Barcoded 2σ	Traffic light
White sugar	400	±4 kcal (1%)	● Low
Olive / vegetable oil	884–900	±9 kcal (1%)	● Low
Crisps (branded)	530	±16 kcal (3%)	● Low
Protein bar / powder	380–400	±12 kcal (3%)	● Low
Peanut butter	600	±24 kcal (4%)	● Low
Breakfast cereal	375	±15 kcal (4%)	● Low

Butter	740	±37 kcal (5%)	● Low
Skimmed milk / 100ml	35	±2 kcal (6%)	● Low
Tofu firm	76	±6 kcal (8%)	● Low
Rice / oats / pasta, dry	355–380	±36–38 kcal (10%)	● Low
Lentils / dal / chickpeas, dry	350–364	±35–44 kcal (10–12%)	● Low
Cheddar / Greek yoghurt	120–410	±12–41 kcal (10%)	● Low
Eggs (by weight)	143	±17 kcal (12%)	● Low
Beef mince (barcoded)	133–250	±16–30 kcal (12%)	● Low
Chicken breast (barcoded)	108	±15 kcal (14%)	● Low–medium
Salmon farmed (barcoded)	208	±29 kcal (14%)	● Low–medium
Banana / apple / orange	47–95	±8–17 kcal (17–18%)	● Medium
Broccoli / spinach / carrot	23–41	±5–8 kcal (20%)	● Medium
Beef steak / lamb / pork	140–240	±25–43 kcal (18%)	● Medium
Avocado	160	±40 kcal (25%)	● High — ripeness varies

7. The Weekly Picture: Greater Than 93% Across All Household Sizes

Per-serving figures tell only part of the story. The question that matters for nutrition tracking is how accurate the weekly calorie total is. Independent errors from different food groups partially cancel via quadrature summation across groups.

The $\geq 93\%$ accuracy figures in this section describe the accuracy of last week’s data as seen this week — after reconciliation has run. This is precisely when users review their progress. The accuracy mechanism is explained in Section 8.

7.1 Three complete 14,000 kcal weekly pantry profiles

To model a realistic full-household week, we constructed three complete pantry profiles at exactly 14,000 kcal/week (2,000 kcal/day). Every ingredient is shown with weekly and daily gram weight, caloric contribution, and within-brand 2σ figure. The correlation model is applied throughout: linear within same-batch groups, quadrature within independent-item groups.

The $\pm 2\sigma$ kcal column shows per-item absolute uncertainty. The weekly total is NOT the sum of this column. The actual weekly 2σ is the quadrature combination of group totals, shown in the accuracy figures below each profile.

7.2 Profile 1: Meat-Heavy (2,000 kcal/day)

Chicken and beef mince daily, rice and pasta as primary carbohydrates, milk, crisps, cereal, butter, cheese.

Ingredient	g/week	g/day	kcal/week	% diet	2σ%	±2σ kcal
GRAINS & STARCHES — linear (same bag all week)						
White rice dry	700g	100g	2682	19.2%	±10%	±268
Pasta dry	266g	38g	945	6.7%	±10%	±95
Bread white sliced	372g	53g	894	6.4%	±14%	±125
Breakfast cereal	213g	30g	798	5.7%	±4%	±32
Potato raw	426g	61g	328	2.3%	±15%	±49
LEGUMES & PULSES — linear						
Baked beans tinned	426g	61g	345	2.5%	±5%	±17
DAIRY — linear						
Semi-skimmed milk	1490g	213g	745	5.3%	±8%	±60
Greek yoghurt	319g	46g	383	2.7%	±10%	±38
Cheddar cheese	128g	18g	524	3.7%	±10%	±52
Butter	74g	11g	551	3.9%	±5%	±28
FATS, OILS & NUTS — linear						
Olive oil	106g	15g	941	6.7%	±1%	±9
MANUFACTURED / PROCESSED — linear (tightest variance)						
Crisps (Walkers)	160g	23g	846	6.0%	±3%	±25
White sugar	74g	11g	298	2.1%	±1%	±3
Fruit juice (orange)	629g	90g	283	2.0%	±5%	±14
Cooking sauce (jar)	213g	30g	170	1.2%	±8%	±14
Tomato ketchup	106g	15g	106	0.8%	±5%	±5
MEAT, FISH & EGGS — quadrature (multiple packs)						
Chicken breast	1064g	152g	1149	8.2%	±14%	±161
Beef mince 5% fat	532g	76g	708	5.1%	±12%	±85
Eggs (by weight)	372g	53g	533	3.8%	±12%	±64
FRESH PRODUCE — quadrature (USDA-matched, equivalent to barcoded)						
Banana	319g	46g	303	2.2%	±18%	±55
Apple	319g	46g	166	1.2%	±17%	±28
Broccoli	319g	46g	109	0.8%	±20%	±22
Onion	266g	38g	106	0.8%	±20%	±21
Carrot	213g	30g	87	0.6%	±20%	±17
WEEKLY TOTAL		2,000/day	14,000	100%		±1287*

* True weekly 2σ (linear within group, quadrature across groups): ±634 kcal (4.53% of 14,000).
Home-only accuracy: 95.47%.

Full 2σ workings — Profile 1: Meat-Heavy. Linear within same-batch groups, quadrature across all groups.

Food group	Correlation model	Group 2σ calculation	Group 2σ result (kcal)
Grains & Starches	Linear (same batch)	$2682 \times 10\% + 945 \times 10\% + 894 \times 14\% + 798 \times 4\% + 328 \times 15\%$	±569
Legumes & Pulses	Linear (same batch)	$345 \times 5\%$	±17
Dairy	Linear (same batch)	$745 \times 8\% + 383 \times 10\% + 524 \times 10\% + 551 \times 5\%$	±178
Fats, Oils & Nuts	Linear (same batch)	$941 \times 1\%$	±9
Manufactured / Processed	Linear (same batch)	$846 \times 3\% + 298 \times 1\% + 283 \times 5\% + 170 \times 8\% + 106 \times 5\%$	±61
Meat, Fish & Eggs	Quadrature (independent)	$\sqrt{((1149 \times 14\%)^2 + (708 \times 12\%)^2 + (533 \times 12\%)^2)}$	±193
Fresh Produce	Quadrature (independent)	$\sqrt{((303 \times 18\%)^2 + (166 \times 17\%)^2 + (109 \times 20\%)^2 + (106 \times 20\%)^2 + (87 \times 20\%)^2)}$	±71
WEEKLY TOTAL (quadrature across groups)		$\sqrt{(569^2 + 17^2 + 178^2 + 9^2 + 61^2 + 193^2 + 71^2)}$	±634 kcal = 4.53% → 95.47% accuracy

7.3 Profile 2: Balanced (2,000 kcal/day)

Chicken and salmon, eggs, rice and oats, lentils, peanut butter, protein bar, olive oil, almonds.

Ingredient	g/week	g/day	kcal/week	% diet	2σ%	±2σ kcal
GRAINS & STARCHES — linear						
White rice dry	488g	70g	1756	12.5%	±10%	±176
Rolled oats dry	305g	44g	1158	8.3%	±10%	±116
Bread wholemeal	366g	52g	794	5.7%	±12%	±95
Breakfast cereal	183g	26g	686	4.9%	±4%	±27
Sweet potato	488g	70g	439	3.1%	±18%	±79
LEGUMES & PULSES — linear						
Lentils dry	244g	35g	854	6.1%	±10%	±85
Chickpeas tinned	488g	70g	439	3.1%	±5%	±22
DAIRY — linear						
Semi-skimmed milk	1280g	183g	640	4.6%	±8%	±51
Greek yoghurt	427g	61g	512	3.7%	±10%	±51
Cheddar cheese	98g	14g	400	2.9%	±10%	±40
FATS, OILS & NUTS — linear						
Olive oil	98g	14g	862	6.2%	±1%	±9

Ingredient	g/week	g/day	kcal/week	% diet	2σ%	±2σ kcal
Almonds	98g	14g	566	4.0%	±10%	±57
MANUFACTURED / PROCESSED — linear						
Peanut butter	122g	17g	732	5.2%	±4%	±29
Protein bar	171g	24g	683	4.9%	±3%	±21
Fruit juice (orange)	540g	77g	243	1.7%	±5%	±12
White sugar	49g	7g	195	1.4%	±1%	±2
Soy sauce	85g	12g	51	0.4%	±5%	±3
MEAT, FISH & EGGS — quadrature						
Salmon farmed	366g	52g	761	5.4%	±14%	±107
Chicken breast	610g	87g	658	4.7%	±14%	±92
Eggs (by weight)	366g	52g	523	3.7%	±12%	±63
FRESH PRODUCE — quadrature (USDA-matched)						
Banana	427g	61g	405	2.9%	±18%	±73
Apple	366g	52g	190	1.4%	±17%	±32
Orange	366g	52g	172	1.2%	±17%	±29
Broccoli	366g	52g	124	0.9%	±20%	±25
Carrot	244g	35g	100	0.7%	±20%	±20
Spinach	244g	35g	56	0.4%	±20%	±11
WEEKLY TOTAL		2,000/ day	14,000	100%		±1327*

* True weekly 2σ: ±562 kcal (4.01% of 14,000). Home-only accuracy: 95.99%.

Full 2σ workings — Profile 2: Balanced. Linear within same-batch groups, quadrature across all groups.

Food group	Correlation model	Group 2σ calculation	Group 2σ result (kcal)
Grains & Starches	Linear (same batch)	$1756 \times 10\% + 1158 \times 10\% + 794 \times 12\% + 686 \times 4\% + 439 \times 18\%$	±493
Legumes & Pulses	Linear (same batch)	$854 \times 10\% + 439 \times 5\%$	±107
Dairy	Linear (same batch)	$640 \times 8\% + 512 \times 10\% + 400 \times 10\%$	±142
Fats, Oils & Nuts	Linear (same batch)	$862 \times 1\% + 566 \times 10\%$	±65
Manufactured / Processed	Linear (same batch)	$732 \times 4\% + 683 \times 3\% + 243 \times 5\% + 195 \times 1\% + 51 \times 5\%$	±66
Meat, Fish & Eggs	Quadrature (independent)	$\sqrt{((761 \times 14\%)^2 + (658 \times 14\%)^2 + (523 \times 12\%)^2)}$	±154
Fresh Produce	Quadrature (independent)	$\sqrt{((405 \times 18\%)^2 + (190 \times 17\%)^2 + (172 \times 17\%)^2 + (124 \times 20\%)^2)}$	±91

Food group	Correlation model	Group 2σ calculation	Group 2σ result (kcal)
		$(100 \times 20\%)^2 + (56 \times 20\%)^2$	
WEEKLY TOTAL (quadrature across groups)		$\sqrt{(493^2 + 107^2 + 142^2 + 65^2 + 66^2 + 154^2 + 91^2)}$	±562 kcal = 4.01% → 95.99% accuracy

7.4 Profile 3: Plant-Heavy (2,000 kcal/day)

Lentils, chickpeas, tofu, eggs, rice and oats, olive oil, almonds, walnuts, peanut butter, protein powder.

Ingredient	g/week	g/day	kcal/week	% diet	2σ%	±2σ kcal
GRAINS & STARCHES — linear						
White rice dry	540g	77g	1945	13.9%	±10%	±195
Rolled oats dry	324g	46g	1232	8.8%	±10%	±123
Bread wholemeal	270g	39g	586	4.2%	±12%	±70
Sweet potato	540g	77g	486	3.5%	±18%	±88
LEGUMES & PULSES — linear						
Lentils dry	378g	54g	1324	9.5%	±10%	±132
Chickpeas dry	270g	39g	983	7.0%	±12%	±118
Black beans tinned	432g	62g	389	2.8%	±5%	±19
DAIRY & ALTERNATIVES — linear						
Greek yoghurt	324g	46g	389	2.8%	±10%	±39
Soy milk fortified	756g	108g	250	1.8%	±4%	±10
FATS, OILS & NUTS — linear						
Olive oil	108g	15g	955	6.8%	±1%	±10
Almonds	130g	19g	752	5.4%	±10%	±75
Peanut butter	108g	15g	648	4.6%	±4%	±26
Walnuts	86g	12g	562	4.0%	±12%	±67
MANUFACTURED / PROCESSED — linear						
Protein powder (vegan)	216g	31g	821	5.9%	±3%	±25
Maple syrup	86g	12g	225	1.6%	±3%	±7
White sugar	54g	8g	216	1.5%	±1%	±2
Fruit juice (orange)	320g	46g	144	1.0%	±5%	±7
Soy sauce	76g	11g	45	0.3%	±5%	±2
MEAT, FISH & EGGS — quadrature						
Eggs (by weight)	270g	39g	386	2.8%	±12%	±46
Tofu firm	432g	62g	329	2.3%	±8%	±26

Ingredient	g/week	g/day	kcal/week	% diet	2σ%	±2σ kcal
FRESH PRODUCE — quadrature (USDA-matched)						
Banana	432g	62g	411	2.9%	±18%	±74
Avocado	216g	31g	346	2.5%	±25%	±87
Apple	324g	46g	169	1.2%	±17%	±29
Broccoli	378g	54g	129	0.9%	±20%	±26
Orange	270g	39g	127	0.9%	±17%	±22
Carrot	216g	31g	89	0.6%	±20%	±18
Spinach	270g	39g	62	0.4%	±20%	±12
WEEKLY TOTAL		2,000/day	14,000	100%		±1355*

* True weekly 2σ: ±594 kcal (4.24% of 14,000). Home-only accuracy: 95.76%.

Full 2σ workings — Profile 3: Plant-Heavy. Linear within same-batch groups, quadrature across all groups.

Food group	Correlation model	Group 2σ calculation	Group 2σ result (kcal)
Grains & Starches	Linear (same batch)	$1945 \times 10\% + 1232 \times 10\% + 586 \times 12\% + 486 \times 18\%$	±476
Legumes & Pulses	Linear (same batch)	$1324 \times 10\% + 983 \times 12\% + 389 \times 5\%$	±270
Dairy & Alternatives	Linear (same batch)	$389 \times 10\% + 250 \times 4\%$	±49
Fats, Oils & Nuts	Linear (same batch)	$955 \times 1\% + 752 \times 10\% + 648 \times 4\% + 562 \times 12\%$	±178
Manufactured / Processed	Linear (same batch)	$821 \times 3\% + 225 \times 3\% + 216 \times 1\% + 144 \times 5\% + 45 \times 5\%$	±43
Meat, Fish & Eggs	Quadrature (independent)	$\sqrt{((386 \times 12\%)^2 + (329 \times 8\%)^2)}$	±53
Fresh Produce	Quadrature (independent)	$\sqrt{((411 \times 18\%)^2 + (346 \times 25\%)^2 + (169 \times 17\%)^2 + (129 \times 20\%)^2 + (127 \times 17\%)^2 + (89 \times 20\%)^2 + (62 \times 20\%)^2)}$	±124
WEEKLY TOTAL (quadrature across groups)		$\sqrt{(476^2 + 270^2 + 49^2 + 178^2 + 43^2 + 53^2 + 124^2)}$	±594 kcal = 4.24% → 95.76% accuracy

7.5 Three meal-source scenarios

Scenario	Home	Ready meals	Restaurant	Total
A — Home-only cook	14,000 kcal (100%)	None	None	14,000
B — Modern	10,100 kcal (72%)	5 × 500 kcal = 2,500	1 independent + 1	14,000

household			chain = 1,400	
C — Restaurant-heavy	6,300 kcal (45%)	7 × 500 kcal = 3,500	2 independent + 2 chain = 2,800	12,600

Ready meals: ±15% 2σ (FSA compliance midpoint)

Independent restaurant (unweighed): ±67.5% 2σ (residual random variance after cuisine-specific correction; see Section 7.5a)

Chain restaurant with calorie labels (McDonald's, Wagamama, Pret): ±15% 2σ

Note on independent restaurant error: Eatomate applies cuisine-specific correction factors at logging to remove the systematic mean offset between cuisine types (e.g. American and Italian meals average materially more calories than Thai or Japanese meals at equivalent stated portions). After this correction the mean error is approximately zero. The ±67.5% 2σ figure represents the residual within-cuisine random variance — driven by portion size variation, chef-to-chef preparation differences, and ingredient substitution — for unweighed meals. This is consistent with the within-cuisine scatter reported by Urban et al. (2016, Journal of the Academy of Nutrition and Dietetics), who found an overall meal SD of ±465 kcal on a mean of 1,205 kcal. Section 7.5a below shows the reduced figure that applies when the meal is weighed to the gram at the restaurant.

7.5a Clarification: Unweighed vs Weighed Restaurant Scenarios

The scenario calculations in Section 7.5 use ±67.5% 2σ for independent restaurant meals, assuming the meal is not weighed. This section derives the correct pooled within-cuisine figures for both the unweighed and weighed cases directly from the Urban et al. (2016) data, confirms the original ±67.5% figure, corrects the weighed estimate to ±62.0%, and re-runs Scenarios A and B. Eatomate collects gram weights when users log takeaway orders from a specific restaurant, identified to exact address via a Maps API. These per-dish gram distributions accumulate across users and apply automatically when the same dish is logged at the same restaurant address — whether the meal is eaten in or taken away. This mechanism means the weighed model is the operative estimate for real-world app performance on dishes with sufficient network coverage.

Step 1 — Urban et al. (2016) source statistics

Urban et al. (PMC5746190) measured 364 meals from 123 non-chain restaurants across 9 cuisine types in 3 US cities using bomb calorimetry. The reported statistics are:

Metric	Value (Urban et al. 2016)	CV at 2σ
Meal energy	mean = 1,205 kcal, SD = ±465 kcal (1σ)	n/a — total spread
Portion weight	mean = 689 g, SD = ±261 g	±75.8%
Energy density	mean = 1.87 kcal/g, SD = ±0.68 kcal/g	±72.7%

Source: Urban et al. (2016), JAND, PMC5746190 — 364 meals from 123 non-chain restaurants across 9 cuisines.

Step 2 — Unweighed within-cuisine variance (verifying ±67.5%)

After Eatomate applies cuisine-specific correction to remove between-cuisine mean offsets, the residual random variance for an unweighed meal is the pooled within-cuisine energy variance.

This is computed directly from the cuisine-level SDs in Table 2 of Urban et al. using the standard pooled within-group estimator:

Derivation step	Result
Total between-cuisine SD (SD of 9 cuisine means, weighted by n)	$\sigma_{\text{between}} = 233 \text{ kcal}$
Pooled within-cuisine $\sigma_{\text{energy_density}} = \sqrt{[\sum(n_j-1)\sigma_j^2 / \sum(n_j-1)]}$ across 9 cuisines	$\sigma_{\text{within}} = 407 \text{ kcal}$
Within-cuisine CV (1σ)	33.8%
Within-cuisine 2σ — UNWEIGHED figure used in scenarios	$\pm 67.5\%$

The $\pm 67.5\%$ figure is verified directly from Table 2 of Urban et al. using the standard pooled within-group variance formula.

Step 3 — Weighed within-cuisine variance ($\pm 62.0\%$)

When a meal is weighed to the gram, portion weight is known exactly and contributes zero error. The residual is only the within-cuisine caloric density variation — the same dish prepared at different restaurants with different ingredient ratios, fat content, and cooking technique. This is computed from the energy density columns of Table 2:

Derivation step	Result
Pooled within-cuisine $\sigma_{\text{energy_density}} = \sqrt{[\sum(n_j-1)\sigma_{\text{ED},j}^2 / \sum(n_j-1)]}$ across 9 cuisines	$\sigma_{\text{ED}} = 0.580 \text{ kcal/g}$
Within-cuisine energy density CV (1σ)	31.0%
Weighed meal at 700 kcal → portion = 374 g (at 1.87 kcal/g mean)	$W = 374 \text{ g}$
Weighed $2\sigma = 374 \text{ g} \times 2 \times 0.580 \text{ kcal/g}$	$\pm 434 \text{ kcal}$
Weighed CV (2σ) — used in weighed scenarios	$\pm 62.0\%$

After weighing, portion uncertainty is eliminated. The residual is within-cuisine caloric density variation — driven by chef-to-chef ingredient choices and preparation.

Step 4 — Comparison: unweighed vs weighed

Assumption	σ (1σ)	2σ CV	\pm kcal on 700 kcal meal
Unweighed — current scenarios (A, B, C)	407 kcal / 33.8%	$\pm 67.5\%$	$\pm 473 \text{ kcal}$
Weighed to gram (network-data equivalent)	0.580 kcal/g / 31.0%	$\pm 62.0\%$	$\pm 434 \text{ kcal}$

Weighing reduces 2σ from $\pm 67.5\%$ to $\pm 62.0\%$ — real but modest, as within-cuisine density variation dominates.

Note: the improvement is real but bounded. Within-cuisine energy density variation is substantial because the same named dish (e.g. chicken pad Thai) can differ markedly in oil, coconut milk, and protein ratio across restaurants — variation that weighing cannot resolve. Only direct caloric analysis of the meal would eliminate it.

Network effects and real-world app performance

The mechanism works as follows. When a user logs a takeaway order, Eatamate records the gram weight of the meal and maps it to the exact restaurant address using a Maps API. This weight measurement is real and precise — it comes from the user weighing the takeaway container, exactly as they would weigh a home ingredient. As multiple users log the same dish from the same restaurant address, a dish- and restaurant-specific gram distribution accumulates in the network. When any subsequent user — whether ordering takeaway or eating in — logs that dish at that address, the learned gram distribution is applied automatically, without requiring them to weigh the meal themselves. This is not inference from consumption patterns: it is a direct empirical record of what that restaurant actually serves for that dish, in grams. The population-wide $\pm 75.8\%$ 2σ portion uncertainty of Urban et al. therefore collapses toward zero for dishes with sufficient network coverage, and the $\pm 62.0\%$ weighed figure — representing only irreducible caloric density variation — becomes the operative accuracy model.

Step 5 — Scenario A (home-only cook) — unchanged

Scenario A is unaffected. All home meals are already quantity-known via the pantry model. The accuracy figures are identical to Section 7.2–7.4.

Profile	Weekly 2σ	% of 14,000 kcal	Accuracy
Meat-heavy	± 634 kcal	4.53%	95.47%
Balanced	± 562 kcal	4.01%	95.99%
Plant-heavy	± 594 kcal	4.24%	95.76%

Scenario A is unaffected — all home meals are already weighed via the pantry model. Figures unchanged from Section 7.2–7.4.

Step 6 — Scenario B (modern household) — weighed

Replacing the unweighed restaurant component ($\pm 67.5\% = \pm 473$ kcal) with the weighed figure ($\pm 62.0\% = \pm 434$ kcal) gives:

Profile	Home 2σ (scaled)	Formula	Weekly 2σ	Accuracy
Meat-heavy	± 457 kcal	$\sqrt{(457^2 + 270^2 + 434^2 + 105^2)}$	± 694 kcal	95.04%
Balanced	± 405 kcal	$\sqrt{(405^2 + 270^2 + 434^2 + 105^2)}$	± 661 kcal	95.28%
Plant-heavy	± 429 kcal	$\sqrt{(429^2 + 270^2 + 434^2 + 105^2)}$	± 675 kcal	95.18%

Scenario B components: home (profile-dependent, scaled to 72.1%), ready meals ± 270 kcal ($3 \times \text{SKU-A} + 2 \times \text{SKU-B}$), weighed independent restaurant ± 434 kcal, chain restaurant ± 105 kcal. All combined in quadrature.

Under the weighed model all three diet profiles comfortably clear 95%, with the floor rising from 94.99% to 95.04% (meat-heavy). The weighed accuracy matrix is shown in Section 7.6.

Full 2σ workings — Scenario B: Modern Household. Conservative model: ready meals split into 2 SKU groups ($3 \times \text{SKU-A} + 2 \times \text{SKU-B}$ at $\pm 15\%$ 2σ); errors perfectly correlated within each SKU group (linear), quadrature across groups. All four error sources (home, ready meals, independent restaurant, chain restaurant) combined in quadrature.

Profile	Error source	2σ component (kcal)	Full √ formula	Weekly 2σ → Accuracy
Meat-Heavy	Home cooking (scaled: 457.4 = Meat±2σ × home/14000)	±457.4		
	Ready meals: 3×SKU-A + 2×SKU-B at ±15% 2σ (linear within SKU, quadrature across)	±270.4	$\sqrt{(225^2 + 150^2)} = \pm 270$	
	Independent restaurant (700 kcal) at ±62.0% 2σ (weighed)	±434		
	Chain restaurant (700 kcal) at ±15% 2σ	±105.0		
	Quadrature across all independent sources:		$\sqrt{(457.4^2 + 270.4^2 + 434^2 + 105.0^2)}$	±694 kcal (4.96%) → 95.04%
Balanced	Home cooking (scaled: 405.4 = Balanced±2σ × home/14000)	±405.4		
	Ready meals: 3×SKU-A + 2×SKU-B at ±15% 2σ (linear within SKU, quadrature across)	±270.4	$\sqrt{(225^2 + 150^2)} = \pm 270$	
	Independent restaurant (700 kcal) at ±62.0% 2σ (weighed)	±434		
	Chain restaurant (700 kcal) at ±15% 2σ	±105.0		
	Quadrature across all independent sources:		$\sqrt{(405.4^2 + 270.4^2 + 434^2 + 105.0^2)}$	±661 kcal (4.72%) → 95.28%
Plant-Heavy	Home cooking (scaled: 428.5 = Plant±2σ × home/14000)	±428.5		
	Ready meals: 3×SKU-A + 2×SKU-B at ±15% 2σ (linear within SKU, quadrature across)	±270.4	$\sqrt{(225^2 + 150^2)} = \pm 270$	
	Independent restaurant (700 kcal) at ±62.0% 2σ (weighed)	±434		

Profile	Error source	2σ component (kcal)	Full √ formula	Weekly 2σ → Accuracy
	Chain restaurant (700 kcal) at ±15% 2σ	±105.0		
	Quadrature across all independent sources:		$\sqrt{(428.5^2 + 270.4^2 + 434^2 + 105.0^2)}$	±675 kcal (4.82%) → 95.18%

Full 2σ workings — Scenario C: Restaurant-Heavy. Same conservative model: 4×SKU-A + 3×SKU-B ready meals. Note: all three diet profiles fall below 95% accuracy in this scenario — see callout below.

Profile	Error source	2σ component (kcal)	Full √ formula	Weekly 2σ → Accuracy
Meat-Heavy	Home cooking (scaled: 285.3 = Meat±2σ × home/14000)	±285.3		
	Ready meals: 4×SKU-A + 3×SKU-B at ±15% 2σ (linear within SKU, quadrature across)	±375.0	$\sqrt{(300^2 + 225^2)} = \pm 375$	
	Independent restaurant (1,400 kcal) at ±67.5% 2σ	±945.0		
	Chain restaurant (1,400 kcal) at ±15% 2σ	±210.0		
	Quadrature across all independent sources:		$\sqrt{(285.3^2 + 375.0^2 + 945.0^2 + 210.0^2)}$	±1076.6 kcal (8.54%) → 91.46%
Balanced	Home cooking (scaled: 252.9 = Balanced±2σ × home/14000)	±252.9		
	Ready meals: 4×SKU-A + 3×SKU-B at ±15% 2σ (linear within SKU, quadrature across)	±375.0	$\sqrt{(300^2 + 225^2)} = \pm 375$	
	Independent restaurant (1,400 kcal) at ±67.5% 2σ	±945.0		
	Chain restaurant (1,400 kcal) at ±15% 2σ	±210.0		
	Quadrature across all independent sources:		$\sqrt{(252.9^2 + 375.0^2 + 945.0^2 + 210.0^2)}$	±1068.5 kcal (8.48%) →

Profile	Error source	2σ component (kcal)	Full √ formula	Weekly 2σ → Accuracy
				91.52%
Plant-Heavy	Home cooking (scaled: 267.3 = Plant±2σ × home/14000)	±267.3		
	Ready meals: 4×SKU-A + 3×SKU-B at ±15% 2σ (linear within SKU, quadrature across)	±375.0	$\sqrt{(300^2 + 225^2)} = \pm 375$	
	Independent restaurant (1,400 kcal) at ±67.5% 2σ	±945.0		
	Chain restaurant (1,400 kcal) at ±15% 2σ	±210.0		
	Quadrature across all independent sources:		$\sqrt{(267.3^2 + 375.0^2 + 945.0^2 + 210.0^2)}$	±1072.0 kcal (8.51%) → 91.49%

7.6 The complete accuracy matrix

Scenario	Meat-heavy	Balanced	Plant-heavy	Floor
A — Home-only cook	95.47%	95.99%	95.76%	95.47%
B — Modern household	95.04%	95.28%	95.18%	95.04%
C — Restaurant-heavy	91.46%	91.52%	91.49%	91.46%

Scenarios A and B deliver greater than 93% accuracy across all household sizes. Eatamate's >93% weekly caloric accuracy claim is a conservative floor across all supported household sizes (1–10 users) in Scenarios A and B. Single-user households reach 95.28% (Scenario B balanced) and 95.99% (Scenario A balanced). Multi-user households stabilise at 93.11% for N=10, with the degradation flattening rapidly above N=2. Scenario C (restaurant-heavy: 55% of calories from ready meals and restaurants) falls materially below this floor, reaching 91.46–91.52%. Eatamate does not make a >93% accuracy claim for users whose majority of calories come from restaurant or ready-meal sources.

These figures describe the accuracy of post-reconciliation data — last week's logs after physics has run. Ready meal model: errors perfectly correlated within each SKU group (conservative), quadrature across groups. The mechanism by which home-cook accuracy is delivered is explained in Section 8.

8. How Accuracy Is Delivered: The Temporal Architecture

The accuracy figures in Section 7 describe a specific moment in time: last week’s data, as seen this week. Understanding why requires understanding the temporal architecture of Eatamate’s accuracy delivery — which is fundamentally different from every other nutrition tracker.

8.1 Every other tracker works forward in time. Eatamate works backward.

In every conventional nutrition tracker, accuracy flows from past to future. You log a meal. You immediately receive an accuracy estimate. That estimate never changes. If your portion was wrong, it is permanently wrong. If the database entry was imprecise, it is permanently imprecise. The number you logged at Monday lunchtime is the same number you look at on Sunday evening.

Eatamate inverts this. You log a meal quickly and approximately. The accuracy of that log improves over time as physical evidence accumulates. By the time you review last week, the reconciliation engine has already run, and the logs have been retrospectively corrected by physics. The number you see on Sunday evening is more accurate than the number you logged on Monday — not less.

Traditional tracker	Eatamate
Monday: log meal → get 432 kcal	Monday: log meal → tap in <2 seconds
Tuesday–Saturday: log more meals	Tuesday–Saturday: log more meals
Sunday: review week	Auto: fresh items expire → IPF runs
Monday’s meal: still 432 kcal	Sunday: review week
Accuracy: ±25%* (never improved)	Accuracy: ≥93% (physics already ran)

** ±25% represents the theoretical worst-case for a non-barcoded, manually-searched database entry — a product logged without a barcode against a generic database item. UK law caps labelled product variance at ±20%, but manual text-search entries carry no such constraint: the wrong generic entry (e.g. ‘chicken breast’ matched to a database average rather than a specific SKU) can deviate by more. Barcode scanning eliminates this class of error entirely.*

8.2 The three-weighing calibration and zero-weighing thereafter

The Eatamate accuracy model begins with a one-time calibration. A user is asked to weigh each meal type they regularly eat three times — three sambar portions, three chicken curry portions, three dal portions. Three measurements are sufficient to estimate a personal Gaussian distribution: a mean portion weight (μ) and a standard deviation (σ) that captures the user’s natural portion variability.

After calibration, the user never weighs again. Every subsequent logging of ‘sambar’ uses the calibrated Gaussian estimate. Each individual log carries the calibration’s portion uncertainty — this is not zero. But this uncertainty is not what the ≥93% accuracy claim is about.

<p>The key distinction Individual meal log (intra-week): carries Gaussian portion uncertainty from calibration.</p>
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This is intentional — speed requires approximate real-time logging.

Weekly aggregate (post-reconciliation): portion error collapses to zero by physics. Mass conservation guarantees that the sum of all ingredient quantities distributed across meals exactly equals the physically known pantry depletion. This is the $\geq 93\%$ accuracy claim.

This is also why the precision of the calibration's σ estimate does not affect the $\geq 93\%$ claim. A wide confidence interval on the calibrated σ means individual meal logs may carry more or less portion uncertainty than the true population variance — but that uncertainty sits entirely in the intra-week bucket. Reconciliation eliminates it regardless of its magnitude. What calibration actually needs to estimate well is μ — the mean portion weight per meal type — and three measurements are sufficient for that purpose. The σ is a temporary scaffold: it governs only the distribution of uncertainty across individual logs before physics runs, not the accuracy of the weekly aggregate after it does.

8.3 The reconciliation lifecycle: event-driven, not calendar-driven

Reconciliation is not a weekly calendar event. It is triggered by physical reality. Different ingredients reconcile on different timescales determined by two factors: their natural expiry time and their probabilistic consumption rate. This distinction creates two categories of pantry item with different reconciliation strategies.

Category	Examples	Reconciliation trigger	User action required	Frequency
Short-expiry items	Fresh produce, dairy, cooked sauces, ready meals	Natural expiry: taxonomy + storage location determines maximal expiry time. Reconciliation runs automatically at expiry.	None — zero bookkeeping	Multiple times per week for typical household
Long-expiry staples	Dal, rice, oats, frozen veg, oil, pasta, tinned goods	Probabilistic consumption threshold: the forward pass recipe breakdown accumulates predicted consumption. When this crosses a caloric threshold, a reweigh is requested.	One reweigh of one item, triggered only when genuinely needed	Every few weeks per staple

The elegance of this design is that the user's bookkeeping burden is almost entirely eliminated. Short-expiry items — which represent the majority of the varied, high-turnover items in a household — require no action at all. Long-expiry staples, which are typically bought in bulk and consumed slowly, require an occasional reweigh that the system requests only when the accumulated uncertainty has grown large enough to matter.

The caloric threshold for triggering a reweigh is calibrated to the accuracy guarantee: the system monitors its own uncertainty and requests a correction at exactly the point where the $\geq 93\%$ accuracy floor would otherwise be threatened. The system is self-regulating.

8.4 Reconciliation is retroactive: it corrects history, not just the future

When a pantry item expires or a reweigh is provided, the system does not simply update its model going forward. It runs a full Iterative Proportional Fitting (IPF) pass over all meals that contained that ingredient since the last reconciliation event. This is a retrospective correction: every meal in the reconciliation window is updated simultaneously to satisfy mass conservation.

The result is that the user’s historical logs become more accurate over time, not less. A meal logged on Monday with $\pm 15\%$ portion uncertainty may, by Sunday, have that uncertainty collapsed to near zero as the IPF engine distributes the known physical ingredient total across all meals in the week.

This is why users care about last week’s data more than real-time accuracy. Real-time logs are fast approximations. Historical logs, after reconciliation, are physics-verified. The $\geq 93\%$ accuracy claim applies to historical data — the data users actually use to make decisions about their diet.

8.5 What reconciliation corrects — and what it cannot

It is important to be precise about what the reconciliation engine eliminates and what it does not. This precision is what makes the $\geq 93\%$ claim honest.

Error source	Before reconciliation	After reconciliation	What remains
Portion weight — individual meal	Calibrated Gaussian ($\mu \pm \text{calibration } \sigma$)	Collapsed to zero by IPF (mass conservation constraint)	Nothing — fully eliminated
Portion weight — weekly aggregate	Σ individual meal errors	Zero by construction: Σ portions = pantry depletion (physics)	Nothing — fully eliminated
Product identity	Eliminated by barcode scan	Already eliminated	Nothing
Caloric density per gram	Biological CV: $\pm 10\text{--}18\%$ per ingredient	Unchanged	Biological CV — irreducible, quantified in Section 7

Reconciliation is physics (mass conservation). It tells you precisely how much of each ingredient was consumed across the week. It does not tell you the caloric density of that specific batch of ingredient — whether this particular bag of lentils was slightly drier or wetter than average, whether this chicken breast came from a fattier or leaner bird. That is the biological CV, and it is the sole remaining source of caloric uncertainty that the $\geq 93\%$ accuracy figures in Section 7 quantify.

8.6 In clinical terms: automated retrospective dietary assessment

In nutrition research, this architecture has a formal name: retrospective dietary assessment. It is considered more reliable than prospective real-time logging precisely because it uses physical

evidence to reconstruct what actually happened, rather than estimating in real time under uncertainty.

The gold standard retrospective method is the 24-hour dietary recall, conducted by a trained dietitian who interviews the subject the day after eating. It is expensive, limited to one day, relies on memory, and cannot be repeated continuously. The National Diet and Nutrition Survey conducts it for approximately 1,000 people over two years at significant public cost.

Eatamate conducts automated, physics-verified, continuous retrospective dietary assessment for every user, every week, as a side effect of pantry management. The user gets a better dietary record than a dietitian-administered recall — because Eatamate’s retrospective correction is grounded in physical measurements (barcode-scanned weights) rather than recalled estimates.

The product insight in one sentence

Eatamate achieves sub-2-second logging AND greater than 93% weekly accuracy not despite the tradeoff between speed and precision, but because reconciliation decouples them entirely. Speed is delivered at logging time. Accuracy is delivered at review time. They operate on different timescales and different physical principles. To our knowledge, no other commercially available nutrition tracker has separated these two problems.

8.7 Worked Example: From Raw Logs to Reconciled Accuracy

This section quantifies what reconciliation actually delivers, numerically, for a real week of eating. The calculation is run in three states: before reconciliation (when IPF has not yet run and ingredient quantities are unknown), after reconciliation for a single-user household (where IPF pins all quantities exactly), and after reconciliation for a multi-user household (where an additional split uncertainty applies). The pre-reconciliation figure is not displayed to users during the week — it describes the theoretical accuracy of the raw unreconciled logs, and exists purely to quantify the improvement that reconciliation delivers.

The weekly menu — Scenario B balanced, 14,000 kcal

The menu below follows the Scenario B balanced structure from Section 7.3: 72.1% home-cooked (10,100 kcal), 17.9% ready meals (2,500 kcal), and 10% restaurant (1,400 kcal). Barcoded items are weighed exactly at logging. Home-cooked dishes share the household pantry and are subject to IPF reconciliation.

Meal item	Days/wk	kcal/serving	Weekly kcal	Category
Oats + semi-skim milk	5	350	1,750	Barcoded — individual, known weight
Greek yoghurt	7	110	770	Barcoded — individual, known weight
Protein bar	5	200	1,000	Barcoded — individual, known weight
Sambar + rice	3	610	1,830	Home-cooked — shared pantry (IPF)

Dal + roti	2	515	1,030	Home-cooked — shared pantry (IPF)
Chicken tikka + rice	3	700	2,100	Home-cooked — shared pantry (IPF)
Salmon + veg	2	600	1,200	Home-cooked — shared pantry (IPF)
Peanut butter + almonds	2	210	420	Barcoded — individual, known weight
Ready meals (5 × 500 kcal)	5	500	2,500	Ready meal
Independent restaurant	1	700	700	Restaurant (weighed, ±62%)
Chain restaurant	1	700	700	Chain restaurant (±15%)
TOTAL			14,000	

State 1: Pre-reconciliation — before IPF has run

Before reconciliation, each home-cooked meal item carries two independent error sources. The portion size error (±50% 2σ per serving, from Byers et al., Int J Epidemiol, 1994, who found intra-individual portion CVs of 34–40%) is independent across occasions — Monday’s sambar and Wednesday’s sambar are separate draws — so errors combine in quadrature across the week. The database match error (±62% 2σ, from Urban et al., 2016, within-cuisine caloric density CV) is fully correlated within the week because the same recipe is used each time, so errors add linearly. Barcoded items carry only the caloric density CV from Section 5, unchanged by reconciliation.

Meal group	Weekly kcal	Portion 2σ	Density 2σ	Group 2σ
Oats + semi-skim milk	1,750	—	±158 kcal	±158 kcal
Greek yoghurt	770	—	±77 kcal	±77 kcal
Protein bar	1,000	—	±30 kcal	±30 kcal
Sambar + rice	1,830	±528 kcal	±1135 kcal	±1252 kcal
Dal + roti	1,030	±364 kcal	±639 kcal	±735 kcal
Chicken tikka + rice	2,100	±606 kcal	±1302 kcal	±1436 kcal
Salmon + veg	1,200	±424 kcal	±744 kcal	±856 kcal
Peanut butter + almonds	420	—	±17 kcal	±17 kcal
Ready meals (5 × 500 kcal)	2,500	—	±168 kcal	±168 kcal
Independent restaurant	700	—	±434 kcal	±434 kcal

Chain restaurant	700	—	±105 kcal	±105 kcal
Weekly 2σ (quadrature across all groups)	14,000			±2272 kcal → 83.8% accuracy

Pre-reconciliation accuracy: 83.8%. This figure is not displayed to users during the week; it is the theoretical accuracy of unreconciled logs, shown here to quantify the improvement IPF delivers.

State 2: Post-reconciliation — single-user household

When IPF runs, it pins the weekly gram total of every pantry ingredient to the physically measured pantry depletion. Portion uncertainty collapses to exactly zero for all home-cooked items — not approximately zero, but zero by construction (mass conservation). The remaining error is the irreducible biological caloric density CV, quantified ingredient-by-ingredient in Section 5 and combined here using the exact ingredient group decomposition from Section 7.3. Non-home items are unaffected by IPF.

Ingredient group (Section 7.3)	Scaled kcal	Group 2σ	Basis
Grains & Starches	3,486	±355	Linear within group × quadrature across groups (Section 7.3)
Legumes & Pulses	932	±77	Linear within group × quadrature across groups (Section 7.3)
Dairy	1,119	±102	Linear within group × quadrature across groups (Section 7.3)
Fats, Oils & Nuts	1,030	±46	Linear within group × quadrature across groups (Section 7.3)
Manufactured/Processed	1,373	±47	Linear within group × quadrature across groups (Section 7.3)
Meat, Fish & Eggs	1,401	±111	Linear within group × quadrature across groups (Section 7.3)
Fresh Produce	755	±65	Linear within group × quadrature across groups (Section 7.3)
Home-cooked subtotal (quadrature)	10,100	±405	Matches Section 7.3 Balanced profile
Ready meals (5 × 500 kcal)	2,500	±270	3×SKU-A + 2×SKU-B at ±15% 2σ, quadrature across SKU groups
Independent restaurant (weighed)	700	±434	Irreducible: within-cuisine caloric density CV (Urban et al. 2016). Not in home pantry; IPF cannot reduce this.
Chain restaurant	700	±105	Label compliance ±15% 2σ
Weekly 2σ (quadrature across all groups)	14,000	±661	95.28% accuracy — matches Whitepaper Section 7.6 Scenario B balanced exactly

Post-reconciliation accuracy: 95.28% (single-user). Anchored to Section 7.3 ingredient group decomposition. The independent restaurant term (± 434 kcal) is the largest remaining error source.

State 3: Post-reconciliation — per-user accuracy in a multi-user household

For a household of N users sharing a pantry, IPF recovers the household-level ingredient totals exactly (as in the single-user case). The additional step is splitting each ingredient’s total between users. This split uses each user’s calibrated Gaussian portion prior (mean and SD estimated from their three weighings per meal item) and a mass-conservation constraint: the sum of all users’ shares must equal the IPF total.

The negative covariance between users is exact: if User A consumed more than their prior, the remaining users must collectively have consumed correspondingly less. This tightens each user’s posterior split uncertainty by a factor $\sqrt{((N-1)/N)}$. For a group appearing n_a times in User A’s week, the split uncertainty (2σ) is: $(\pm 50\% / \sqrt{n_a}) \times \sqrt{((N-1)/N)}$, combining in quadrature with the biological CV.

Ingredient group	Scaled kcal	Bio CV 2σ	n_a	Split 2σ	Combi ned	Group 2σ
Grains & Starches	3,486	$\pm 10\%$	8	$\pm 12.5\%$	$\pm 16.1\%$	± 563 kcal
Legumes & Pulses	932	$\pm 8\%$	5	$\pm 15.8\%$	$\pm 17.8\%$	± 166 kcal
Dairy	1,119	$\pm 9\%$	—	— (barcod ed)	$\pm 9.1\%$	± 102 kcal
Fats, Oils & Nuts	1,030	$\pm 5\%$	—	— (barcod ed)	$\pm 4.6\%$	± 47 kcal
Manufactured/ Processed	1,373	$\pm 3\%$	—	— (barcod ed)	$\pm 3.5\%$	± 48 kcal
Meat, Fish & Eggs	1,401	$\pm 8\%$	5	$\pm 15.8\%$	$\pm 17.7\%$	± 248 kcal
Fresh Produce	755	$\pm 9\%$	5	$\pm 15.8\%$	$\pm 18.0\%$	± 136 kcal
Ready meals / restaurants	3,900	varies	—	—		± 522 kcal
Weekly 2σ (quadrature)	14,000					± 844 kcal \rightarrow 93.97% accuracy

Per-user accuracy in a 2-user household: 93.97%. Split uncertainty adds in quadrature with biological CV. Barcoded items (dairy, fats, manufactured) are consumed individually and carry no split uncertainty.

Per-user accuracy as household size varies from 1 to 10

The table below shows how per-user accuracy varies with household size. The accuracy drop is sharpest from $N=1$ to $N=2$ (-1.3 percentage points) and flattens rapidly: from $N=3$ to $N=10$ the additional degradation is under 0.5 percentage points. This is because $\sqrt{((N-1)/N)}$ saturates toward 1 quickly, so the split uncertainty converges to its maximum value of $\pm 50\% / \sqrt{n_a}$ and stops

growing. Even at N=10 (the maximum supported household size), per-user accuracy is 93.11% — a 2.4× improvement over the pre-reconciliation baseline of 83.8%.

N users	Split 2σ range	Weekly 2σ	Accuracy	vs pre-recon	Note
1	0% (single user)	±661 kcal	95.28%	3.4×	Full accuracy — single-user household
2	12.5–15.8%	±844 kcal	93.97%	2.7×	Sharp drop; covariance tightens split
3	14.4–18.3%	±896 kcal	93.60%	2.5×	Accuracy stabilising
4	~13.7–17.0%	±922 kcal	93.42%	2.5×	
5	~14.3–17.6%	±936 kcal	93.31%	2.4×	
6	~14.9–18.2%	±946 kcal	93.24%	2.4×	
7	~15.5–18.8%	±953 kcal	93.19%	2.4×	
8	~16.1–19.4%	±958 kcal	93.16%	2.4×	
9	~16.7–20.0%	±962 kcal	93.13%	2.4×	
10	16.8–21.2%	±965 kcal	93.11%	2.4×	Maximum household size (limit)

Per-user accuracy by household size. Split 2σ range reflects variation across ingredient groups (grains appear 8×/week; legumes, meat, produce appear 5×/week). Source for portion CV: Byers et al. (1994), Int J Epidemiol, intra-individual CV 34–40%.

What reconciliation delivers — in three numbers

83.8% → 95.28% → 93.97% 83.8%: the accuracy of raw unreconciled logs (not shown to users during the week). Each home-cooked meal carries both a portion size error (±50% 2σ per serving, independent across occasions) and a database match error (±62% 2σ, fully correlated within the week). Combined, these dominate the weekly total. 95.28%: the accuracy after IPF runs for a single-user household. Portion error collapses to exactly zero by mass conservation. Only the irreducible biological caloric density CV remains. This figure matches the whitepaper Scenario B balanced figure from Section 7.6 exactly. The independent restaurant meal (±434 kcal) is the largest single remaining error source — irreducible because it is a caloric density error, not a portion error. 93.97%: the per-user accuracy in a 2-user household, after the IPF total is split between users via their Gaussian portion priors. The split uncertainty adds in quadrature with the biological CV. Accuracy stabilises at ~93.1% for households of 3 or more. The system flags all users to reweigh one meal item if the household total deviates by more than 15% from the prior week's observed consumption, self-correcting for drift in portion habits.

9. The Critical Assumption: Random vs Systematic Error

The $\geq 93\%$ accuracy figures assume caloric errors are random, not systematic. Random errors partially cancel across food groups. Systematic errors accumulate.

If a specific brand consistently runs 8% above its label — because their supplier's animals are systematically fatter than average — that offset does not cancel. It persists every serving, every day.

The $\geq 93\%$ figure covers random biological and manufacturing variance. It does not capture systematic brand-level label errors. The foods most at risk: lean mince (FSA 2021 found 25% non-compliance), avocado (ripeness-dependent fat content), and loose fruit where variety matching could introduce a small consistent offset.

For barcoded supermarket products, systematic errors are expected to be small. Manufacturers are commercially incentivised to be on-label, and the FSA Basket of Goods programme enforces this through regular testing.

Bounding the systematic error impact

The FSA 2021 Basket of Goods survey found approximately 25% of lean mince samples outside label tolerance. As a worst-case bound: lean mince represents $\sim 5\%$ of the weekly diet in the meat-heavy profile. If that 5% carries a persistent $+10\%$ caloric offset (systematic over-labelling), the weekly caloric total is overstated by $0.05 \times 10\% = 0.5\%$. Applied to the meat-heavy home-cook scenario (95.47% accuracy), this degrades the floor to approximately 94.97% — still well above the $\geq 93\%$ accuracy floor.

10. Micronutrient Uncertainty: From Grams to Screening

The preceding analysis established that post-reconciliation ingredient quantities are known to gram-level precision for home-cooked meals, and that weekly caloric accuracy exceeds 93% across Scenarios A and B. This section asks: given those quantities, what can we say about *micronutrient* intake?

Eatamate tracks 27 micronutrients: 13 vitamins, 14 minerals, and 3 additional nutritional markers (fibre, sugar, saturated fat). For 24 of these, composition variability data is available to propagate uncertainty bounds. The remaining 3 (biotin, saturated fat, sugar) are reported as point estimates; see Section 10.3 for details.

The mathematical framework is identical to the caloric analysis: linear addition within same-batch food groups, quadrature summation across independent groups. The key difference is that micronutrient composition CVs are typically 10–20% per ingredient (compared to 1–18% for calories), reflecting greater biological variability in mineral and vitamin content. However, the same quadrature compression applies: across 7 independent food groups, a 20% per-ingredient CV compresses to a weekly CV of approximately 7–10%.

10.1 Three Sources of Micronutrient Uncertainty

Micronutrient uncertainty enters from three distinct pathways, depending on how the food item was logged.

Meal source	Micro uncertainty mechanism	Typical per-nutrient 2σ
Home-cooked (post-recon)	USDA/CoFID composition CV only. Ingredient grams known exactly via IPF. Uncertainty is purely biological: how much iron is in this specific batch of lentils.	$\pm 10\text{--}20\%$ per ingredient, compressing to $\pm 4\text{--}15\%$ weekly via quadrature
Barcoded multi-ingredient	Solver recovers ingredient weights from label macros. Two sources in quadrature: (1) USDA composition CV, (2) FSA label tolerance $\pm 15\%$ propagated through solver weight allocation.	$\pm 8\text{--}25\%$ per nutrient per serving
Restaurant (DB recipe match)	Generic recipe from cuisine-specific database. USDA composition CV plus recipe-level variation. Oil correction factors applied for cooking method.	$\pm 20\text{--}40\%$ per nutrient per meal. Largest single source.

Single-ingredient barcoded items (fruit juice, milk, olive oil, sugar) have a direct USDA profile with no solver decomposition needed. Their micro uncertainty is simply the USDA composition CV, identical to the home-cooked pathway.

10.2 USDA Composition CVs: The Irreducible Biological Floor

The National Academy of Sciences (1986) published coefficients of variation for nutrient composition in commonly consumed foods. These represent the biological variability in nutrient content across samples of the same food type. For iodine, the USDA/FDA/ODS-NIH Iodine Database (Release 4.0, 2024) provides per-food standard deviations; the Pehrsson et al. (2016) analysis of Total Diet Study data confirms substantially higher variability than other minerals.

Nutrient group	Composition CV (1σ)	Primary driver
Calories	$\pm 5\%$	Tighter than most micros
Iron, Zinc, Copper, Manganese	$\pm 20\%$	Soil composition, cultivar
Calcium, Phosphorus, Potassium, Sodium	$\pm 10\%$	More stable across growing conditions
Magnesium, Selenium	$\pm 20\%$	Soil-dependent
Iodine	$\pm 30\%$	Highly variable: soil, feed, iodophors (Pehrsson 2016)
Vitamins A, C, D, E, K	$\pm 20\%$	Light, heat, and storage sensitive
B vitamins (B1–B6, B12, Folate)	$\pm 10\text{--}20\%$	B3 tighter ($\pm 10\%$); B12 wider ($\pm 20\%$)
Choline	$\pm 15\%$	Intermediate
Fibre	$\pm 10\%$	Analytical method dependent

Source: NAS (1986), Table E-3, pp.129–146; Pehrsson et al. (2016, AJCN, PMC5004502) for iodine; USDA/FDA/ODS-NIH Iodine Database Release 4.0 (2024).

10.2a Cooking Method Inference and Retention Factor Application

The composition CVs in Section 10.2 describe biological variability in raw ingredient nutrient content. For home-cooked meals, post-reconciliation gram weights are raw weights — the quantities logged before cooking. Applying raw USDA values to these quantities would systematically overstate the micronutrient content of heat-sensitive vitamins, some of which lose 35–40% of their content during standard preparation. Eatomate corrects for this by inferring the cooking method for each ingredient and applying the corresponding USDA Nutrient Retention Factor (Release 6, 2007) before computing the weekly micronutrient total.

Cooking method inference is performed once per (ingredient, meal-context) pair using a Mistral language model call. The inferred method — for example, CHICKEN_ROASTED or VEG_GREENS_STIRFRY — is cached permanently in the database and reused for all subsequent occurrences. At scale, the cache hit rate approaches 100%; the inference cost is a one-time operation per unique combination. The retained method maps to a USDA Release 6 retention code, and the corresponding per-nutrient retention factors are applied as multipliers to the raw USDA composition values before propagating uncertainty bounds.

The retention factor itself carries uncertainty. USDA reports factors to the nearest 5%, so all retention factors carry an implicit ± 2.5 percentage-point rounding uncertainty, treated as a uniform $\pm 2.5\%$ error (approximately $\pm 1.4\%$ 1σ). This is propagated in quadrature with the composition CV for each nutrient and ingredient. For most nutrients the retention uncertainty is small relative to the 10–20% composition CV; it is material only for highly heat-labile vitamins (C, B1, Folate) in high-temperature or long-duration cooking.

USDA Release 6 Retention Factors: Key Eatomate Ingredient Categories

The table below shows the exact retention factors used by Eatomate for each ingredient-cooking-method combination, drawn directly from USDA Table of Nutrient Retention Factors, Release 6 (2007). Only the eight nutrients where cooking losses are material are shown; minerals (Ca, Fe, Zn, Mg, P, K, Cu) and B12 in plant foods are also shown where retention differs meaningfully from 100%. Stable nutrients (Se, Mn, B12 in plant foods [not applicable], Na, Vitamins D/E/K/B5) are not shown as their retention is 95–100% across all methods.

Ingredient / Inferred Method (USDA R6 code)	Vit C	B1 Thiamin	B6	Folate	B12	Choline	B2	Fe
CHICKEN — roasted/broiled/fried (0805)	80%	70%	80%	60%	65%	70%	90%	90%
CHICKEN — simmered without drippings (0855)	80%	55%	50%	60%	50%	70%	95%	90%
TURKEY — roasted (1805)	80%	65%	70%	60%	65%	70%	85%	95%
EGGS — fried/scrambled (0103)	80%	85%	95%	75%	85%	85%	95%	100%
EGGS — hard cooked/poached (0105)	80%	85%	95%	75%	85%	80%	95%	100%
BEEF — roasted (0601)	80%	55%	50%	95%	70%	90%	95%	100%
BEEF — broiled ground (0603)	80%	80%	60%	85%	80%	90%	95%	95%

Ingredient / Inferred Method (USDA R6 code)	Vit C	B1 Thiamin	B6	Folate	B12	Choline	B2	Fe
BEEF — braised/stewed without drippings (0651)	80%	45%	35%	65%	60%	90%	85%	100%
PORK — roasted (1254)	80%	60%	85%	95%	80%	100%	95%	100%
FINFISH lean <5% fat — baked (2301)	80%	90%	90%	90%	90%	100%	95%	100%
FINFISH fatty >5% fat — baked (2451)	80%	95%	90%	90%	85%	100%	100%	100%
VEG GREENS — boiled, water cover, drained (3005)	55%	80%	85%	60%	100%	100%	90%	95%
VEG GREENS — stir-fry (3015)	85%	90%	95%	85%	100%	100%	95%	100%
VEG ROOTS — boiled, little water, drained (3454)	70%	85%	95%	70%	100%	100%	95%	95%
VEG ROOTS — steamed (3464)	75%	90%	95%	80%	100%	100%	95%	100%
VEG OTHER — boiled, little water, drained (3774)	80%	85%	90%	70%	100%	100%	95%	95%
VEG OTHER — steamed (3784)	85%	90%	90%	85%	100%	100%	95%	100%
POTATOES — baked in skin (3301)	80%	85%	95%	90%	100%	100%	95%	100%
POTATOES — boiled, pared, drained (3308)	75%	80%	95%	75%	100%	100%	95%	95%
SWEET POTATOES — boiled, pared, drained (3708)	75%	80%	95%	75%	100%	100%	95%	95%
LEGUMES — boiled, drained, 15/20 min (lentils) (0501)	65%	65%	70%	60%	100%	100%	75%	85%
LEGUMES — boiled, drained, 45/75 min (chickpeas, dry beans) (0521)	65%	60%	65%	45%	100%	100%	70%	80%
OATMEAL — regular/quick cooked (0352)	80%	80%	90%	70%	100%	100%	90%	95%
RAW ingredients — salad, raw fruit, milk, oils	100%	100%	100%	100%	100%	100%	100%	100%

Source: USDA Table of Nutrient Retention Factors, Release 6 (2007), Nutrient Data Laboratory, BHNRC, ARS, USDA. Retention codes in parentheses. Factors reported to nearest 5% as per USDA methodology. B12 shown as 100% for plant foods (lentils, chickpeas, vegetables) as B12 does not occur naturally in plant foods; the 100% figure reflects retention of any fortified B12 if present. Legume folate retention (45%–60%) reflects confirmed thermal degradation of naturally-occurring food folate; this is a critical correction as raw lentil folate values overstate consumed folate by up to 55% for long-cook preparations.

Impact on Weekly Micronutrient Estimates

Applying retention factors changes the absolute micronutrient totals but does not alter the structure of the uncertainty propagation. The corrected weekly estimate for nutrient n in ingredient i is:

$$n_{ii}(\text{cooked}) = n_{ii}(\text{raw}) \times RF_{ii} \pm 2\sigma: \sqrt{[(CV_{\text{composition}} \times RF)^2 + (CV_{RF} \times n_{\text{cooked}})^2]}$$

Where RF is the retention factor (0–1.0), $CV_{\text{composition}}$ is the USDA composition CV from Section 10.2, and $CV_{RF} = 0.014$ (the 1σ uncertainty from USDA’s ± 2.5 percentage-point rounding). The retention factor correction is applied at ingredient level before quadrature summation across food groups. Post-correction, the weekly CI structure is identical to Section 10.4 except that all heat-labile vitamin estimates are lower, and some previously “confirmed above RDA” nutrients may shift to “intake unclear” — which is precisely the clinical value of the correction.

The folate correction for legumes is the most significant single adjustment. A Balanced profile consuming 244 g/week of dry lentils (cooked for ~20 minutes, drained) carries a 60% folate retention factor (code 0501). Applied to the raw USDA folate value of ~181 $\mu\text{g}/100\text{ g}$, the post-cooking estimate is ~109 $\mu\text{g}/100\text{ g}$ — a 40% reduction. At the weekly level this moves lentil folate contribution from ~221 μg to ~133 μg , a difference large enough to shift the weekly folate screening status from confirmed above RDA to intake unclear for the Balanced profile. For chickpeas cooked 45–75 minutes (code 0521, 45% folate retention) the correction is even larger.

Minerals are largely unaffected by the retention correction — Fe, Zn, Ca, Mg, and P retain 80–95% across all cooking methods, and the small loss leaches into cooking water which is discarded. The screening status of mineral-dense ingredients is therefore robust to cooking method inference errors. Vitamin C in boiled greens (55% retention, code 3005) is the largest absolute reduction, but because Vitamin C is present in such excess relative to the RDA in the Balanced and Plant-Heavy profiles, the corrected value remains confirmed above RDA. The clinically consequential corrections are: Folate in legumes, Thiamin in long-braised beef (45%), B6 in slow-simmered chicken (50%), and Vitamin B12 in roasted versus simmered chicken (65% vs 50%).

10.3 The 27 Tracked Nutrients

Eatomate tracks the following nutrients across all meal sources. For 24 nutrients, full uncertainty propagation is performed. For 3 nutrients (marked *), composition variance data is not available or not meaningful for screening; these are reported as point estimates.

Nutrient	Category	Unit	Daily RDA	CV (1 σ)	Screening status
Iron	Major mineral	mg	8.7	20%	Full propagation
Zinc	Trace mineral	mg	9.5	20%	Full propagation
Calcium	Major mineral	mg	700	10%	Full propagation
Magnesium	Major mineral	mg	300	20%	Full propagation

Phosphorus	Major mineral	mg	550	10%	Full propagation
Potassium	Major mineral	mg	3500	10%	Full propagation
Sodium	Major mineral	mg	2400	10%	Full propagation
Manganese	Trace mineral	mg	2.3	20%	Full propagation
Copper	Trace mineral	mg	1.0	20%	Full propagation
Selenium	Trace mineral	mcg	55	20%	Full propagation
Iodine	Trace mineral	mcg	150	30%	Full propagation (Pehrsson 2016)
Vitamin A	Fat-soluble	mcg	700	20%	Full propagation
Vitamin C	Water-soluble	mg	40	20%	Full propagation
Vitamin D	Fat-soluble	mcg	10	20%	Full propagation
Vitamin E	Fat-soluble	mg	12	20%	Full propagation
Vitamin K	Fat-soluble	mcg	75	20%	Full propagation
Thiamin (B1)	Water-soluble	mg	1.0	20%	Full propagation
Riboflavin (B2)	Water-soluble	mg	1.3	20%	Full propagation
Niacin (B3)	Water-soluble	mg	16.5	10%	Full propagation
Pantothenic acid (B5)	Water-soluble	mg	5	20%	Full propagation
Vitamin B6	Water-soluble	mg	1.4	20%	Full propagation
Biotin (B7)*	Water-soluble	mcg	30	—	Point estimate only
Folate (B9)	Water-soluble	mcg	200	20%	Full propagation
Vitamin B12	Water-soluble	mcg	2.4	20%	Full propagation
Fibre	Macronutrient detail	g	30	10%	Full propagation
Sugar*	Macronutrient detail	g	—	—	Point estimate (no deficiency RDA)
Saturated fat*	Macronutrient detail	g	—	—	Point estimate (no deficiency RDA)

* *Biotin: published composition values disagree by up to 247× between analytical methods (Mock et al. 2004); propagated confidence intervals would be meaningless until the underlying data improves. Sugar and saturated fat: tracked as upper-limit markers, not deficiency nutrients — screening logic does not apply. RDAs shown are UK Reference Nutrient Intakes.*

10.4 Weekly Micronutrient Profile: Balanced Diet (Scenario A)

The table below shows the complete 24-nutrient weekly profile for the Balanced diet (Profile 2, Section 7.3), with all values corrected for cooking method using USDA Nutrient Retention Factors Release 6 (2007). Post-reconciliation ingredient grams are known exactly; cooking method is inferred by Mistral and cached permanently per (ingredient, meal-context) pair. The residual uncertainty is the USDA composition CV per ingredient, propagated in quadrature with the ±2.5 percentage-point retention factor rounding uncertainty.

Nutrient	Unit	Weekly total	±2σ	95% CI	% RDA	CV%	Screening status
MINERALS							
Iron	mg	105.1	20.2	[85–125]	173%	9.6%	✓ Confirmed above RDA (95% CI)
Zinc	mg	83.4	14.9	[68–98]	125%	8.9%	✓ Confirmed above RDA (95% CI)
Calcium	mg	5660.0	608.5	[5052–6268]	116%	5.4%	✓ Confirmed above RDA (95% CI)
Magnesium	mg	2862.1	481.0	[2381–3343]	136%	8.4%	✓ Confirmed above RDA (95% CI)
Phosphorus	mg	11066.1	879.4	[10187–11946]	287%	4.0%	✓ Confirmed above RDA (95% CI)
Potassium	mg	21574.2	1414.3	[20160–22988]	88%	3.3%	✗ Confirmed below RDA (95% CI)
Sodium	mg	12631.9	1350.5	[11281–13982]	75%	5.3%	✓ Intake confirmed low (95% CI)
Manganese	mg	45.5	11.5	[34–57]	282%	12.7%	✓ Confirmed above RDA (95% CI)
Copper	mg	11.7	2.1	[10–14]	166%	9.1%	✓ Confirmed above RDA (95% CI)
Selenium	mcg	864.1	159.9	[704–1024]	224%	9.3%	✓ Confirmed above RDA (95% CI)
VITAMINS							

Vitamin A	mcg	9041.6	1947.8	[7094–10989]	185%	10.8 %	✓ Confirmed above RDA (95% CI)
Vitamin C	mg	873.0	171.8	[701–1045]	312%	9.8%	✓ Confirmed above RDA (95% CI)
Vitamin D	mcg	54.2	16.5	[38–71]	77%	15.2 %	? Intake unclear (95% CI)
Vitamin E	mg	96.9	18.3	[79–115]	115%	9.4%	? Intake unclear (95% CI)
Vitamin K	mcg	1738.3	496.9	[1241–2235]	331%	14.3 %	✓ Confirmed above RDA (95% CI)
Thiamin (B1)	mg	10.2	1.9	[8–12]	146%	9.2%	✓ Confirmed above RDA (95% CI)
Riboflavin (B2)	mg	14.0	2.1	[12–16]	154%	7.4%	✓ Confirmed above RDA (95% CI)
Niacin (B3)	mg	195.7	18.9	[177–215]	169%	4.8%	✓ Confirmed above RDA (95% CI)
Pantothenic acid (B5)	mg	60.8	9.8	[51–71]	174%	8.1%	✓ Confirmed above RDA (95% CI)
Vitamin B6	mg	19.6	3.1	[16–23]	200%	7.9%	✓ Confirmed above RDA (95% CI)
Vitamin B12	mcg	27.0	5.9	[21–33]	160%	10.9 %	✓ Confirmed above RDA (95% CI)
Folate	mcg	2466.0	369.5	[2097–2836]	176%	7.5%	✓ Confirmed above RDA (95% CI)
MACRONUTRIENT DETAIL							
Fibre	g	228.9	22.5	[206–251]	109%	4.9%	? Intake unclear (95% CI)

Post-reconciliation weekly micronutrient profile — Profile 2: Balanced (14,000 kcal/week). All values post-retention-factor correction using USDA Nutrient Retention Factors Release 6 (2007). Linear within same-batch groups, quadrature across independent groups. CV% is post-quadrature (1σ). Traffic light: green = lower bound \geq weekly RDA; amber = CI spans RDA; red = upper bound $<$ weekly RDA. Sodium: low intake is a positive signal. Choline: AI (Adequate Intake) used as RDA proxy.

10.5 Worked Examples: Three Nutrients, Three Screening Outcomes

Three nutrients illustrate the three possible screening outcomes. The mathematics follows the identical linear-within-group, quadrature-across-groups structure used for calories in Sections 7.2–7.4.

Vitamin D — INTAKE UNCLEAR (95% CI) (Balanced profile)

Vitamin D has limited food sources. In the Balanced profile, the only meaningful contributors are salmon (11.0 mcg/100g), eggs (2.0 mcg/100g), fortified protein bar (2.5 mcg/100g), and fortified breakfast cereal (1.7 mcg/100g), with trace amounts from dairy. The weekly total is 54.2 mcg against a weekly RDA of 70 mcg (77% of target). The 95% CI of [38–71 mcg] spans the RDA threshold, so the screening status is INTAKE UNCLEAR (95% CI) — the user may or may not be meeting their vitamin D requirement from food alone.

Eatomate would surface this as: “Your vitamin D intake is estimated at 57.6 mcg/week \pm 16.5 mcg (95% CI: 41–74 mcg). The weekly target is 70 mcg. Your intake may be insufficient from food sources alone — consider sunlight exposure or supplementation, particularly in winter months.”

Vitamin B12 — CONFIRMED ABOVE RDA (95% CI) in Balanced, CONFIRMED BELOW RDA (95% CI) in Plant-Heavy

Vitamin B12 is found exclusively in animal products and fortified foods. In the Balanced profile (salmon 366g/week, chicken 610g/week, eggs 366g/week, dairy), the weekly total is 29.2 mcg \pm 6.2 mcg. The lower bound (22.9 mcg) exceeds the weekly RDA (16.8 mcg), so the screening status is CONFIRMED ABOVE RDA (95% CI) with high confidence.

In the Plant-Heavy profile, the only B12 sources are eggs (270g/week \rightarrow 2.4 mcg), fortified soy milk (756g/week \rightarrow 3.0 mcg), fortified protein powder (216g/week \rightarrow 2.2 mcg), and Greek yoghurt (324g/week \rightarrow 2.6 mcg). The weekly total is 10.2 mcg \pm 2.6 mcg. The **upper** bound (12.8 mcg) falls below the weekly RDA (16.8 mcg), meaning the user is confirmed below RDA at 95% CI — even at the upper bound of the estimate, the weekly target is not met.

This is a clinically actionable finding

No other consumer nutrition tracker can make this statement with quantified confidence, because none has the ingredient-level gram precision to propagate uncertainty through to a weekly screening threshold. A conventional tracker would show “B12: 1.5 mcg/day (61% of RDA)” — a point estimate with no indication of whether to act on it. Eatomate shows that even under the most favourable assumptions about food composition, this user’s B12 intake is inadequate.

Calcium — CONFIRMED ABOVE RDA (95% CI) in Balanced, INTAKE UNCLEAR (95% CI) in Plant-Heavy

In the Balanced profile, dairy dominates: semi-skimmed milk (1,280g/week \rightarrow 1,536 mg), cheddar (98g/week \rightarrow 707 mg), Greek yoghurt (427g/week \rightarrow 470 mg). Combined with almonds, fortified cereal, and vegetables, the weekly total is 5,995 mg \pm 614 mg against a weekly RDA of 4,900 mg. The lower bound (5,381 mg) clears the RDA: CONFIRMED ABOVE RDA (95% CI).

In the Plant-Heavy profile, without cheddar or semi-skimmed milk, calcium drops to 4,956 mg ± 392 mg. The lower bound (4,564 mg) falls below the 4,900 mg weekly RDA, shifting the status to INTAKE UNCLEAR (95% CI). The point estimate barely meets the target, but the uncertainty band means we cannot be confident the user is getting enough calcium.

10.6 Dietary Pattern Sensitivity: Balanced vs Plant-Heavy

The table below shows nutrients where the screening status changes between dietary profiles. This is the core value proposition of micronutrient screening: identical quadrature mathematics applied to different dietary patterns produces different, actionable conclusions.

Nutrient	% RDA	Balanced	% RDA	Plant-Heavy	Δ	Clinical note
Vitamin B12	174%	✓ Confirmed above RDA (95% CI)	61%	✗ Confirmed below RDA (95% CI)	↓ ↓	Only animal sources
Vitamin D	82%	? Intake unclear (95% CI)	17%	✗ Confirmed below RDA (95% CI)	↓	UK deficiency epidemic
Niacin (B3)	175%	✓ Confirmed above RDA (95% CI)	84%	✗ Confirmed below RDA (95% CI)	↓ ↓	Meat/fish dominant source
Calcium	122%	✓ Confirmed above RDA (95% CI)	101%	? Intake unclear (95% CI)	↓	Drops without dairy
Vitamin E	126%	✓ Confirmed above RDA (95% CI)	117%	? Intake unclear (95% CI)	↓	Nut sources help but insufficient
Potassium	89%	✗ Confirmed below RDA (95% CI)	98%	? Intake unclear (95% CI)	↑	Hard to meet from any profile
Zinc	119%	? Intake unclear (95% CI)	130%	✓ Confirmed above RDA (95% CI)	↑	Plant phytates but higher intake
Fibre	104%	? Intake unclear (95% CI)	146%	✓ Confirmed above	↑	Plant diets excel

					RDA (95% CI)			
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Nutrients where screening status changes between Balanced and Plant-Heavy profiles. ↑ = improves in plant-heavy; ↓ = worsens.

10.7 The Screening Framework: From Confidence Intervals to Actionable Advice

Point estimates of micronutrient intake are nearly useless for dietary guidance. A point estimate of 57.6 mcg/week vitamin D tells the user nothing about whether they should act. The confidence interval transforms this into a decision:

Screening bucket	Definition	What it means	App action
✓ Confirmed above RDA (95% CI)	Lower bound of 95% CI ≥ weekly RDA	Even in the worst plausible case, intake meets the target	No action needed. Green indicator.
? Intake unclear (95% CI)	CI spans the weekly RDA	Intake may or may not be adequate	Amber indicator. Suggest rich foods. Monitor over subsequent weeks.
✗ Confirmed below RDA (95% CI)	Upper bound of 95% CI < weekly RDA	Even in the best plausible case, intake falls short	Red indicator. Specific dietary recommendation. Flag for supplementation.

The key insight: the **upper** bound screens for deficiency (if even the best case falls short, the user is definitely deficient), while the **lower** bound screens for sufficiency (if even the worst case meets the target, the user is definitely sufficient). This inversion — using opposite tails for opposite conclusions — is what makes the screening conservative and clinically safe.

10.8 Barcoded Multi-Ingredient Products: The Solver Method

For barcoded products with multiple ingredients, the declared ingredient list and label macros are used to recover plausible ingredient weights via constrained optimisation. The solver minimises macronutrient discrepancy subject to ingredient ordering constraints, UK FSA label tolerance ($\pm 15\% 2\sigma$, with $\pm 20\%$ legal hard limit), and declared percentages where available.

Once ingredient weights are recovered, micronutrient contributions are summed from USDA profiles. Two uncertainty sources propagate in quadrature: (1) the USDA composition CV per ingredient, and (2) the FSA label tolerance propagated through the solver weight allocation. Three products demonstrate the method across categories:

Product	Serving	Ingredients	Macro error	Notable features
Planty Jerk Tofu Bowl	400g	31	38.0%	Continuous tofu pressing model: nigari base profile $\times k=1.89$. All 24 micros scale linearly with pressing factor. 4 variant combos; all within legal $\pm 20\%$ band.
Pret Kale & Cauli Mac & Cheese	359g	13	28.2%	Nested béchamel sub-recipe tree. Declared %: cheddar 8%, cauliflower 14%, hard cheese 6%, kale 5.5%. Dairy-heavy calcium profile.
Caffè Nero	220g	3	26.7%	Continuous milk scaling model: semi-skimmed base

Cappuccino				× k=1.15 for steam concentration. All macros within 95% CI. Sub-second solve.
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The continuous scaling model treats concentration as a continuous optimisation variable rather than selecting from discrete USDA entries. A base profile is scaled by a pressing/dilution factor k that the solver optimises jointly with ingredient weights. For tofu, $k = 1.0$ represents the base nigari entry (9.0g protein/100g); $k = 1.89$ represents firm pressing (17.0g protein/100g). All micronutrients scale linearly with k because pressing removes water (zero nutrients) and concentrates the soybean fraction. This generalises to any dilution ingredient: milk, yoghurt, coconut milk, stock, and bean pastes.

Planty Jerk Tofu Bowl 400g — Solver Micronutrient Profile

Macro validation: Cal: 423.5 (✓ IN 95%CI) | Pro: 20.1 (✓ IN 95%CI) | Fat: 22.3 (✓ IN 95%CI) | Carb: 40.5 (⚠ IN LEGAL). Total error: 38%.

Nutrient	Unit	Per serving	$\pm 2\sigma$	95% CI	% RDA	CV%	Status
MINERALS							
Iron	mg	4.84	0.99	[3.9–5.8]	56%	10.2 %	X Confirmed below RDA (95% CI)
Zinc	mg	2.64	0.58	[2.1–3.2]	28%	11%	X Confirmed below RDA (95% CI)
Calcium	mg	349.6	55.0	[295–405]	50%	7.9%	X Confirmed below RDA (95% CI)
Magnesium	mg	119.5	23.0	[96–142]	40%	9.6%	X Confirmed below RDA (95% CI)
Phosphorus	mg	355.9	36.5	[319–392]	65%	5.1%	X Confirmed below RDA (95% CI)
Potassium	mg	953.6	64.9	[889–1019]	27%	3.4%	X Confirmed below RDA (95% CI)
Sodium	mg	409.7	61.9	[348–472]	17%	7.6%	X Confirmed below RDA (95% CI)
Manganese	mg	1.91	0.40	[1.5–2.3]	83%	10.4 %	? Intake unclear (95% CI)
Copper	mg	0.65	0.12	[0.5–0.8]	65%	9.6%	X Confirmed below RDA (95% CI)
Selenium	mcg	23.5	5.90	[18–29]	43%	12.6 %	X Confirmed below RDA

							(95% CI)
VITAMINS							
Vitamin A	mcg	383.1	128.3	[255–511]	55%	16.7 %	X Confirmed below RDA (95% CI)
Vitamin C	mg	41.7	9.29	[32–51]	104%	11.1 %	? Intake unclear (95% CI)
Vitamin D	mcg	0.08	0.03	[0.1–0.1]	1%	20%	X Confirmed below RDA (95% CI)
Vitamin E	mg	3.29	1.03	[2.3–4.3]	27%	15.7 %	X Confirmed below RDA (95% CI)
Vitamin K	mcg	69.8	14.7	[55–84]	93%	10.5 %	? Intake unclear (95% CI)
Thiamin (B1)	mg	0.30	0.05	[0.3–0.3]	30%	8.3%	X Confirmed below RDA (95% CI)
Riboflavin (B2)	mg	0.30	0.06	[0.2–0.3]	23%	9.5%	X Confirmed below RDA (95% CI)
Niacin (B3)	mg	4.86	0.44	[4.4–5.3]	29%	4.6%	X Confirmed below RDA (95% CI)
Pantothenic acid (B5)	mg	1.50	0.36	[1.1–1.9]	30%	12%	X Confirmed below RDA (95% CI)
Vitamin B6	mg	0.45	0.07	[0.4–0.5]	32%	7.3%	X Confirmed below RDA (95% CI)
Folate	mcg	166.6	29.3	[137–196]	83%	8.8%	X Confirmed below RDA (95% CI)
Choline	mg	90.1	13.4	[77–103]	16%	7.4%	X Confirmed below RDA (95% CI)
MACRONUTRIENT DETAIL							
Fibre	g	8.88	0.57	[8.3–9.4]	30%	3.2%	X Confirmed below RDA (95% CI)

Per-serving micronutrient profile from solver weight recovery. 23 nutrients reported: 0 confirmed above RDA, 3 intake unclear, 20 confirmed below RDA relative to daily RDA. Uncertainty reflects USDA composition CV only (single serving; weekly quadrature compression does not apply to individual products).

Pret Kale & Cauli Mac & Cheese 359g — Solver Micronutrient Profile

Macro validation: Cal: 520.5 (✓ IN 95%CI) | Pro: 26.9 (✓ IN 95%CI) | Fat: 25.3 (✓ IN 95%CI) | Carb: 38.4 (⚠ IN LEGAL). Total error: 28.2%.

Nutrient	Unit	Per serving	±2σ	95% CI	% RDA	CV%	Status
MINERALS							
Iron	mg	2.49	0.54	[1.9–3.0]	29%	10.9 %	X Confirmed below RDA (95% CI)
Zinc	mg	2.89	0.56	[2.3–3.5]	30%	9.7%	X Confirmed below RDA (95% CI)
Calcium	mg	639.1	70.7	[568–710]	91%	5.5%	? Intake unclear (95% CI)
Magnesium	mg	56.5	9.83	[47–66]	19%	8.7%	X Confirmed below RDA (95% CI)
Phosphorus	mg	480.4	47.5	[433–528]	87%	4.9%	X Confirmed below RDA (95% CI)
Potassium	mg	367.6	36.0	[332–404]	11%	4.9%	X Confirmed below RDA (95% CI)
Sodium	mg	1557.0	203.6	[1353–1761]	65%	6.5%	X Confirmed below RDA (95% CI)
Manganese	mg	0.50	0.12	[0.4–0.6]	22%	12.2 %	X Confirmed below RDA (95% CI)
Copper	mg	0.17	0.04	[0.1–0.2]	17%	12.4 %	X Confirmed below RDA (95% CI)
Selenium	mcg	39.7	10.3	[29–50]	72%	13%	X Confirmed below RDA (95% CI)
VITAMINS							
Vitamin A	mcg	329.3	68.2	[261–397]	47%	10.4 %	X Confirmed below RDA (95% CI)
Vitamin C	mg	30.4	9.48	[21–40]	76%	15.6 %	X Confirmed below RDA (95% CI)
Vitamin D	mcg	0.36	0.07	[0.3–0.4]	4%	10.4 %	X Confirmed below RDA (95% CI)

Vitamin E	mg	1.35	0.32	[1.0–1.7]	11%	11.8 %	X Confirmed below RDA (95% CI)
Vitamin K	mcg	90.8	33.1	[58–124]	121%	18.2 %	? Intake unclear (95% CI)
Thiamin (B1)	mg	0.31	0.07	[0.2–0.4]	31%	10.7 %	X Confirmed below RDA (95% CI)
Riboflavin (B2)	mg	0.50	0.10	[0.4–0.6]	39%	10.1 %	X Confirmed below RDA (95% CI)
Niacin (B3)	mg	2.73	0.35	[2.4–3.1]	17%	6.3%	X Confirmed below RDA (95% CI)
Pantothenic acid (B5)	mg	1.07	0.22	[0.8–1.3]	21%	10.3 %	X Confirmed below RDA (95% CI)
Vitamin B6	mg	0.25	0.05	[0.2–0.3]	18%	9.2%	X Confirmed below RDA (95% CI)
Vitamin B12	mcg	0.95	0.23	[0.7–1.2]	39%	12%	X Confirmed below RDA (95% CI)
Folate	mcg	63.1	12.5	[51–76]	32%	9.9%	X Confirmed below RDA (95% CI)
Choline	mg	43.6	6.57	[37–50]	8%	7.5%	X Confirmed below RDA (95% CI)
MACRONUTRIENT DETAIL							
Fibre	g	3.61	0.42	[3.2–4.0]	12%	5.8%	X Confirmed below RDA (95% CI)

Per-serving micronutrient profile from solver weight recovery. 24 nutrients reported: 0 confirmed above RDA, 2 intake unclear, 22 confirmed below RDA relative to daily RDA. Uncertainty reflects USDA composition CV only (single serving; weekly quadrature compression does not apply to individual products).

Caffè Nero Cappuccino Regular 220g — Solver Micronutrient Profile

Macro validation: Cal: 89.6 (✓ IN 95%CI) | Pro: 5.9 (✓ IN 95%CI) | Fat: 3.5 (✓ IN 95%CI) | Carb: 8.9 (✓ IN 95%CI). Total error: 26.7%.

Nutrient	Unit	Per serving	±2σ	95% CI	% RDA	CV%	Status
MINERALS							
Iron	mg	0.11	0.03	[0.1–0.1]	1%	13.3	X Confirmed

						%	below RDA (95% CI)
Zinc	mg	0.73	0.28	[0.5–1.0]	8%	19.3 %	X Confirmed below RDA (95% CI)
Calcium	mg	211.7	42.0	[170–254]	30%	9.9%	X Confirmed below RDA (95% CI)
Magnesium	mg	37.3	10.1	[27–47]	12%	13.5 %	X Confirmed below RDA (95% CI)
Phosphorus	mg	170.1	32.5	[138–203]	31%	9.6%	X Confirmed below RDA (95% CI)
Potassium	mg	345.7	54.7	[291–400]	10%	7.9%	X Confirmed below RDA (95% CI)
Sodium	mg	86.5	15.5	[71–102]	4%	9%	X Confirmed below RDA (95% CI)
Manganese	mg	0.01	0.01	[0.0–0.0]	1%	20%	X Confirmed below RDA (95% CI)
Copper	mg	0.01	0.01	[0.0–0.0]	1%	20%	X Confirmed below RDA (95% CI)
Selenium	mcg	3.55	1.40	[2.1–5.0]	6%	19.7 %	X Confirmed below RDA (95% CI)
VITAMINS							
Vitamin A	mcg	33.2	13.3	[20–47]	5%	20%	X Confirmed below RDA (95% CI)
Vitamin D	mcg	0.17	0.07	[0.1–0.2]	2%	20%	X Confirmed below RDA (95% CI)
Thiamin (B1)	mg	0.07	0.03	[0.0–0.1]	7%	19.9 %	X Confirmed below RDA (95% CI)
Riboflavin (B2)	mg	0.44	0.13	[0.3–0.6]	34%	15.4 %	X Confirmed below RDA (95% CI)
Niacin (B3)	mg	3.70	0.70	[3.0–4.4]	22%	9.5%	X Confirmed below RDA (95% CI)
Pantothenic acid	mg	0.70	0.28	[0.4–1.0]	14%	20%	X Confirmed

(B5)								below RDA (95% CI)
Vitamin B6	mg	0.07	0.03	[0.0–0.1]	5%	19.9%		X Confirmed below RDA (95% CI)
Vitamin B12	mcg	0.70	0.28	[0.4–1.0]	29%	20%		X Confirmed below RDA (95% CI)
Folate	mcg	8.86	3.50	[5.4–12]	4%	19.7%		X Confirmed below RDA (95% CI)
Choline	mg	28.0	8.39	[20–36]	5%	15%		X Confirmed below RDA (95% CI)
MACRONUTRIENT DETAIL								
Fibre	g	0.13	0.03	[0.1–0.1]	0%	10%		X Confirmed below RDA (95% CI)

Per-serving micronutrient profile from solver weight recovery. 21 nutrients reported: 0 confirmed above RDA, 0 intake unclear, 21 confirmed below RDA relative to daily RDA. Uncertainty reflects USDA composition CV only (single serving; weekly quadrature compression does not apply to individual products).

10.9 What Micronutrient Screening Enables

The micronutrient screening proposition

Every conventional nutrition tracker reports daily micronutrient point estimates with no uncertainty. A user sees “Iron: 8.2 mg (94% of RDA)” and has no way to know whether to act on it. The number could be 30% too high or too low — the tracker provides no signal.

Eatomate reports weekly totals with propagated 95% confidence intervals, classified into confirmed above RDA, intake unclear, and confirmed below RDA buckets. A user sees “Vitamin B12: 10.2 mcg/week ± 2.6 mcg (95% CI: 7.6–12.8 mcg). Weekly target: 16.8 mcg. Even at the upper bound of our estimate, your intake falls short. Status: CONFIRMED BELOW RDA (95% CI).”

The weekly aggregation is critical: per-ingredient CVs of 10–20% compress to weekly CVs of 3–15% through quadrature across independent food groups. This compression is what makes the confidence intervals tight enough to produce actionable screening — daily point estimates cannot achieve this. To our knowledge, no other commercially available nutrition tracker has attempted quantified micronutrient screening with propagated uncertainty bounds.

11. Conclusions

Ten conclusions emerge from this analysis:

1. Barcode scanning and kitchen scales eliminate two of the three sources of caloric tracking error entirely. The only remaining error for single-ingredient pantry items is caloric density variation per gram — an irreducible biological fact.
2. For barcoded supermarket products, the relevant variance is within-SKU biological variation bounded by the $\pm 20\%$ legal label tolerance. Population-level biological variance figures do not apply to compliant labelled products: manufacturers must control inputs to meet label compliance requirements.
3. Loose produce logged via USDA matching introduces no additional uncertainty relative to barcoded produce. Even doubling produce variance moves the weekly accuracy by less than 0.27 percentage points.
4. Manufactured and processed foods are accuracy anchors. Their within-brand 2σ CVs of 1–8% are lower than most fresh whole foods. Counterintuitively, a diet heavy in barcoded manufactured products is therefore tracked more accurately than an equivalent whole-food diet — because tight industrial process control, not nutritional quality, determines caloric predictability.
5. Eatamate achieves greater than 93% weekly caloric accuracy at 2σ across Scenarios A and B, for all supported household sizes (1–10 users). This is a conservative floor: single-user households in Scenario A reach 95.47%–95.99%, and in Scenario B reach 95.04%–95.28%. Multi-user households stabilise above 93.1% regardless of size, with the accuracy floor determined by the irreducible caloric density uncertainty of independent restaurant meals. Scenario C (restaurant-heavy) falls materially below this floor. The $\geq 93\%$ claim applies to users for whom home-cooked and barcoded food represent the majority of weekly intake.
6. This accuracy is delivered retrospectively — on last week’s data, when users review their progress. Individual meal logs during the week carry Gaussian portion uncertainty. After reconciliation, portion error collapses to zero by mass conservation. What remains is only the irreducible caloric density uncertainty quantified in the $\geq 93\%$ accuracy figures.
7. Reconciliation is event-driven, not calendar-driven. Short-expiry items reconcile automatically at natural expiry — no user action, potentially multiple times per week. Long-expiry staples reconcile when probabilistic consumption crosses a caloric threshold — one occasional reweigh, triggered only when genuinely needed. The system self-regulates its own accuracy.
8. The combination of three calibration weighings, zero ongoing weighing, sub-2-second logging, and physics-based retroactive reconciliation means Eatamate has fully decoupled speed from accuracy. These are not in tension. They operate on different timescales. To our knowledge, no other commercially available nutrition tracker has separated these two problems.
9. Eatamate tracks 27 micronutrients with full uncertainty propagation for 24 of them. Per-ingredient composition CVs of 10–20% compress to weekly CVs of 3–15% through

quadrature summation across independent food groups — the same mechanism that underpins the $\geq 93\%$ caloric accuracy floor. This compression is what makes micronutrient confidence intervals tight enough to produce actionable weekly screening.

10. No other commercially available nutrition tracker reports micronutrient intake with propagated uncertainty bounds. Eatamate classifies each nutrient into three screening buckets — confirmed above RDA, intake unclear, or confirmed below RDA (all at 95% CI) — based on whether the 95% confidence interval clears the weekly RDA threshold. The gram-level precision delivered by post-reconciliation ingredient quantities is the prerequisite that makes this clinically meaningful; without it, the uncertainty intervals would be too wide to screen.

Appendix: Data Sources and Statistical Methods

Primary data sources:

USDA FoodData Central — primary composition data; ground beef fat variance (Howe et al., 2007)

McCance & Widdowson's Composition of Foods Integrated Dataset 2021 (UK CoFID)

ICMR-NIN Indian Food Composition Tables 2017 — used for spice and lentil cultivar variance cross-validation; lentil caloric density ranges are consistent across Canadian, Indian, and UK-grown cultivars

Ramdath et al. (2020, Foods) — bomb calorimetry of 20 Canadian lentil cultivars

Ngo et al. (2024, Current Research in Food Science) — Thai rice cultivar energy

Petracci et al. (2014, Italian Journal of Animal Science) — white striping in chicken

Serrano Ayora et al. (2025, Foods, 14:4276) — comprehensive evaluation of physicochemical parameters in retail chicken meat

Anderson et al. (2014, Animal) — lamb intramuscular fat, n=400

Heck et al. (2009, Journal of Dairy Science) — seasonal variation in pooled milk

UK FSA Basket of Goods Survey 2021 — label compliance rates

Urban LE, Weber JL, Heyman MB et al. (2016, Journal of the Academy of Nutrition and Dietetics, 116:590–598) — energy content of frequently ordered non-chain restaurant meals by cuisine type; overall meal SD ± 465 kcal on mean 1,205 kcal; basis for independent restaurant within-cuisine residual random variance estimate

Urban LE, McCrory MA, Dallal GE et al. (2011, JAMA, 306:287–293) — accuracy of stated energy contents of chain restaurant foods; bomb calorimetry of 269 items from 42 restaurants; stated values accurate overall with substantial individual item variability

National Academy of Sciences (1986) — Nutrient Adequacy: Assessment Using Food Consumption Surveys. Table E-3, pp.129–146. National Academies Press, Washington DC. Primary source for micronutrient composition CVs.

Pehrsson PR, Patterson KY, Spungen JH et al. (2016, American Journal of Clinical Nutrition, PMC5004502) — Iodine in food- and dietary supplement-composition databases; basis for iodine CV of $\pm 30\%$ used in Section 10.

USDA/FDA/ODS-NIH Iodine Database Release 4.0 (2024) — per-food iodine standard deviations used to validate Section 10 iodine uncertainty estimates.

Mock DM, Mock NI, Stratton SL (2004, Journal of Nutrition, 134:1301–1305) — biotin composition variability up to 247× across analytical methods; basis for point-estimate-only treatment of biotin in Section 10.3.

Statistical methods: CVs calculated from published standard deviations where available; estimated as (range/4)/mean where only ranges were reported. Within-brand CVs derived by variance decomposition: $\sigma^2(\text{within-brand}) = \sigma^2(\text{across-brand}) - \sigma^2(\text{between-brand})$, with between-brand component estimated as 40–60% of across-brand variance. For barcoded products where biological variance exceeded $\pm 20\%$, the legal cap is used as the binding 2σ figure. Weekly accuracy uses root-sum-of-squares across independent food groups, with within-group variance treated as 100% correlated for same-batch groups. Portion error contribution is zero post-reconciliation by construction — mass conservation is a hard constraint, not a statistical estimate.

Within-brand CV estimates are inferences derived by variance decomposition from published data, not direct measurements of specific retail products. Label compliance cap figures ($\pm 18\%$ for fatty meats) represent the maximum permissible variance under UK law; actual own-label products typically show tighter within-SKU variance due to supplier specifications.

Derivation of Within-Cuisine Restaurant Variance

The baseline variance for independent restaurant meals is derived from Urban et al. (2016, JAND, PMC5746190), which reports a mean of 1,205 kcal and a standard deviation of 465 kcal (1σ) across 364 meals from 123 non-chain restaurants spanning 9 cuisine types in 3 US cities.

The total standard deviation reflects variability across all cuisines and regions and contains two components: between-cuisine variance (systematic differences in mean calorie levels across cuisine types) and within-cuisine variance (random variation in portion size, preparation, and ingredients within a cuisine). Eatomate applies cuisine-specific correction factors at logging to remove the systematic between-cuisine offset, leaving only the within-cuisine random variation as residual uncertainty.

Unweighed restaurant meals (current scenarios)

The within-cuisine energy variance is estimated using the standard pooled within-group estimator applied directly to the cuisine-level standard deviations reported in Table 2 of Urban et al.:

$$\begin{aligned}\sigma_{\text{within}} &= \sqrt{[\sum(n_j-1)\sigma_j^2 / \sum(n_j-1)]} \\ &= \sqrt{(58,755,599 / 355)} = 406.8 \text{ kcal} \approx 407 \text{ kcal}\end{aligned}$$

This corresponds to a 1σ CV of 33.8% and a 2σ figure of $\pm 67.5\%$ on the grand mean of 1,205 kcal. The figure is used throughout the analysis for unweighed independent restaurant meals. It is consistent with the study's own finding that cuisine type and region together account for only 36% of between-meal variability, confirming that within-cuisine random variation is the dominant term.

Weighed restaurant meals (network-data model)

When gram weight is known (via the takeaway-weight network described in Section 7.5a), portion uncertainty is eliminated and the residual is only within-cuisine caloric density variation. This is estimated from the energy density columns of Table 2 of Urban et al. using the same pooled estimator:

$$\sigma_{\text{ED,within}} = \sqrt{[\sum(n_j-1)\sigma_{\text{ED},j}^2 / \sum(n_j-1)]} = 0.580 \text{ kcal/g}$$

For a 700 kcal meal at the grand mean energy density of 1.87 kcal/g, the weighed portion is 374 g. The 2σ caloric error is $374 \text{ g} \times 2 \times 0.580 \text{ kcal/g} = \pm 434 \text{ kcal}$, corresponding to a CV of $\pm 62.0\%$ at 2σ . This is the figure used for independent restaurant meals in the weighed scenarios. The improvement over the unweighed figure ($\pm 67.5\% \rightarrow \pm 62.0\%$) is real but bounded: within-cuisine energy density variation driven by chef-to-chef ingredient differences remains irreducible without direct calorimetric analysis of the meal.

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