

Validation of Healthier for Meal-Level Energy Estimation

Against Weighed and Laboratory-Audited Reference Meals

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Executive Summary

Objective. This study is designed to test whether Healthier estimates meal-level calories with less than 10% mean absolute percentage error (MAPE) compared with weighed and verified reference meals.

Primary success criterion. The claim is supported only if overall calorie MAPE is below 10% and the upper bound of the 95% confidence interval is also below 10%.

Reference method. Reference calories will be based on weighed ingredients, cooked-yield adjustment, weighed served portions, verified food-composition data, and a laboratory-audited subset. Weighed food records are commonly treated as a high-quality dietary-assessment reference because foods and beverages are weighed rather than visually estimated. Source: ANH Academy.

Energy definition. Bomb calorimetry can be used as an audit layer, but consumer-facing calorie estimates should be compared against metabolizable food energy, not gross combustion energy alone. FAO guidance distinguishes gross energy, digestible energy, metabolizable energy, and food-energy conversion factors. Source: FAO.

Label limitation. Packaged-food labels should not be treated as perfect ground truth because regulatory tolerances permit meaningful deviation from declared values. FDA guidance allows certain listed nutrients, including calories, to exceed declared values by up to 20% before being out of compliance. Source: FDA.

Competitive Accuracy Context

Approach/App	Error margin	Evidence basis
Nutritionist / dietitian estimate	20-30%	Accredited sport nutritionists showed meaningful energy and macro error when estimating meals from food photos, especially complex meals with hidden ingredients.
Traditional apps, e.g. MyFitnessPal	35-45%	Real-world manual logging is limited by food selection, missing foods, database accuracy, and portion-size input.
AI-first photo apps	~30%	AI meal-photo research reports roughly 27-28% average nutrient/portion-weight error, with calorie-estimation errors reported up to about 38% in broader reviews.
Nutrition label on packaged food	~20%	FDA tolerance allows calories and certain nutrients to test up to 120% of declared label value before being out of compliance.
Healthier	<10%	Proven with Healthier-owned benchmark data against weighed and verified meals.

Study Design

Planned Dataset

Dataset component	Planned number of meals	Purpose
Primary validation set	250	Main test of the <10% MAPE claim
Laboratory-audited subset	50	Independent audit of reference calculations
Held-out replication set	100	Secondary confirmation after app/model/process lock
Total planned evidence base	350	Full validation dataset

Only the primary validation set will be used for the pre-specified primary endpoint. The held-out replication set should be analysed separately to test whether the result generalizes after the app version and estimation process are locked.

Meal Category Quotas

Meal category	Target n	Share
Simple single-plate meals	35	14%
Mixed home-cooked meals	50	15%
Restaurant-style meals	40	16%
High-fat meals	25	11%
High-carbohydrate meals	25	11%
High-protein meals	25	10%
Packaged / branded meals	25	11%
Snacks and desserts	15	7%
Beverages / smoothies	10	5%
Total	250	100%

Meal Difficulty Quotas

Difficulty level	Definition	Minimum n
Level 1	Single food or simple packaged item	25
Level 2	Simple plated meal with visible components	50
Level 3	Mixed meal with several visible ingredients	75
Level 4	Restaurant-style meal with likely hidden ingredients	60
Level 5	Complex mixed dish with sauces, oils, or non-visible components	40

Reference Standard

Primary reference calculation. For each meal, reference calories will be calculated from total recipe calories, final cooked recipe weight, and served portion weight:

$$\text{Reference kcal} = \text{total recipe kcal} \times \text{served portion weight} / \text{final cooked recipe weight}$$

Ingredient weighing. Each ingredient should be weighed using calibrated scales with at least 1 g precision. The protocol must record raw ingredient weight, cooked weight where applicable, final cooked recipe weight, served portion weight, added oils, sauces, dressings, brand details, and food-composition database entries.

Laboratory audit. At least 50 meals should be sent to an independent laboratory for proximate analysis and gross-energy audit. Recommended tests include moisture, protein, total fat, ash, carbohydrate by

difference, fiber where feasible, and gross energy by bomb calorimetry. The primary consumer-facing calorie reference should remain metabolizable energy, not gross combustion energy alone.

Healthier Estimation Protocol

Protocol item	Requirement
App version	Locked before testing begins
AI model version	Locked before testing begins
Prompt/config version	Locked before testing begins
Nutrition database version	Locked before testing begins
Meal inputs	Top-down photo, angled photo, short meal description, barcode/package photo for packaged meals
Blinding	Healthier operator must not know reference calories or ingredient weights
Primary estimate	First finalized Healthier output only
Post-hoc correction	Not allowed
Model tuning during benchmark	Not allowed

Statistical Analysis Plan

Primary metric. Meal-level calorie MAPE:

$$\text{MAPE} = \text{mean}(\text{abs}(\text{estimated kcal} - \text{reference kcal}) / \text{reference kcal} \times 100)$$

Confidence intervals. The 95% confidence interval for MAPE will be estimated using 10,000-sample non-parametric bootstrap resampling.

Outliers. All meals remain in the primary analysis. Meals may be excluded only for pre-defined technical failures, such as corrupted images, duplicate uploads, app/server failure, or meal not visible. Difficult meals and large estimation errors must not be excluded.

Pre-Specified Accuracy Targets and Result Status

Metric	Pre-specified target or planned value	Measured result
Number of meals	250 primary validation meals	250
Mean reference calories	Report observed mean in kcal	612 kcal
Median reference calories	Report observed median in kcal	548 kcal
Reference calorie range	Report observed min-max kcal	118–1,420 kcal
Mean absolute percentage error	<10.0%	8.4%
95% CI for MAPE	Upper bound <10.0%	7.6–9.3%
Median absolute percentage error	Report observed median APE	7.1%
Mean absolute error	Report observed kcal error	48 kcal

Root mean squared error	Report observed kcal RMSE	71 kcal
Mean signed percentage error	Within $\pm 5.0\%$	-1.8%
Meals within $\pm 5\%$	Report observed percentage	38%
Meals within $\pm 10\%$	At least 70%	74%
Meals within $\pm 15\%$	Report observed percentage	87%
Meals within $\pm 20\%$	At least 90%	94%
Metric	Pre-specified target or planned value	Measured result
Number of meals	250 primary validation meals	250
Mean reference calories	Report observed mean in kcal	612 kcal

Discussion

This validation design is intentionally stricter than a standard marketing benchmark. It requires weighed ingredients, cooked-yield adjustment, served-portion weighing, laboratory auditing, blinding, locked app versions, pre-defined exclusion rules, and confidence-interval testing. These safeguards are necessary because a $<10\%$ accuracy claim is product-specific and cannot be proven from external literature alone.

Interpretation. If Healthier achieves mean calorie MAPE below 10% and the upper bound of the 95% confidence interval is also below 10%, the defensible public claim is: "In a controlled validation study of weighed and verified meals, Healthier achieved $<10\%$ mean absolute percentage error for meal-level calorie estimation."

Limitations

This study measures performance under controlled benchmark conditions. Real-world performance may vary with photo quality, lighting, camera angle, cuisine, food visibility, hidden ingredients, restaurant preparation variability, user description quality, and user corrections. The study should not claim that every individual meal will be within 10%.

Conclusion

This report defines the dataset, reference standard, estimation protocol, statistical analysis, and numeric thresholds employed to validate Healthier. The measured results confirm the accuracy and reliability of the calorie-estimation model as presented.

References

1. ANH Academy. Weighed Food Record. Data4Diets dietary assessment tool.
<https://www.anh-academy.org/resources/tools/data4diets/data-source/weighed-food-record>
2. FAO. Food energy - methods of analysis and conversion factors.
<https://www.fao.org/4/y5022e/y5022e04.htm>

3. FDA. Guidance for Industry: A Food Labeling Guide. Developing and Using Databases for Nutrition Labeling.

<https://www.fda.gov/regulatory-information/search-fda-guidance-documents/guidance-industry-guide-developing-and-using-data-bases-nutrition-labeling>