



Piperine and extract standardization: what the Haq review shows about the quality of black pepper products

Dr. A. Colonnese¹, R. Panzironi²

¹ Nutrition Biologist, Latina, Italy

² Independent Researcher, Latina, Italy

1. ABSTRACT

The review by Haq and colleagues examines piperine as the characteristic component of black pepper, describing its origin, studied activities, and application limits. Regarding product quality, the most useful point is distinguishing the whole spice from an extract: the latter can be measured and controlled, but it does not represent the entire food. The authors' summary describes piperine as a natural alkaloid—a nitrogen-containing plant substance—responsible for much of the pungent sensation of black pepper. The authors report that its quantity in pepper can vary from approximately 2% to 7.4%, a range indicating that the spice does not have an identical composition in all samples. The publication also collects experimental studies on the potential biological activities of piperine, including cell and animal models. These results explain the scientific interest in the molecule, but they do not equate to clinical evidence of benefit for those consuming black pepper in cooking. Regarding the topic of quality, the review is primarily helpful in understanding why manufacturers and researchers use extracts with a declared concentration. Standardization consists of verifying and maintaining a defined amount of a substance chosen as a reference, in this case, piperine. This reduces variability between batches, but it does not make an extract equivalent to whole black pepper: during extraction, purification, and formulation, the concentration, overall composition, and storage conditions change. The review is neither a clinical trial nor a direct analysis of individual commercial products.

VIDEO ARTICLE



ARTICLE INFORMATION

Received: October 21, 2026

Revised: October 21, 2026

Accepted: October 21, 2026

Published: October 2026

DOI 10.5281/zenodo.placeholder

KEYWORDS

controllo del contenuto di piperina negli estratti
estratto standardizzato di piperina
contenuto di piperina nel pepe nero
qualità degli estratti di pepe nero
variabilità della piperina
analisi della piperina

MISSION

LIFE Science Hub – Journal of Science was founded with the aim of making scientific knowledge accessible without giving up methodological rigour, quality of sources and authoritativeness of content. The journal promotes the dissemination of knowledge in the health, nutrition, medical and longevity sciences, building a bridge between the world of research and society.

Through articles, reviews, in-depth analyses and expert contributions, the Journal champions evidence-based medicine and science, fostering a correct interpretation of scientific data and countering misinformation. Every piece of content is developed with the aim of translating the complexity of research into understandable, useful and applicable information, while keeping intact the principles of accuracy, transparency and scientific independence.

Free from political, industrial and commercial influence, the journal stands as an authoritative and independent editorial space, dedicated to promoting scientific culture, professional development and the growth of health awareness among the public.



2. WHAT THIS RESEARCH ANALYZED

For the reader, the initial message is simple: piperine is an important component of black pepper, but black pepper is not the same thing as piperine. Haq and colleagues in 2021 examined extensive literature on the isolated molecule and the *Piper nigrum* plant. They considered its dietary origin, its presence in pepper, proposed biological mechanisms, and results obtained primarily in cells and animals. The most relevant data regarding quality concerns variability: the authors indicate that the piperine content in black pepper ranges approximately between 2% and 7.4%. In practice, the raw plant material can have different concentrations even before being ground or processed. This does not establish which product is better, but it explains why analytical measurements are needed when one wants to declare a precise concentration.

3. WHAT RESULTS EMERGE FROM THE STUDY

The review shows that piperine is studied both for its sensory role and for its potential interactions with biological processes. Most of the activities discussed, however, are derived from *in vitro* studies (on cells or biological components outside the organism) and *in vivo* studies in animals. These models are useful for formulating hypotheses, not for automatically estimating effects in normal human nutrition. In terms of products, the practical result is that a declared concentration requires a reliable measurement method. An analytical standard is a reference substance used to compare the signal obtained from the sample. Techniques such as high-performance liquid chromatography, or HPLC, separate the components of a mixture and allow for the quantification of piperine. The review by Haq and colleagues does not propose a single method or a universal quality threshold; instead, it describes the scientific context that makes standardization useful.

4. WHY THIS STUDY IS RELEVANT

The value of the publication is primarily interpretive. It helps avoid a common error: transferring data produced with purified piperine or concentrated extracts to the whole spice. If a preparation is standardized, the amount of the chosen molecule is

controlled across batches. This increases the reproducibility of the formulation, meaning the possibility of obtaining samples that are more similar to one another. However, this greater uniformity does not prove that the extract has a health effect, nor does it establish that it is equivalent to pepper used as a condiment. The whole product also contains volatile oils and other constituents; the extract therefore modifies the composition of the food matrix, which is the set of substances naturally present in the food itself. The next step is to evaluate how well these differences are documented by independent analyses.

5. STUDY LIMITATIONS AND WHAT IT DOES NOT DEMONSTRATE

Haq and colleagues published a narrative review in 2021, not a systematic review with predefined criteria for searching, selecting, and combining studies. For this reason, it offers a useful overview, but not a single quantitative estimate of the strength of the evidence. Furthermore, it brings together experiments that vary significantly in terms of model, dose, duration, and piperine preparation. The publication does not prove that a certain percentage of piperine guarantees the efficacy, safety, or superiority of a product. It also does not demonstrate that a value measured in the laboratory remains unchanged during storage, transport, and use. Finally, the range reported for black pepper cannot be used to calculate the amount actually consumed by a person without knowing the weight of the product, the analytical method, and the formulation.

6. INDEPENDENT CONFIRMING EVIDENCE

Independent verifications converge on the fact that the composition is not uniform and that quality control requires targeted analysis. Ahmad and colleagues compared black pepper samples from three commercial sources using accelerated extraction, chromatography, spectroscopy, and analysis of other components. The measured piperine differed between samples, with the highest value found in the analyzed Pakistani sample. This is direct confirmation of the need to distinguish between raw material and standardized product, but it concerns only three samples and does not allow for general rankings between origins [1]. Alqarni and colleagues analyzed four commercial spices and showed that both the



sample and the extraction method influence the amount of piperine recovered. Ultrasound-assisted extraction yielded higher values than the traditional procedure in all four products. This supports the transition from raw material to analytical result: what is measured also depends on the procedure. This is direct confirmation for technical control, not proof of biological differences in humans [2]. Park and colleagues developed a model using near-infrared spectroscopy, a technique that estimates composition by reading how the sample absorbs non-visible light, comparing it with HPLC. The work argues that many samples of ground pepper can be checked more quickly after proper calibration. This is indirect confirmation of the utility of batch control; the limitation is that the method must be validated for the samples and conditions of use intended [3].

7. CONFLICTING EVIDENCE

No directly conflicting evidence of sufficient relevance has been identified; this does not prove the absence of contrary results. However, some studies downplay the idea that every condition necessarily leads to significant differences. Kozukue and colleagues analyzed four commercial ground black pepper products and found relatively similar piperine values, ranging from 10.17% to 11.68% by weight. The same study, however, showed that light and duration of exposure promote isomerization, i.e., a change in the spatial arrangement of the molecule. The limited sample size does not negate the variability described by Haq, but it indicates that selected products can be similar [4]. Another clarification comes from the stress tests conducted by Kotte and colleagues. Under experimental conditions, piperine proved to be more stable to heat than to acid or alkaline hydrolysis, oxidation, and photolysis; degradation products were also identified in a black pepper extract. This contradicts the overly general idea that every heat treatment inevitably reduces piperine. The laboratory model does not reproduce a normal pantry or a recipe, so it defines conditions of chemical vulnerability rather than the actual shelf life of the products [5].

8. QUADRO COMPARATIVO E SINTESI DELLE EVIDENZE

The following publications evaluate how the composition and measurement of piperine can change based on the sample, extraction method, and

environmental conditions.

Quadro comparativo

Publication	Model and main data	Relationship with the Haq study	Interpretative limitation
Ahmad et al., 2020 [1]	Three commercial samples; higher piperine in the analyzed Pakistani sample.	Confirms variability and the utility of standardization.	Three samples do not represent all available products.
Alqarni et al., 2021 [2]	Four commercial spices; ultrasound with higher piperine recovery than the traditional method.	Confirms that the method alters the analytical result.	Technical study, not clinical.
Park et al., 2020 [3]	Ground pepper; near-infrared spectroscopy compared with HPLC.	Supports rapid quality control of batch composition.	The estimate depends on the method's calibration.
Kotte et al., 2014 [5]	Piperine and extract subjected to chemical, light, and thermal stress.	Qualifies the role of storage conditions.	Experimental conditions not comparable to domestic use.
Kozukue et al., 2007 [4]	Four ground products; piperine between 10.17% and 11.68% by weight.	Downsizes the idea of inevitably large differences.	Small number of products and specific commercial context.

9. SINTESI EDITORIALE E CONCLUSIONI

EDITORIAL CONCLUSION

The review by Haq and colleagues clarifies why piperine is the most widely used chemical reference for describing black pepper and its extracts. Its most solid contribution, for reading labels and formulations, is the reminder that the amount of the molecule in plant material is not fixed. A piperine standard can therefore make an extract more uniform across batches, but it does not transform the extract into the whole spice and does not demonstrate a clinical advantage. Independent analyses confirm that the sample, extraction procedure, and measurement method can alter the obtained value. At the same time, some commercial products may show relatively similar levels, while stability depends on the type of chemical stress considered. The most prudent conclusion is to always distinguish between composition, quality control, and health effects: these are related questions, but they require different evidence. The percentage on the label informs about the formulation; it is not, by itself, a measure of efficacy.

Aggiornato al 21/10/2026. Questo contenuto riflette una sintesi divulgativa

delle evidenze scientifiche al momento della pubblicazione e non sostituisce il parere medico.

10. TRANSPARENCY AND SCIENTIFIC RESPONSIBILITY

Artificial Intelligence was used solely as a tool for editorial and documentary support. All content, interpretations, bibliographic citations and conclusions have been verified, reviewed and approved by the author, who assumes full scientific responsibility for them.

The manuscript was also subjected to independent peer review prior to publication.

To ensure the greatest transparency, the complete history of the article, including the dates of submission, revision, acceptance and publication, as well as information on the peer review process, is available on the dedicated Article History page.

11. RIFERIMENTI BIBLIOGRAFICI

- [1] **Quality variation and standardization of black pepper (*Piper nigrum*): A comparative geographical evaluation based on instrumental and metabolomics analysis**
Ahmad et al., 2020
Biomedical Chromatography
DOI: <https://doi.org/10.1002/bmc.4772>



- [2] **Combining Normal/Reversed-Phase HPTLC with Univariate Calibration for the Piperine Quantification with Traditional and Ultrasound-Assisted Extracts of Various Food Spices of *Piper nigrum* L. under Green Analytical Chemistry Viewpoint**
Alqarni et al., 2021
Molecules
DOI: <https://doi.org/10.3390/molecules26030732>
- [3] **Application of Non-Destructive Rapid Determination of Piperine in *Piper nigrum* L. (Black Pepper) Using NIR and Multivariate Statistical Analysis: A Promising Quality Control Tool**
Park et al., 2020
Foods
DOI: <https://doi.org/10.3390/foods9101437>
- [4] **Kinetics of Light-Induced Cis–Trans Isomerization of Four Piperines and Their Levels in Ground Black Peppers as Determined by HPLC and LC/MS**
Kozukue et al., 2007
Journal of Agricultural and Food Chemistry
DOI: <https://doi.org/10.1021/jf070831p>
- [5] **Identification and characterization of stress degradation products of piperine and profiling of a black pepper (*Piper nigrum* L.) extract using LC/Q-TOF-dual ESI-MS**
Chandra Bose. Kotte et al., 2014
Anal. Methods
DOI: <https://doi.org/10.1039/C4AY01088D>