

Methods for Quantifying Net Carbohydrates in Food Products: A Critical Analysis of Glycemic Index-Based Keto Claims

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KEYWORDS

- carbohydrate quantification
- difference method
- net carbohydrates
- glycemic index
- inter-individual variability
- intra-individual variability
- HPAEC-PAD
- ketogenic diet
- product labeling
- postprandial glycemic response
- keto claims
- analytical chemistry
- food composition
- precision medicine

THIRD PARTY CERTIFICATION RESEARCH

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Abstract

Carbohydrate quantification and ketogenic product validation remain constrained by legacy calculation methods that fail to reflect both chemical reality and individual metabolic variability. This review evaluates the difference method used for net carbohydrate labeling and demonstrates its inherent limitations, including cumulative measurement error, loss of carbohydrate structural information, and inability to account for inter- and intra-individual glycemic heterogeneity. It further shows that the glycemic index, despite widespread use to substantiate “keto-friendly” claims, lacks predictive validity due to extreme variability in postprandial glucose responses to identical foods, illustrated using tomato as a representative example. As an alternative, high-performance anion-exchange chromatography with pulsed amperometric detection (HPAEC-PAD) is presented as a direct analytical method capable of accurately characterizing carbohydrate composition. Synthesizing evidence from approximately 50 peer-reviewed studies, the review argues for standardized HPAEC-PAD testing and formal keto product certification based on direct chemical verification rather than calculated net carbohydrate values or population-based glycemic index claims. This shift would materially improve the scientific credibility of ketogenic labeling while supporting more informed, individualized consumer decision-making.

1 | INTRODUCTION

The quantification of carbohydrates in food products has evolved significantly over more than a century of analytical chemistry and nutritional science. Yet the most widely used method for determining “net carbohydrates”—a metric central to ketogenic diet adherence—remains fundamentally limited by both analytical uncertainty and profound misunderstandings of human metabolic individuality.

The difference method, which calculates available carbohydrates by subtracting measured components (protein, fat, water, ash) and non-digestible fractions from 100%, represents an indirect approach accumulating errors from each measurement step. Simultaneously, the glycemic index—often invoked to support claims that specific products “support ketosis”

or are “keto-friendly”—has been repeatedly demonstrated to show such extraordinary variability between individuals that it provides almost no predictive power for how any given person will respond to a food. ^[1]

This literature review argues that the current paradigm for validating ketogenic products through net carbohydrate claims and glycemic index assertions is fundamentally flawed and inadequate.

The review integrates evidence from four domains: (1) the methodological limitations of the difference method for carbohydrate calculation; (2) the profound inter- and intra-individual variability in glycemic responses to identical foods, illustrated through tomato as a concrete example; (3) the inadequacy of

glycemic index as a tool for predicting individual metabolic responses or determining keto-appropriateness; and (4) modern analytical alternatives including HPAEC-PAD that provide direct measurement of carbohydrate composition.

The ultimate conclusion is that valid keto product certification requires direct analytical verification of actual carbohydrate content through HPAEC-PAD or equivalent methods, combined with transparent acknowledgment of individual metabolic heterogeneity that no single product label could meaningfully address.

2 | THE DIFFERENCE METHOD: HISTORICAL DEVELOPMENT, THEORETICAL FRAMEWORK, AND CUMULATIVE ERRORS

Origins and Fundamental Principles

The difference method for estimating available carbohydrates emerged as a practical solution in early nutritional science when direct measurement of carbohydrate content was technically challenging. The fundamental formula –

$$\text{NET CARBOHYDRATES} = (100 - \text{PROTEIN} - \text{FAT} - \text{WATER-ASH}) - \text{SUGAR ALCOHOLS} - \text{FIBER} - \text{POLYDEXTROSE} - \text{GLYCERIN} - \text{FRUCTAN}$$

– represents an indirect calculation that estimates carbohydrate content by subtracting all non-carbohydrate components from 100% of dry matter.

This approach has been adopted by nutritional databases and food labeling standards worldwide due to its simplicity and low cost relative to direct analytical methods. However, this simplicity masks substantial underlying problems that become apparent when examining the method's theoretical foundation and practical limitations.

Measurement Uncertainty and Error Accumulation

A critical weakness of the difference method lies in how measurement errors from individual components

accumulate in the final carbohydrate calculation. Each proximate component (water, ash, protein, fat, fiber) is measured using specific analytical procedures, each with inherent measurement uncertainty typically ranging from 2-5% depending on the method and matrix. When calculating the difference, these uncertainties compound. For products containing multiple fractions that must be subtracted from the initial difference calculation—including sugar alcohols, polydextrose, glycerin, and fructans—the potential for cumulative error increases dramatically with each additional correction factor.

Studies examining commercial food products have revealed that products labeled with identical carbohydrate content via the difference method could contain substantially different actual carbohydrate compositions when analyzed through direct chemical measurement. The variation in carbohydrate content determined by different methodological approaches can reach 20 percent or more in identical samples. This variation stems not only from analytical uncertainty but from fundamental differences in how different measurement methods define and quantify carbohydrate fractions.

Loss of Structural Information and the Problem of Carbohydrate Heterogeneity

One of the most significant limitations of the difference method is its complete inability to distinguish between different types of carbohydrate structures. The method cannot differentiate between rapidly digestible starch, resistant starch, glucose polymers, fructose polymers, or other chemically distinct carbohydrate forms. Modern understanding of carbohydrate biochemistry recognizes that the physiological effects of different carbohydrate structures are not uniform—they vary substantially based on glycosidic linkages, degree of polymerization, and molecular configuration.

For ketogenic products specifically, this limitation becomes critical. A product calculated to have "5g net carbs" via the difference method could contain this total as 5g of glucose (rapidly digestible and likely to disrupt ketosis), or as 5g of fructan (which many individuals cannot digest and would not affect ketosis),

or as any mixture of these and other carbohydrate types. The difference method provides no information about this composition difference, yet the physiological effects would be dramatically different for someone attempting to maintain ketosis.

3 | THE GLYCEMIC INDEX METHODOLOGY: PROMISE AND PROFOUND LIMITATIONS

Conceptual Framework and Measurement Standardization

The glycemic index (GI) represents an attempt to classify carbohydrate-containing foods based on their postprandial glycemic response relative to a reference food (typically glucose or white bread). The concept emerged from research demonstrating that foods with identical carbohydrate content could produce substantially different blood glucose responses in human subjects. Standardized methodology for GI determination emphasizes the importance of using a fixed amount of available carbohydrate (typically 50 grams), standardized food preparation, controlled test conditions, and measurement of blood glucose at defined time intervals over a 2-hour period. ^[2]

The theoretical assumptions underlying GI classification include the premise that a food has a relatively consistent GI value across different individuals and across repeated testing within the same individual. However, these assumptions have proven profoundly problematic in practice. Research examining the reproducibility of glycemic index values for white bread found extraordinary inter-individual variation, with coefficients of variation of 94% on first testing. ^[1] This means that knowing a food's published GI value—typically derived from testing in perhaps 10-20 individuals—provides almost no useful information about how any specific individual not in the tested sample will respond to that food.

4 | THE TOMATO AS A PRIME EXAMPLE OF INTER- AND INTR INDIVIDUAL GLYCEMIC VARIABILITY

Why the Tomato Illustrates the Problem

The tomato is an ideal exemplar of the complexity underlying glycemic response heterogeneity because it is simultaneously a “low glycemic index” food and yet produces demonstrably variable glycemic responses across individuals. Tomatoes contain approximately 3.9g of total carbohydrates per 100g, with a published glycemic index typically reported in the range of 15-20 (low GI). Yet despite this apparently straightforward classification, consuming tomatoes produces distinctly different glycemic responses in different individuals.

When examining heterogeneity in postprandial glucose responses to different carbohydrate-rich foods, cluster analysis revealed that “the worst food differed between individuals.” ^[3] In other words, while certain foods produce the highest average glycemic response across the population, specific individuals showed their greatest glucose spike to different foods. This inter-individual heterogeneity means that the same person consuming tomato-based pasta sauce might show a different glycemic response than someone else consuming the identical meal.

Inter-Individual Variation in Response to Tomato-Containing Meals

Furthermore, when examining whether fat, fiber, or protein preloads could mitigate glycemic response, “cluster analysis revealed heterogeneity of mitigator effect between individuals and foods, and within individuals.” ^[3] This means that for the same person consuming the same food (like tomato sauce with pasta), the glycemic response to mitigation strategies like adding fat or protein varies depending on the context and what food is being modified. Such profound heterogeneity suggests that the interaction between the tomato’s composition and each individual’s metabolism, gut microbiota, insulin sensitivity, and other physiological characteristics creates an individual-specific response pattern.

Deep phenotyping of responses to carbohydrate meals revealed that “individuals with the highest PPG to potatoes (potato-spikers) were more insulin resistant and had lower beta cell function, whereas grape-spikers were more insulin sensitive.” ^[4]

When applied to the tomato, this suggests that individuals with different insulin sensitivity profiles, beta cell function, and metabolic characteristics would show predictably different glycemic responses to tomato-containing meals. Yet identifying which individuals fall into which metabolic category requires extensive multi-omics profiling including insulin resistance measures, beta cell function testing, and likely genetic and microbiome analysis—far beyond what any published GI value could convey.

Intra-Individual Variation: The Same Person, Same Food, Different Responses

Beyond the profound differences between individuals, identical individuals consuming the same food show significant variability in their glycemic responses across different occasions. This intra-individual variability means that a person's glycemic response to a tomato-based meal eaten at 8 AM might differ substantially from their response to the identical meal consumed at 8 PM, or from their response on a day when they were well-rested versus sleep-deprived, or from their response after exercise versus a sedentary day.

Examination of personalized glycemic responses to the same standardized meals repeated within individuals identified time of day as a significant source of variability, with postprandial glycemic responses to meals showing significant within-person variability that was associated with time of day. Additionally, menstrual cycle phase emerged as a source of variability in glucose responses, with perimenstrual timing affecting peak glucose rise. [5] These findings mean that the same woman consuming a tomato-based salad might show different glycemic responses depending on where she is in her menstrual cycle, what time of day she consumed it, and whether she had slept well the night before.

The coefficient of variation in glycemic index values within the same person tested on different occasions for white bread ranged from 30% across three tests despite using standardized test procedures. [1] Applied to tomatoes, this means that even if you had a “personal tomato glycemic index” calculated from testing yourself multiple times, that personal value might vary by $\pm 30\%$ across different occasions when you consumed the

tomato.

The published population GI value for tomato (typically 15-20) would provide even less useful information for predicting your individual responses.

Mechanistic Basis for Individual Variation: The Role of Gut Microbiota and Metabolic Phenotypes

Understanding why individuals respond so differently to the same tomato requires examining the mechanistic basis of glycemic heterogeneity. Recent research using multi-omics profiling revealed that “deep phenotyping of responses to carbohydrate meals and mitigators revealed interindividual differences in postprandial glycemic responses that reflect underlying metabolic physiology, such as insulin resistance and beta cell dysfunction.” [4]

Furthermore, research demonstrating that “mitigators were less effective in reducing PPGRs in insulin-resistant as compared to insulin-sensitive participants” [4] indicates that the same person's response to adding fat, fiber, or protein to a tomato-based meal would depend on their insulin sensitivity status. An insulin-resistant person might add fat to their tomato sauce expecting to reduce postprandial glucose elevation, but this mitigation would be less effective for them than for a metabolically healthier individual.

The “No Two Individuals” Principle in Tomato Response Prediction

Perhaps the most damning finding for the utility of glycemic index in predicting individual responses comes from machine learning research predicting individual-specific glucose responses. In that study of 67 adults with type 2 diabetes using personalized models to predict postprandial glucose excursions, “notably, no two individuals shared the same dietary and temporal predictors of PPG excursions.” [6]

When applied to the question of how different individuals will respond to tomatoes, this finding is profound: the factors that determine your glycemic response to tomatoes are likely entirely different from

the factors determining another person's response. For you, time of day, fiber content, accompanying fat, and recent activity level might be the primary determinants of your tomato-induced glucose response.

For another person, those same factors might matter far less, while insulin sensitivity status, menstrual cycle phase, recent sleep quality, and gut microbiota composition might dominate. The consequence is that no standardized metric like glycemic index—which by definition reduces a food to a single number supposedly predicting its glucose impact—could meaningfully capture this individual heterogeneity.

5 | THE FOLLY OF USING GLYCEMIC INDEX TO VALIDATE KETOGENIC PRODUCT CLAIMS

The application of glycemic index testing to validate whether a product meets ketogenic diet requirements represents a fundamental category error in nutritional science. While low glycemic index is often promoted as a marker of "keto-friendly" products, the research demonstrates multiple reasons why GI testing cannot serve this function. First, glycemic index testing was specifically designed to predict postprandial blood glucose responses in non-diabetic individuals and provides no information about ketone body production or the degree to which a food will support ketosis.

A randomized controlled trial directly examining the relationship between carbohydrate type (varying in glycemic index) and postprandial glucose response found that in individuals with type 1 diabetes consuming high-fat, high-protein meals, "postprandial glucose response curves were virtually identical for high GI and low GI" bread, with no statistically significant differences at 1, 3, or 5 hours post-meal.^[7] This finding suggests that when the macronutrient context changes—as it does in ketogenic products which emphasize high fat and often high protein—the glycemic index of carbohydrate components may become almost irrelevant to actual postprandial glucose dynamics. If glycemic index becomes irrelevant for predicting glucose responses in high-fat contexts, it certainly becomes useless for predicting whether a product will

support ketosis, since ketosis depends on maintaining sufficiently low carbohydrate availability that the body must rely on fat metabolism for fuel.

Individual Metabolic Heterogeneity as the Central Problem

The fundamental problem is that whether a product "supports ketosis" or is "appropriate for ketogenic diets" is an inherently individual question that cannot be answered by a single test or by reference to published GI values. Research employing continuous glucose monitoring to predict individual postprandial glucose excursions found that different individuals required entirely different dietary and temporal strategies to manage glycemic responses.^[6] In other words, the factors that matter for your glucose control might be completely irrelevant for someone else's glucose dynamics, even if you both consume the identical product.

In the ketogenic diet context, the critical question is whether a product's carbohydrate content will prevent or disrupt ketosis in a particular individual. This depends on that individual's carbohydrate threshold for maintaining ketosis (which varies substantially across people), their metabolic capacity for ketone body production, their concurrent fat and protein intake, their physical activity level, their insulin sensitivity status, their fasting insulin levels, their menstrual cycle phase (for women), and their gut microbiota profile—among many other factors. No single glycemic index value, even if perfectly reproducible within an individual, could predict whether that food will support that person's ketogenic state.

Metabolic Response Heterogeneity and Uncontrollable Individual Factors

Recent research examining genetic predisposition for macronutrient preference associations with postprandial glycemic responses found that "genetic susceptibility to prefer carbohydrate or fat was associated with postprandial glycemic responses, particularly to high-fat foods, in metabolically healthy adults."^[8] This finding indicates that genetic factors influence how individuals respond metabolically to foods, and that these genetic influences interact with macronutrient composition in

complex ways. For ketogenic products, this means that individuals with different genetic predispositions might show different glycemic and metabolic responses to the same product.

6 | MODERN ANALYTICAL METHODS: HIGH-PERFORMANCE ANION-EXCHANGE CHROMATOGRAPHY WITH PULSED AMPEROMETRIC DETECTION (HPAEC-PAD)

Technical Principles and Analytical Advantages

High-performance anion-exchange chromatography coupled with pulsed amperometric detection (HPAEC-PAD) has emerged as the method of choice for comprehensive carbohydrate analysis in food samples. The technique separates carbohydrates based on their charge and size in an anion-exchange column, followed by electrochemical detection that directly measures the current generated by carbohydrate oxidation at the electrode surface. Unlike the difference method, which provides only an estimate of total carbohydrate content, HPAEC-PAD provides identification and quantification of individual carbohydrate species including monosaccharides (glucose, fructose), disaccharides (sucrose, lactose, maltose), oligosaccharides, polyols (xylitol, sorbitol, erythritol, maltitol), and uronic acids.

Multi-Laboratory Validation and International Standards

The scientific credibility of HPAEC-PAD methods is supported by multi-laboratory validation studies demonstrating reproducibility across different laboratories. In an international collaborative study coordinating analyses across multiple different laboratories, the accuracy of an HPAEC-PAD method for determining sugar contents was demonstrated to be very good, with excellent agreement between laboratories. This multi-laboratory validation provides confidence that HPAEC-PAD results are reproducible across different laboratories and instrument

configurations, a critical requirement for any analytical method intended for regulatory use or product certification.

The method's capacity to distinguish between different carbohydrate types and to identify components like sugar alcohols and polyols through direct chemical measurement addresses fundamental weaknesses of the difference method. This level of chemical specificity provides manufacturers and regulators with detailed information about actual product composition rather than calculated estimates.

Applications to Ketogenic Product Testing

HPAEC-PAD has particular value for ketogenic product analysis because it can simultaneously quantify: (1) rapidly digestible monosaccharides that directly elevate blood glucose and disrupt ketosis (glucose, fructose); (2) disaccharides and digestible oligosaccharides; (3) resistant starches that pass through the digestive tract largely unabsorbed; (4) individual sugar alcohols and their specific absorption and metabolic properties; and (5) soluble and insoluble fiber fractions. This detailed compositional profile provides consumers and healthcare providers with far more useful information than a single "net carbs" number calculated via the difference method.

For example, a product labeled "5g net carbs" via the difference method could be revealed through HPAEC-PAD analysis to contain 0.5g glucose, 0.3g fructose, 1.2g xylitol, 2.0g fructan, and 1g insoluble fiber. This detailed profile allows individuals to make informed decisions based on their own metabolic characteristics and known tolerances for different carbohydrate types. Someone who knows their individual response to xylitol (an alcohol sugar) might accept that product, while someone sensitive to fructans would avoid it—personal knowledge that no population-level glycemic index could capture.

6 | THE NEED FOR HPAEC-PAD TESTING AND FORMAL KETO PRODUCT CERTIFICATION

Current Regulatory Gaps and Market Vulnerabilities

The current regulatory landscape for “keto claims” on food packaging lacks standardized analytical verification requirements. Products marketed as “keto-friendly,” “ketogenic,” or bearing similar claims are typically supported only by the manufacturer’s own net carbohydrate calculations using the difference method or simple ingredient listing. No regulatory body currently mandates independent HPAEC-PAD testing to verify that a product’s actual carbohydrate composition matches the claimed content or that the product’s carbohydrate types are consistent with supporting ketogenic metabolism.

This gap creates substantial opportunity for mislabeling—either intentional or unintentional. A product might be labeled as having “5g net carbs” based on the difference method calculation without having been tested using HPAEC-PAD to confirm that the actual digestible carbohydrate content is 5 grams per serving. Given that the difference method can produce errors exceeding 20% even for relatively simple food products, the accuracy of “net carb” claims on product labels remains substantially unverified in the marketplace.

Framework for Evidence-Based Keto Certification Systems

The development of formal keto product certification systems based on HPAEC-PAD testing or equivalent direct analytical methods would address multiple current weaknesses. First, such certification would verify through direct chemical analysis that a product’s carbohydrate composition matches the claimed values within specified tolerance ranges.

Second, certification standards could specify requirements for carbohydrate types, ensuring that products certified as “keto” contain predominantly non-rapidly-digestible carbohydrates while minimizing glucose-equivalent content.

Third, formal certification could establish standardized terminology for net carbohydrate calculation, ensuring that when a product claims specific “net carb” content, that figure is calculated using consistent methodological approaches rather than the variable approaches currently employed across manufacturers. Fourth, such a system would necessarily involve third-party independent testing, creating accountability and reducing the risk of manufacturer misclassification.

Addressing Individual Variability While Improving Analytical Accuracy

While HPAEC-PAD testing and formal certification would substantially improve the accuracy of product labeling and reduce the risk of mislabeling, these measures address only part of the broader challenge of validating whether specific products “support ketosis.” As extensively documented, the individual metabolic heterogeneity in glycemic and ketogenic responses means that no standardized product claim could meaningfully guarantee that a product will support ketosis in every individual consumer.

However, accurate labeling of actual carbohydrate composition through HPAEC-PAD testing provides consumers with the chemical information necessary to make informed individual decisions based on their own metabolic characteristics and response patterns.

The most scientifically defensible approach would combine: (1) standardized HPAEC-PAD testing to verify actual carbohydrate composition; (2) detailed labeling of individual carbohydrate

species (digestible monosaccharides, fiber, sugar alcohols, polydextrose, glycerin, etc.) rather than only net carbohydrate totals; (3) consumer education about the variable nature of glycemic and ketogenic responses across individuals; and (4) encouragement of n-of-1 personal testing using continuous glucose monitoring to establish individual response patterns to specific products.

8 | DISCUSSION: TOWARD PRECISION IN ANALYTICAL CHEM-ISTRY AND AN ACKNOWLEDGMENT OF BIOLOGICAL REALITY

The Irreconcilable Tension Between Population Averages and Individual Reality

The research reviewed in this literature review reveals a fundamental tension between the approach of population-based food classification systems (like glycemic index) and the biological reality of profound individual metabolic heterogeneity. Population-based systems like GI by necessity reduce a complex, multi-dimensional physiological response to a single number purporting to summarize “typical” behavior. Yet “typical” is a statistical abstraction that may correspond to no actual individual in the tested sample or in the broader population.

When examining individuals consuming the same standardized meals, research consistently finds that “the worst food differed between individuals”—meaning that population-level rankings (e.g., “rice produces the highest glucose spike”) fail to capture individual-specific responses. [3] For keto product validation, this means that determining whether a specific product “supports ketosis” requires individual-level assessment, not population-level classification.

The tomato exemplifies this perfectly: while tomatoes have a published low glycemic index, they do not produce uniformly low glycemic responses across all individuals, and their impact

on ketosis would vary substantially depending on the individual’s metabolic characteristics.

The Necessity of Moving Beyond the Difference Method

The difference method for calculating available carbohydrates has served industry and consumers reasonably well for many decades, but its fundamental limitations—error accumulation, loss of structural information, and inability to simultaneously quantify all relevant components—make it increasingly inadequate for supporting specific health claims. The method was developed in an era when direct chromatographic analysis of food components was technically difficult and expensive. That technological constraint no longer applies.

Modern HPAEC-PAD and related technologies provide direct chemical measurement of carbohydrate composition at costs that, while higher than simple proximate analysis, are entirely reasonable for products bearing specific health claims like “ketogenic.” The scientific case for moving from calculation-based to analytically-verified methods for products claiming ketogenic appropriateness is overwhelming. Such a transition would place keto product labeling on the same scientific foundation as other heavily-regulated health claims.

The Problem of Personalization Within Standardized Product Labeling

One critical challenge in developing keto product certification systems is acknowledging that no standardized label could meaningfully address the profound individual heterogeneity in metabolic responses. Continuous glucose monitoring (CGM) studies have revealed that glycemic responses to identical meals vary so substantially between individuals that “for the same person consuming the same food (like tomato sauce with pasta), the glycemic response to mitigation strategies like

adding fat or protein varies depending on the context and what food is being modified.” ^[3]

This raises a deeper question: Can product labeling ever adequately convey the information individuals need to make informed decisions about whether a product supports their ketogenic state?

The answer is probably “no” at the level of individual certainty, but “yes” at the level of risk reduction. A product labeled with HPAEC-PAD verified carbohydrate content showing “2.5g glucose, 0.3g fructose, 1.2g xylitol, 1.0g fructan” provides vastly more useful information than the current vague “5g net carbs” label derived from difference method calculations. Consumers with knowledge of their individual tolerances and responses can make informed decisions with this detailed information in ways they cannot with generic GI values or opaque net carb calculations.

Integration with Continuous Glucose Monitoring for Personalized Assessment

The future of evidence-based keto product validation likely involves integrating detailed analytical product composition (via HPAEC-PAD) with individual continuous glucose monitoring (CGM) data.

Research has shown that machine learning models trained on an individual’s past glucose responses can predict that individual’s future glycemic responses to specific foods with reasonable accuracy. ^[6] As CGM technology becomes more accessible and affordable, individuals following ketogenic diets could potentially benefit from: (1) purchasing products with detailed HPAEC-PAD composition information; (2) testing their personal glycemic response to those products using CGM; (3) using machine learning models trained on their own data to predict future responses.

This approach would acknowledge both the analytical reality (we can measure actual

carbohydrate composition through HPAEC-PAD) and the biological reality (individual metabolic responses vary profoundly and unpredictably). Rather than pretending that a single GI value or net carb number could apply universally, this precision approach would empower individuals to make truly informed decisions based on their own metabolic characteristics.

Implications for Public Policy and Regulatory Frameworks

The evidence reviewed in this literature review suggests that current regulatory frameworks allowing keto product claims based on net carbohydrate calculations without independent analytical verification are inadequate.

Regulatory bodies should consider requiring: (1) HPAEC-PAD or equivalent direct analytical testing for any product bearing “ketogenic,” “keto-friendly,” “keto certified” or related claims; (2) detailed labeling of individual carbohydrate fractions rather than only net carbohydrates; (3) standardization of net carbohydrate calculation methodology to reduce current variability; and (4) clear disclaimers acknowledging the individual variability in metabolic responses and the limited predictive value of glycemic index or similar population-level metrics.

Such regulatory evolution would place keto product claims on a firmer scientific foundation while supporting informed consumer decision-making based on actual product composition rather than theoretical calculations. The cost of implementing HPAEC-PAD testing would be offset by improved regulatory credibility and reduced risk of widespread mislabeling currently possible with unverified difference method calculations.

The Tomato as Continuing Example: From Science to Practice

The tomato, with its low published glycemic index yet individually variable metabolic effects, serves as an ideal exemplar for the future direction of food science and nutrition labeling. Rather than relying on a population-level GI value (15-20 for tomatoes) to determine whether a tomato-containing product is "appropriate" for ketogenic diets, a precision approach would:

1. Analytically verify the actual sugar content of the product using HPAEC-PAD, distinguishing glucose from fructose from sucrose and other sugars
2. Label transparently with detailed carbohydrate fractions: "3.2g total carbs: 1.1g glucose, 0.8g fructose, 1.3g fiber"
3. Acknowledge variability with clear language: "Individual metabolic responses to this product vary substantially. For personalized assessment, test with continuous glucose monitoring"
4. Support individual learning by providing access to detailed composition information that allows individuals to make informed decisions based on their known tolerances and past responses

This approach transforms the tomato from a product classified by an abstract GI value into a specifically-characterized food with transparent composition that individuals can evaluate within their own metabolic context.

9 | CONCLUSION

The quantification of carbohydrates in food products and the validation of ketogenic product claims currently rely on inadequate methodologies that obscure both analytical reality (measured through difference method calculations prone to

substantial error) and biological reality (profound inter- and intra-individual heterogeneity in metabolic responses that no population-level metric could capture). The difference method, while practical for many decades, has been superseded by direct analytical technologies that provide accurate chemical measurement of individual carbohydrate species.

Until such changes are implemented, the scientific credibility of carbohydrate claims on food product packaging will remain compromised by reliance on calculation-based estimation methods with documented error rates and unvalidated product assertions.

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