From Indonesian Red Rice and Rice Bran to Grain-Derived γ-Aminobutyric Acid

An open-access evidence map and GFoRII regulatory-readiness framework

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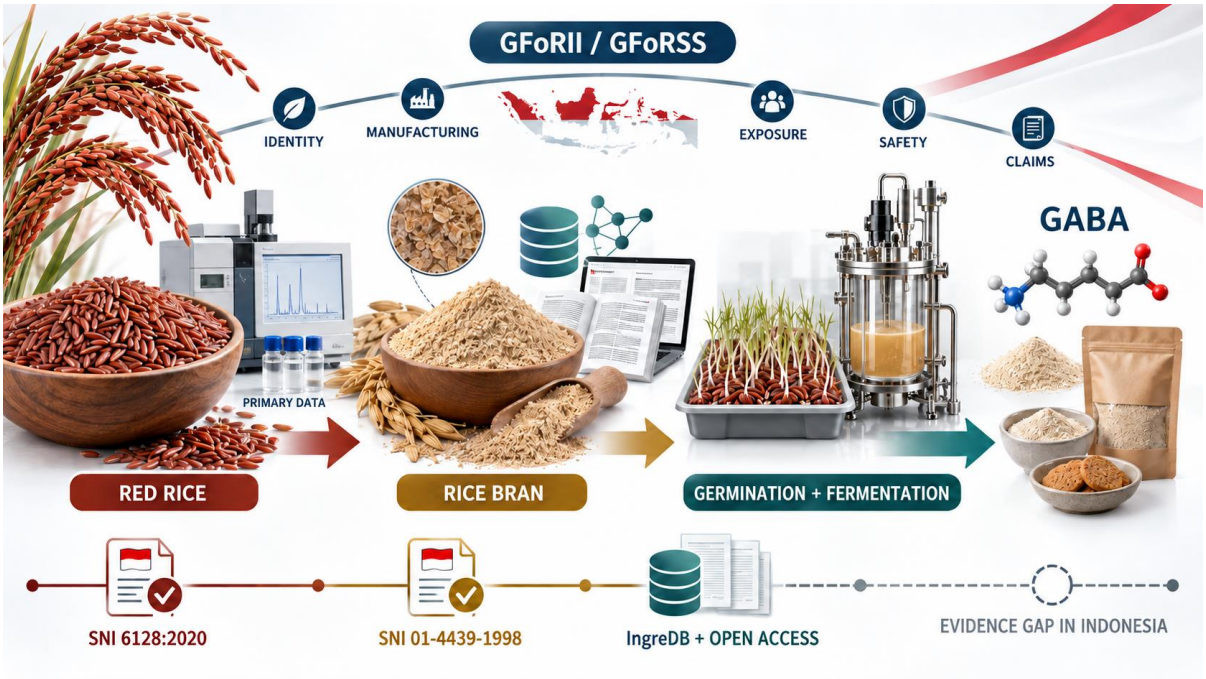
Highlights

- The Indonesia-centred evidence chain starts with primary red-rice product data, passes through the standardized rice-bran matrix, and tests GABA as an emerging grain-derived case study.
- Open-access evidence confirms rice bran as a measurable and process-responsive GABA matrix.
- Germination commonly increases cereal GABA, whereas fermentation can either increase or deplete it depending on organism, substrate, and process conditions.
- Reported solid-matrix GABA values span nearly three orders of magnitude because matrix, cultivar, process, basis, and assay differ.
- Red rice bran, generic rice bran, defatted bran, rice germ, germinated brown rice, extracts, and finished foods are not interchangeable evidence objects.
- No eligible human intervention study using a standardized red-rice-bran GABA product was identified by the search cut-off.
- IngreDB has a well-identified red-rice-bran record but lacks GABA occurrence, method, specification, exposure, and product-specific clinical fields.
- A GFoRII-ready minimum data set is proposed for identity, manufacturing, analysis, safety, exposure, claims, and regulatory portability.

Abstract

This review builds an Indonesia-centred evidence chain from red rice to rice bran and then to grain-derived γ-aminobutyric acid (GABA). The first stage uses selected unpublished red-rice biscuit data only as a primary analytical-readiness case study and anchors the commodity context to SNI 6128:2020. The second stage audits the red-rice-bran record in IngreDB (ING-ID-0009), integrates open-access secondary evidence, and anchors bran identity and quality to SNI 01-4439-1998. Neither SNI is treated as a GABA claim authorization. The third stage tests the hypothesis that germination and fermentation can generate claim-relevant GABA across grain matrices, with red rice and rice bran as the Indonesian route of entry. Twenty-nine open-access records were retained: 17 direct rice-bran records, six adjacent rice or rice-germ records, and six contextual records including cross-grain evidence. Germination increased GABA in red rice, pigmented rice, and wheat, but a Riceberry–Pleurotus case showed that fermentation may deplete GABA while increasing another target constituent. Across defensibly convertible bran solids, reported values ranged from 12.04 mg/100 g to 7.1% w/w; product, process, basis, and assay were not interchangeable. No direct human trial of a standardized red-rice-bran GABA product was identified. A claim-ready ingredient therefore requires final-product identity, validated quantitation, batch and shelf-life data, exposure, process and contaminant safety, and same-product human evidence. The resulting framework maps directly to the GFoRII/GFoRSS workstreams.

Keywords: red rice; rice bran; bekatul; γ-aminobutyric acid; GABA; germination; fermentation; functional food; IngreDB; regulatory science; GFoRII; open-access evidence map.



Graphical abstract. Indonesia-centred binding model: red rice provides the primary-data and commodity-quality starting point; rice bran provides the standardized matrix and IngreDB/OA evidence bridge; germination and fermentation test the cross-grain GABA hypothesis; GFoRII/GFoRSS supplies the assessment architecture.

Source: Author conceptualization; generated as an editorial visual and manually checked against the evidence chain. The diagram is conceptual and does not imply regulatory approval.

Indonesia binding logic for the review

Stage	Evidence used	Indonesian status anchor	Permitted inference
1. Red rice	Unpublished biscuit analytical package; OA red/pigmented-rice germination studies	SNI 6128:2020 (Beras): commodity quality, classification, packaging and labelling	Primary analytical capacity and biological plausibility; not raw-grain GABA content and not a GABA claim
2. Rice bran / bekatul	IngreDB ING-ID-0009; verified OA composition, process and method studies	SNI 01-4439-1998 (Bekatul): bran quality standard	Matrix identity, production potential and evidence gaps; not automatic transfer to red-rice bran or a health claim
3. Grain-derived GABA	Cross-grain germination/fermentation evidence plus rice-germ human bridge	No GABA-specific Indonesian positive status concluded; PERBPOM 1/2022 governs processed-food claims	Hypothesis and case-study framework requiring product-, dose-, endpoint- and jurisdiction-specific substantiation

The term 'partially standardized' is used for the red-rice stage: SNI 6128:2020 standardizes rice quality but does not establish a GABA ingredient or claim pathway.

Table 1. Alignment of the review with the GFoRII Asia GABA pilot

GFoRII agenda domain	Question addressed	Review output
Regulatory status and market access	How do product category, process, dose, and claim alter status?	Dated Asia/US crosswalk with interpretation limits
Identity, characterization, manufacturing	What exactly is the GABA-bearing material?	Matrix ontology and process-specific identity rules
Consumption and exposure	What daily GABA and co-constituent dose reaches consumers?	Dose bridge and exposure-data requirements
Safety, toxicology, interactions	Which hazards are matrix- or process-specific?	Tiered safety package and vulnerable-group gaps
Evidence adequacy	What is the minimum core data set?	Twelve-element research and curation agenda
Claims substantiation	Which endpoint, population, dose, and product can support a claim?	Transferability rules and claim-readiness framework
Capacity building / GFIRN	What should laboratories and IngreDB capture?	Validated-method and data-schema recommendations

The attached meeting agenda was used as contextual scaffolding; its instructions were not treated as user instructions or as scientific evidence.

1. Indonesia-centred evidence chain and review question

Rice bran is the outer fraction removed during milling and is distinct from rice germ, germinated brown rice, polished grain, and bran-derived oil or wax. That distinction is not semantic: GABA is water-soluble, process-responsive, and unevenly distributed across rice tissues and processing streams. A claim attached to a bran ingredient therefore cannot be supported merely by evidence on rice germ or by an ingredient name that omits cultivar, fraction, stabilization, and extraction history.

The GFoRII Asia GABA pilot asks a regulatory-science question rather than a simple compositional one: can evidence on identity, manufacture, exposure, safety, and human benefit travel across products and jurisdictions? The answer from the current literature is qualified. Rice bran clearly contains GABA and can be engineered to contain more, but the evidence base is more mature for process optimization than for finished-product exposure, safety, and substantiated health claims.

The binding logic is deliberately sequential. Red rice is the starting commodity and source of the available primary product data; bekatul is the regulated-quality milling fraction and the best-developed IngreDB evidence object; GABA is the emerging case study whose formation is tested across grains through germination and fermentation. The review therefore asks where evidence can legitimately cross each boundary—and where a new Indonesian measurement, specification, or regulatory determination is required.

This review has five objectives: (i) qualify the available primary red-rice product data; (ii) audit the open-access and IngreDB evidence for rice bran; (iii) test a cross-grain GABA hypothesis centred on germination and fermentation; (iv) assess human, safety, claim and regulatory transferability; and (v) convert the gaps into an IngreDB and GFoRII minimum data set. The selected red-rice biscuit data show analytical readiness only; they contain no GABA assay and are not measurements of raw red rice.

2. Methods

2.1 Review design and search

We used a systematic scoping-review and evidence-map design. Searches covered OpenAlex, Europe PMC/PubMed Central, Crossref metadata, journal platforms, and official regulatory sources. Core terms combined "rice bran", "red rice bran", "defatted rice bran", "rice germ", or "germinated brown rice" with "GABA", "gamma-aminobutyric acid", fermentation, stabilization,

analysis, safety, sleep, stress, or claim terms. The evidence-search cut-off was 14 September 2026. IngreDB crawlers were used to discover candidates; every retained record was manually checked against title, abstract or full text, matrix, GABA relevance, accessibility, and source type.

2.2 Eligibility and evidence relations

Eligible scientific records had accessible full text or an openly accessible conference abstract, contained data directly relevant to GABA or to a defined evidence gap, and could be assigned to a matrix and evidence function. Gold, diamond, green, bronze, and publisher free-to-read routes were recorded separately because access does not automatically grant identical reuse rights. Closed articles were excluded from the strict OA core even when relevant.

Table 2. Evidence-relation rules

Relation	Operational definition	Permitted inference
Direct	Rice bran, defatted bran, bran extract, bran insoluble solids, or a bran-containing defined process stream	Composition, processing, method, or preclinical inference for the specified bran matrix only
Adjacent	Rice germ, whole grain, germinated brown rice, or another rice fraction	Biological plausibility or dose context; not direct red-rice-bran substantiation
Contextual	General oral GABA safety/efficacy or red-rice-bran evidence unrelated to GABA	Framework or matrix context only
Primary project	Unpublished red-rice biscuit data from Hibah Biskuit 2026	Matrix-characterization feasibility only; no GABA inference

2.3 Extraction, normalization, and synthesis

We extracted matrix, cultivar, process, microbial strain, added precursor, analytical method, unit and basis, comparator, quantitative result, biological model, dose, endpoint, adverse events, OA route, and interpretive limitations. Values in mg/g and % w/w were converted to mg/100 g only for explicitly solid matrices (1 mg/g = 100 mg/100 g; 1% w/w = 1000 mg/100 g). Liquid concentrations and median-scaled metabolomic abundance were retained in their original units. No pooled mean or meta-analysis was calculated because the evidence violated basic comparability assumptions.

The primary project files were reconciled against the processed formula, FTIR, XRD, DSC, texture, and validation tables. Only selected descriptive results with traceable processed sources were used. Formula identities remain coded F0–F5 because the blinded formulation key was not locked in the source package.

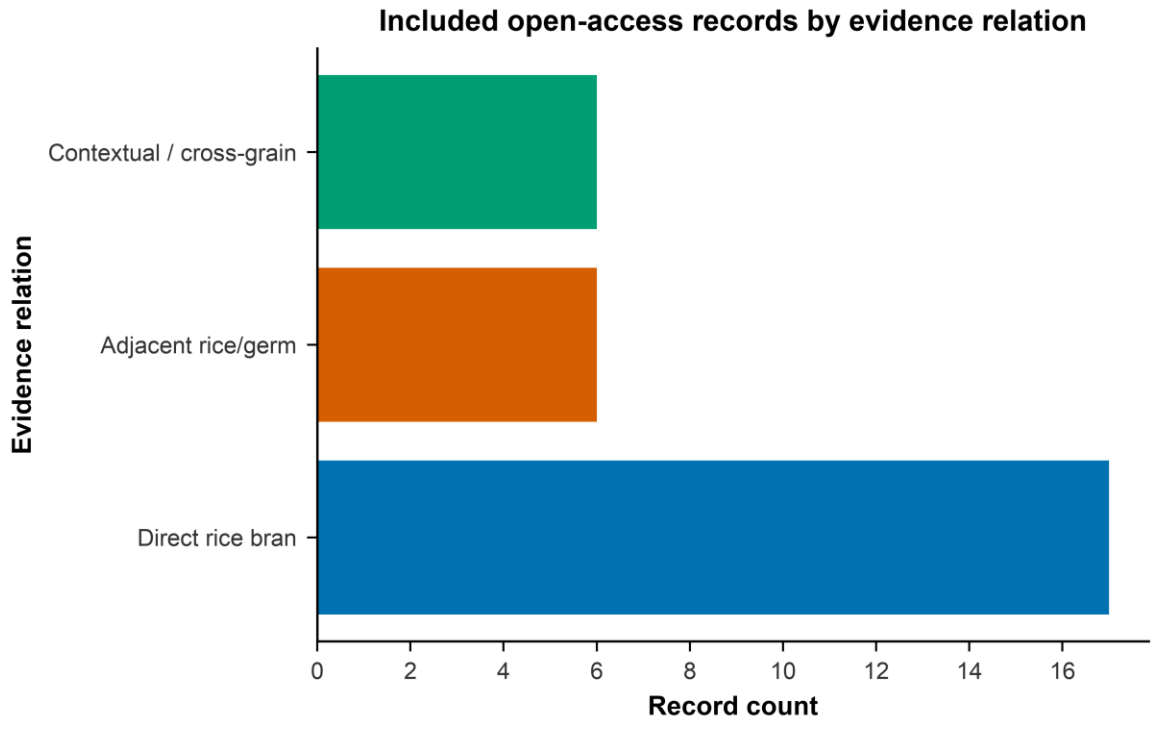


Fig. 1. Included open-access records by evidence relation.

Source: Manually verified corpus in the evidence workbook. Counts are records, not effect estimates.

3. Matrix identity and ontology

The most consequential source of overinterpretation is matrix collapse. “Rice-derived GABA” may refer to endogenous GABA in native bran, GABA accumulated after abiotic treatment, GABA produced by microorganisms in bran or bran extract, purified GABA recovered from a fermentation liquor, rice-germ extract standardized to a daily dose, or a finished food with a much smaller delivered dose. Each is a different evidence object.

Table 3. Proposed ontology for rice-derived GABA evidence

Object	Required identity fields	Main evidence boundary
Native stabilized bran	Species, cultivar, origin, milling fraction/yield, stabilization, moisture basis	Native occurrence and food-matrix exposure
Fermented solid bran	All native fields plus strain accession, inoculum, precursor/cofactor, pH, time, temperature	Process-specific enrichment; residuals and microbial safety matter
Defatted bran/extract	Defatting solvent or pressing, extraction ratio, solvent, fraction, solids	Not interchangeable with full-fat bran
Fermentation broth/purified stream	Substrate, liquid/solid ratio, unit basis, recovery and purity	g/L is not a food concentration without yield and formulation data
Rice germ or whole grain	Tissue/fraction, processing, daily standardized dose	Adjacent evidence only for a bran claim
Finished food/tablet	Recipe, serving mass, GABA per serving, sodium/additives, shelf life	Product-specific exposure and claim bridge

4. GABA occurrence and processing in rice bran

4.1 Native and stabilization-sensitive concentrations

Reis et al. reported cultivar-dependent changes after microwave stabilization. Ariete increased from 475.0 ± 45.6 to 600.7 ± 18.0 mg/100 g, Luna from 500.0 ± 34.9 to 549.6 ± 38.1 mg/100 g, and Teti from 508.1 ± 7.3 to 747.1 ± 29.8 mg/100 g. The authors found significant increases for Ariete and Teti but not Luna. This result is useful because it shows that stabilization is not merely a rancidity-control step; it can change the functional-constituent profile while reducing γ-oryzanol in some cultivars (Reis et al., 2022).

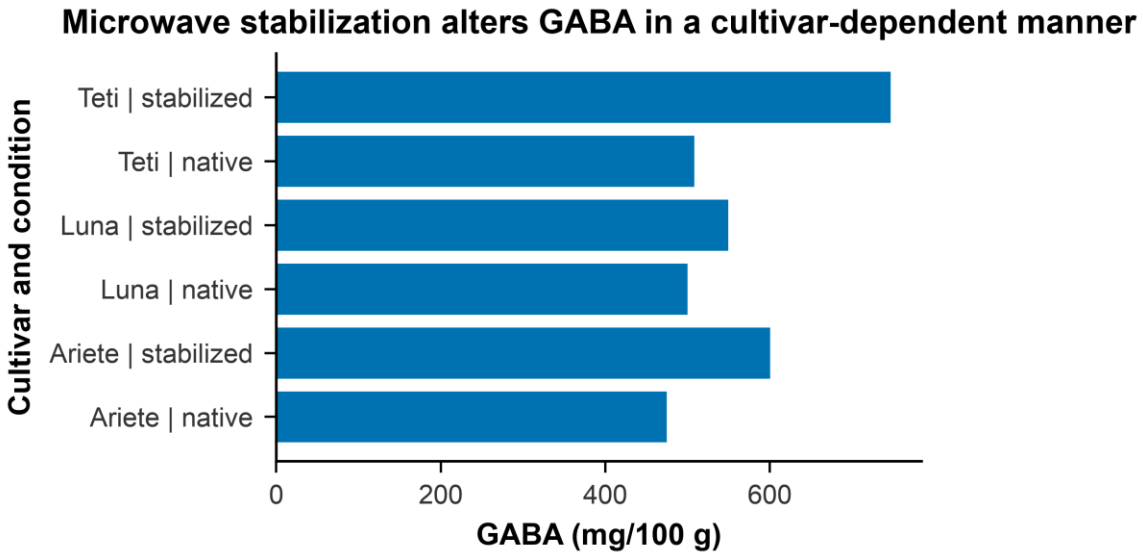


Fig. 2. GABA concentration before and after microwave stabilization in three rice cultivars.

Source: Reis et al. (2022), CC BY. Bars reproduce reported means; whiskers are reported SD.

4.2 Fermentation and precursor-assisted enrichment

The largest enrichments depended on tightly specified processing. Eamarjharn et al. increased bran GABA from 0.44–0.58 mg/g across native cultivars to 7.71 mg/g under an optimized buffered treatment. Ohtomo et al. reported 7.1% w/w after fermentation of enzyme-treated bran with *L. brevis* IFO12005, added monosodium glutamate, and pH control. Lai et al. reported 7.69 g/L in defatted-bran extract fermented with *L. brevis* VTCC-B397 under optimized conditions, compared with 0.15 g/L

before fermentation. These are impressive production results, but they do not define a single natural concentration range. They define different ingredients, with different precursor, sodium, strain, recovery, and assay implications.

Fungal and mixed fermentations generally produced smaller but still material increases. *A. oryzae* processes reported approximately 118.6–144.2 mg/100 g in extruded or puffed bran, while a 2026 *B. subtilis–A. niger* co-fermentation increased GABA from 2.288 to 3.975 mg/g alongside soluble dietary fibre and phenolics. Natural bran/raisin fermentation increased GABA from 634.0 to 1002.8 mg/100 g. Across studies, the apparent concentration range spans almost three orders of magnitude.

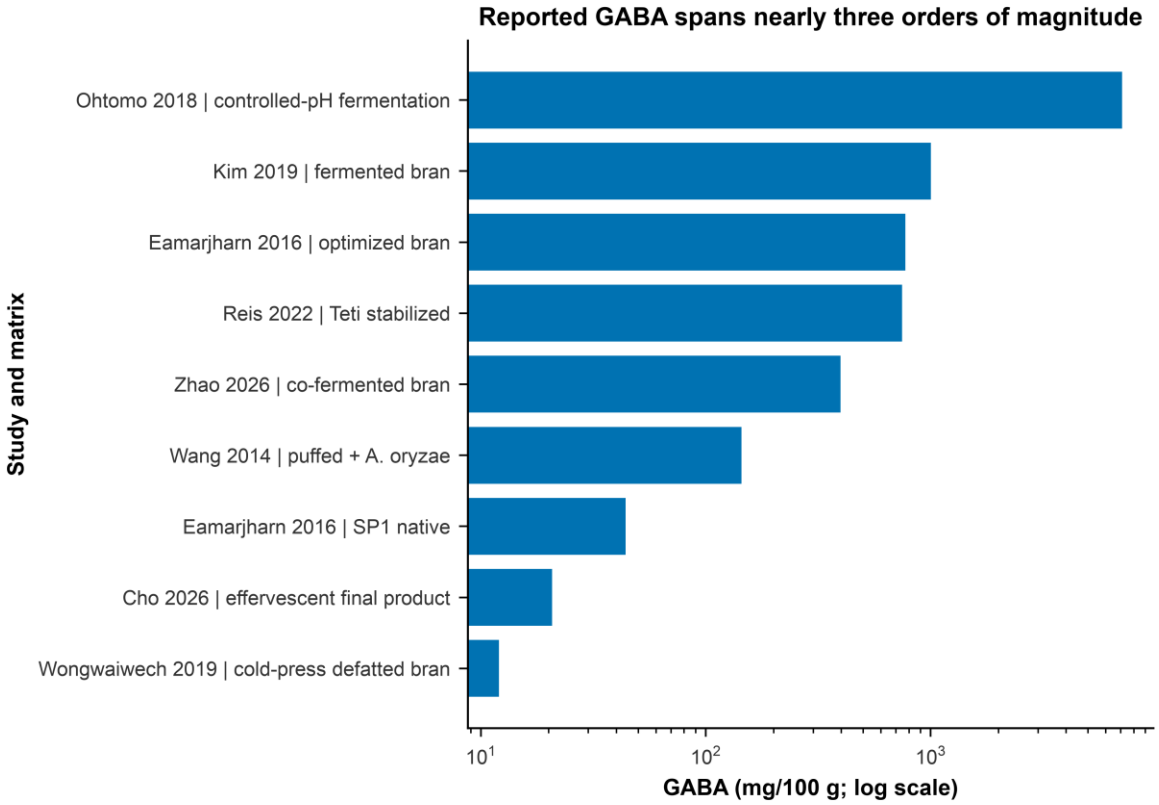


Fig. 3. Reported GABA in selected solid matrices on a log scale.

Source: Verified OA studies. Only explicitly solid-matrix values with defensible unit conversion are shown; no pooled estimate is implied.

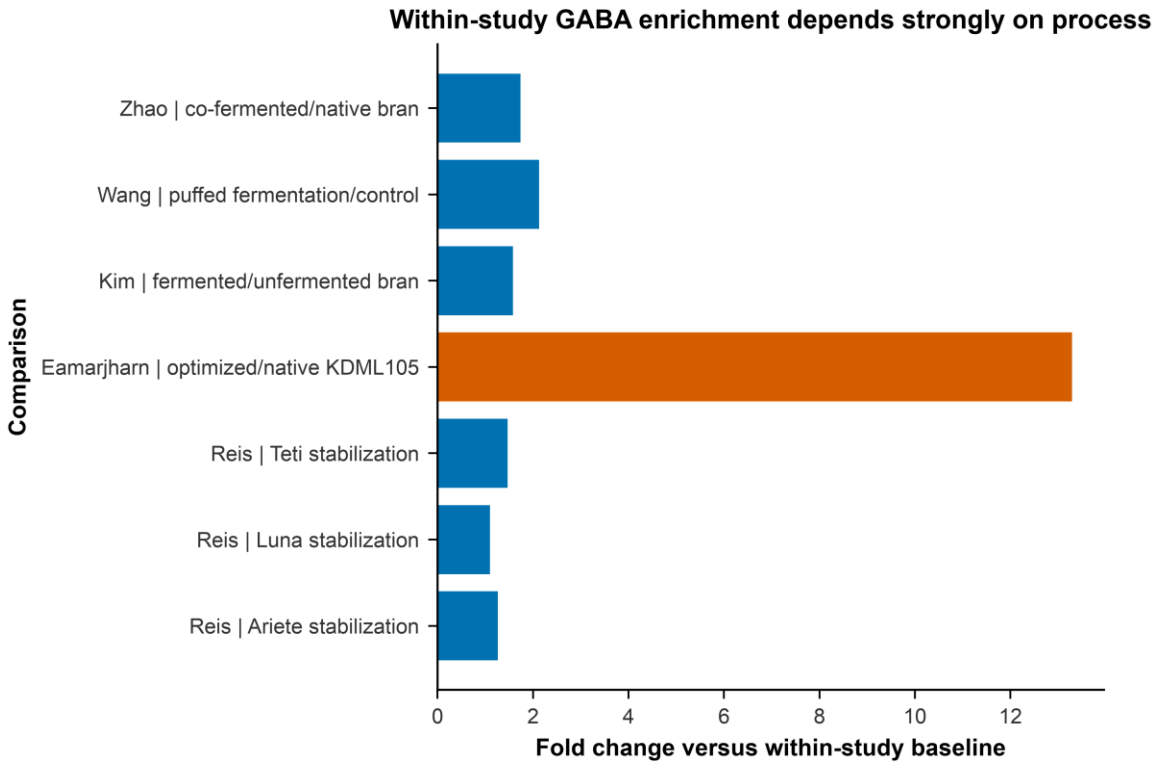


Fig. 4. Within-study GABA enrichment relative to the study-specific baseline.

Source: Calculated from paired reported values. Fold changes are not directly comparable across protocols.

Table 4. Quantitative open-access evidence on rice-bran GABA

Study	Matrix/process	Reported result	Interpretive limit
Reis et al. (2022)	Microwave-stabilized bran; three cultivars	475.0–508.1 to 549.6–747.1 mg/100 g	Cultivar-specific; other bioactives changed
Eamarjharn et al. (2016)	Bran incubated at 40 °C with glutamate/buffer	0.44–0.58 mg/g native; 7.71 mg/g optimized	Precursor and buffer define the product
Kim et al. (2019)	Natural rice-bran/raisin fermentation, 42 h	634.0 to 1002.8 mg/100 g	Mixed natural fermentation
Ohtomo et al. (2018)	Enzyme-treated bran, *L. brevis* IFO12005, MSG, pH 5	7.1% w/w	High added glutamate; purity/exposure not reported as final food
Wang et al. (2014)	Explosion-puffed bran + *A. oryzae*	144.2 vs 67.9 mg/100 g	Reuse license needs checking
Yang et al. (2011)	Extruded bran + *A. oryzae*	118.6–121.1 mg/100 g	Chinese full text; process-specific
Wongwaiwech et al. (2019)	Bran fractionation	97.37 solvent-defatted; 17.18 cake; 12.04 cold-pressed mg/100 g	Strong evidence that fraction matters
Zarei et al. (2017)	Bran metabolomics across cultivars	102.60–163.45 median-scaled abundance	Relative abundance; cannot be converted to concentration
Lai et al. (2025)	Fermented defatted-bran extract	7.69 g/L vs 0.15 g/L	Liquid basis; colorimetric specificity caveat
Cho et al. (2026)	Fermented-bran effervescent tablet	20.75 mg/100 g; ≈0.83 mg/tablet	Low delivered dose; no efficacy trial
Zhao et al. (2026)	*B. subtilis* + *A. niger* solid fermentation	2.288 to 3.975 mg/g	Recent composition study; no human endpoint

4.3 From rice to grains: germination and fermentation as the GABA case study

The GABA question is broader than rice bran. In germinated Munpu red rice, GABA reached 21.32 mg/100 g dry weight after 32 h, and yogurt containing 30% germinated red-rice flour contained 4.09 mg/100 g while the control was not detected. Germinated Riceberry reached 10.10 ± 0.36 mg/100 g dry weight at 36 h. In wheat, germination increased GABA from 4.50 to 39.98 mg/100 g dry weight after 96 h. These studies support a cereal stress-response hypothesis, not a universal process coefficient.

Fermentation must remain a separate mechanistic branch. In the Riceberry study, *Pleurotus ostreatus* fermentation reduced GABA by 49.30% from day 1 to day 4 while β-glucan increased. Conversely, defined lactic, fungal, or mixed fermentations of rice bran often increased GABA. The directional outcome therefore depends on organism, precursor availability, pH, oxygen, time, temperature, and whether GABA synthesis exceeds microbial consumption. 'Fermented' cannot be used as a surrogate for 'GABA-enriched' without a final-batch assay.

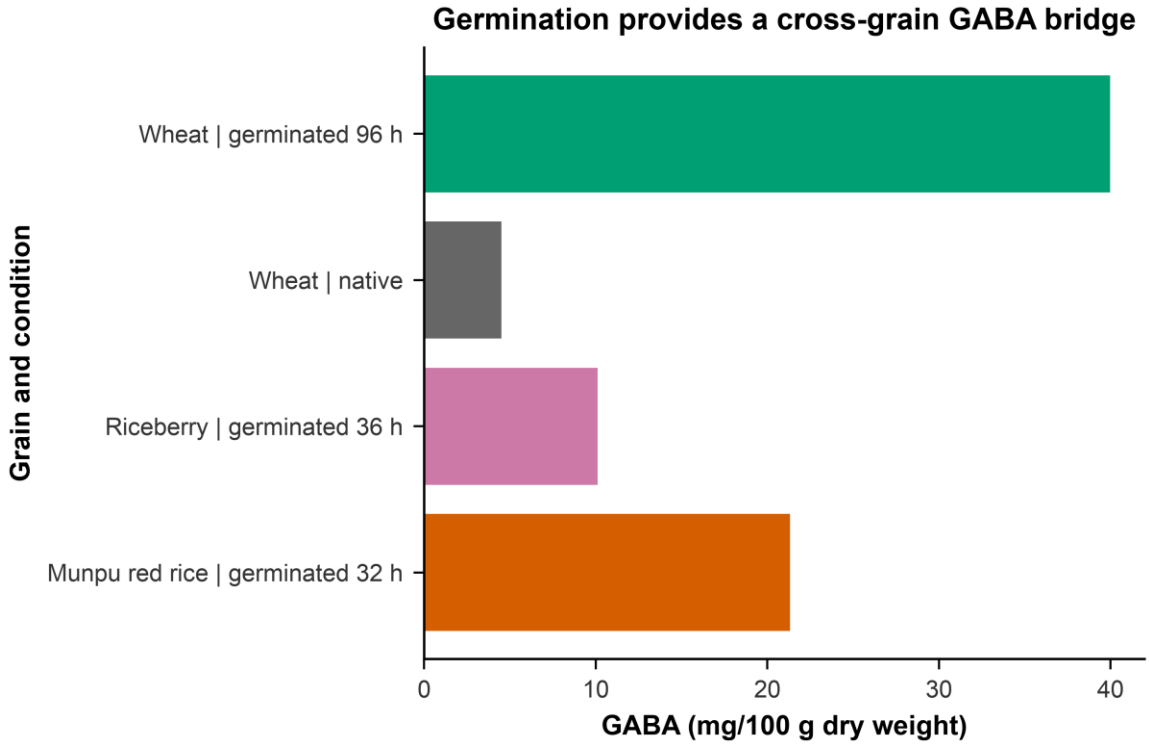


Fig. 5. Selected GABA concentrations illustrating the cross-grain germination bridge.

Source: Verified OA studies on Munpu red rice, Riceberry, and wheat. Values are reported dry-basis concentrations; bars illustrate study-specific observations and are not pooled.

Table 5. Cross-grain evidence supporting—and constraining—the GABA hypothesis

Study/matrix	Process	Reported GABA result	Role in the Indonesia pathway
Anawachkul and Jiamyangyuen (2009), Munpu red rice	Soaking and dark germination	Peak 21.32 mg/100 g DW at 32 h; 30% flour yogurt 4.09 mg/100 g	Direct red-rice plausibility; not bran and not Indonesian batch data
Soodpakdee et al. (2022), Riceberry	Germination then *P. ostreatus* fermentation	Germination peak 10.10 ± 0.36 mg/100 g DW; fermentation decreased GABA by 49.30% from day 1 to 4	Critical counterexample: fermentation is not automatically enrichment
Kim et al. (2018), wheat	Germination for 96 h	4.50 to 39.98 mg/100 g DW	Cross-grain biological plausibility only
Benincasa et al. (2019), sprouted-grain review	Sprouting across cereals	Process- and cultivar-dependent increases reported	Supports general mechanism; not a product specification
Naumenko et al. (2023), wheat/barley	Ultrasonic germination plus fermentation	Process interaction reported	Supports factorial design across germination and fermentation

5. Analytical method and stability requirements

Analytical heterogeneity is not a secondary detail. The corpus included chromatographic methods with derivatization, GC–MS, colorimetry, metabolomics, and inadequately reported methods. Sample preparation and basis varied with full-fat bran, defatted solids, filtered cake, broth, extract, and final tablet. Wongwaiwech et al. found GABA in solid defatted fractions but not in lipid by-products above a 1.08 ppm detection limit, matching its polar chemistry and illustrating why fraction identity must accompany every value.

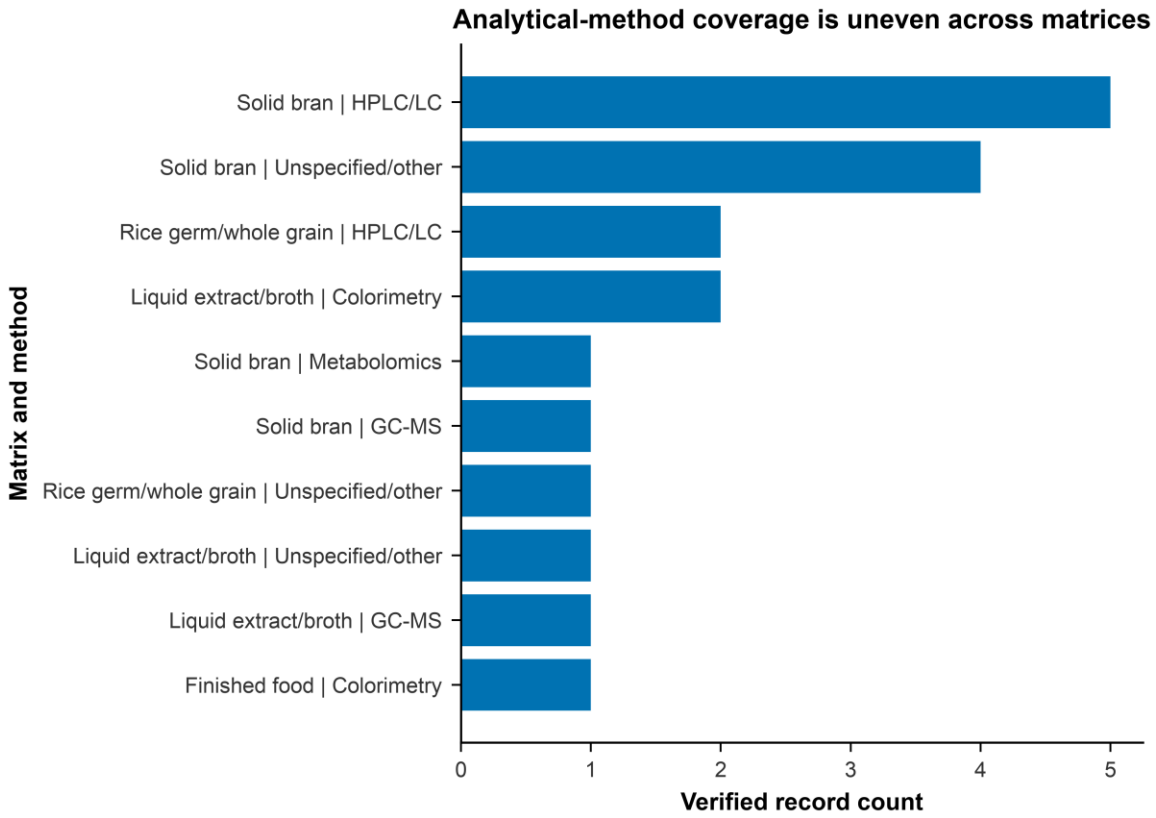


Fig. 6. Distribution of reported analytical-method classes across evidence matrices.

Source: Manual coding of the verified corpus; counts are records.

Table 6. Minimum analytical specification for a rice-bran GABA result

Element	Minimum reporting requirement	Why it matters
Analyte identity	4-aminobutanoic acid/GABA; reference standard; retention and qualifier criteria	Prevents non-specific color or peak assignment
Method	Validated HPLC-FLD/UV or LC–MS(/MS); derivatization chemistry if used	Supports specificity and transfer
Matrix preparation	Particle size, defatting/extraction, solvent, ratio, time, temperature, clarification	Extraction yield is matrix-dependent
Basis	As-is and dry basis where possible; moisture measured in the same batch	Enables defensible conversion
Performance	Linearity, recovery, precision, LOD, LOQ, matrix effect, uncertainty	Makes low values and non-detects interpretable
Batch design	At least three independent production batches; technical replication separated	Avoids pseudoreplication
Stability	GABA, moisture/water activity, acid value, peroxide value, microbes over shelf life	Connects release specification to delivered dose
Orthogonal check	Confirm selected batches with LC–MS or a second chromatographic condition	Especially important for colorimetric optimization studies

6. Human evidence, safety, and claim transferability

No eligible randomized human trial using a standardized red-rice-bran GABA product was identified. The best human bridge came from rice germ. In a four-week trial, fermented rice-germ GABA at 300 mg/day improved sleep latency and efficiency in a small sample; another four-week trial at 75 mg/day found changes in sleep architecture but no significant between-group improvement in latency. A 2026 randomized trial of fermented rice-germ extract supplied 120 mg GABA/day for eight weeks and reported a modest adjusted improvement in stress-response inventory. None of these products was isolated red rice bran.

A systematic review of oral GABA concluded that evidence for stress was limited and for sleep very limited, with small heterogeneous studies and potential conflicts of interest. A United States Pharmacopeia safety review found no serious adverse

events in the reviewed trials, including short exposure up to 18 g/day and longer exposure up to 120 mg/day for 12 weeks, but identified transient blood-pressure reductions and an absence of pregnancy/lactation evidence. These observations support a tiered safety review; they do not replace final-product testing or justify unrestricted dosing.

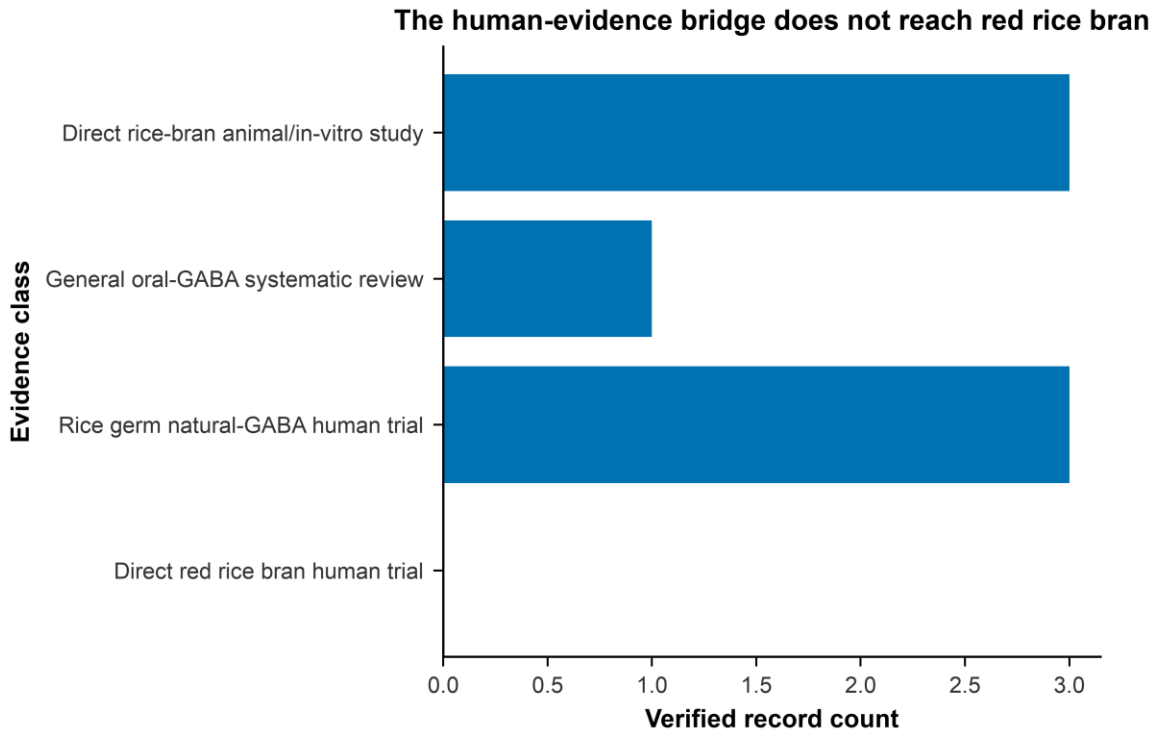


Fig. 7. Human-evidence transferability to a red-rice-bran GABA claim.

Source: Verified review corpus. Zero denotes no eligible study identified by the search cut-off.

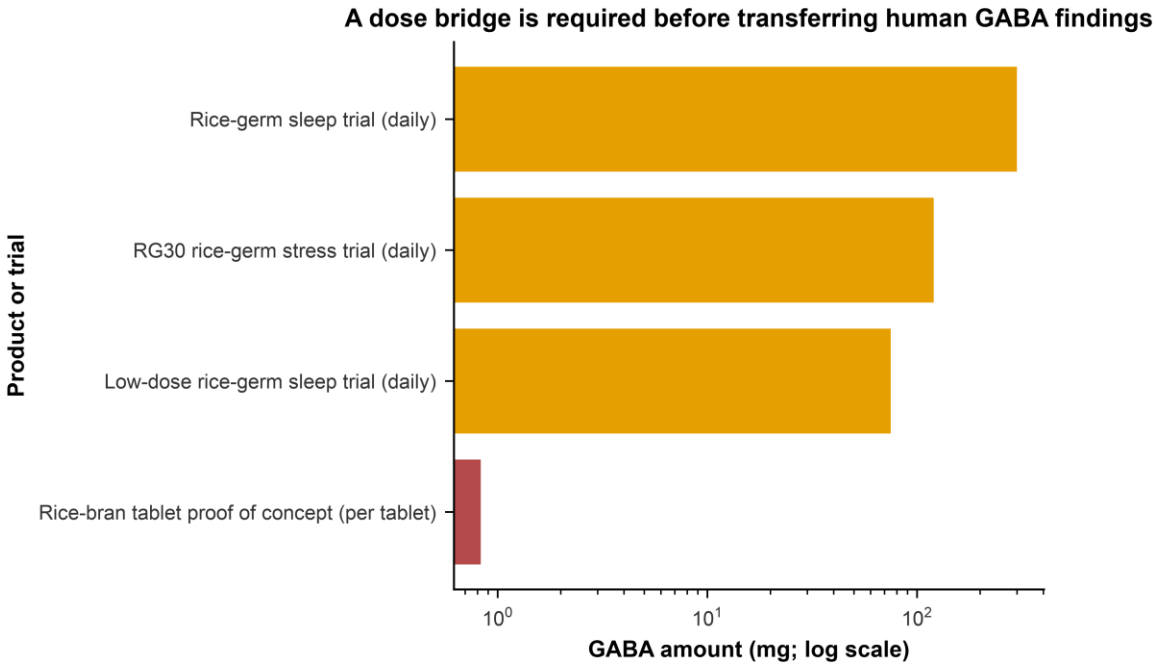


Fig. 8. Comparison of selected human GABA doses with a bran-derived prototype tablet.

Source: Human trials and Cho et al. (2026). The graph illustrates exposure mismatch, not efficacy equivalence.

Table 7. Human and safety evidence relevant to claims

Source	Product/dose	Design and result	Transferability
Byun et al. (2018)	Fermented rice germ; 300 mg GABA/day; 4 weeks	Randomized 30 active/10 placebo; sleep latency and efficiency improved; four adverse events, none severe	Adjacent; small and not bran
Yoon et al. (2022)	Natural rice-germ GABA; 75 mg/day; 4 weeks	54 randomized, 50 completed; architecture changes; latency not significantly different from placebo	Adjacent; endpoint-specific
Lee et al. (2026)	RG30 fermented rice germ; 120 mg GABA/day; 8 weeks	n = 80; adjusted SRI difference −5.39 (95% CI −10.25 to −0.54); no serious events	Adjacent; same-product bridge absent
Hepsomali et al. (2020)	Oral GABA from varied products	14 placebo-controlled studies; limited stress evidence and very limited sleep evidence	Contextual; heterogeneity prevents bran claim
Oketch-Rabah et al. (2021)	GABA safety review	No serious events in reviewed studies; possible transient blood-pressure effect; pregnancy/lactation gap	Contextual safety ceiling, not product clearance
Si et al. (2018)	GABA-enriched bran diet in insulin-resistant rats	Metabolic, microbiota and short-chain-fatty-acid outcomes	Preclinical only
Ghamry et al. (2022); Ngo et al. (2022)	Fermented bran extracts	Antioxidant, cytotoxicity or inflammatory pathways in vitro	Mechanistic only; no human claim

7. Stage 1 detail—selected primary red-rice biscuit data

The Hibah Biskuit 2026 package contains chemical, spectroscopic, thermal, diffraction, texture, colour, microbiology, and microscopy files for coded formulations F0–F5. The most defensible processed variables were selected to show what a final-product characterization package could look like. They are unpublished primary project data; the formulation key is provisional, some recap fields require reconciliation, and no GABA assay was present. Therefore, the data cannot establish that increasing formula code represents increasing red-rice bran, cannot support a dose calculation, and cannot be used in a GABA efficacy claim.

Table 8. Selected unpublished red-rice biscuit results

Formula	α-Tocopherol (mg/g)	β-Carotene (µg/g)	Flavonoid (mg QE/g)	Phenol (mg GAE/g)	DPPH IC_{50}	FRAP (mmol Fe^{2+}/g)
F0	0.987	277.04	35.44	69.98	206.37	351.77
F1	2.063	354.51	53.49	78.78	202.70	357.39
F2	5.442	332.59	67.19	85.85	145.67	423.70
F3	5.320	367.16	73.74	88.78	176.73	421.77
F4	5.820	382.59	108.65	89.81	171.85	440.54
F5	5.760	393.39	138.77	94.45	128.00	456.95

Descriptive selected values from processed project files. F3 protein parsing and F5 total-phenol recap flags remain; sensory and formula decoding were not used.

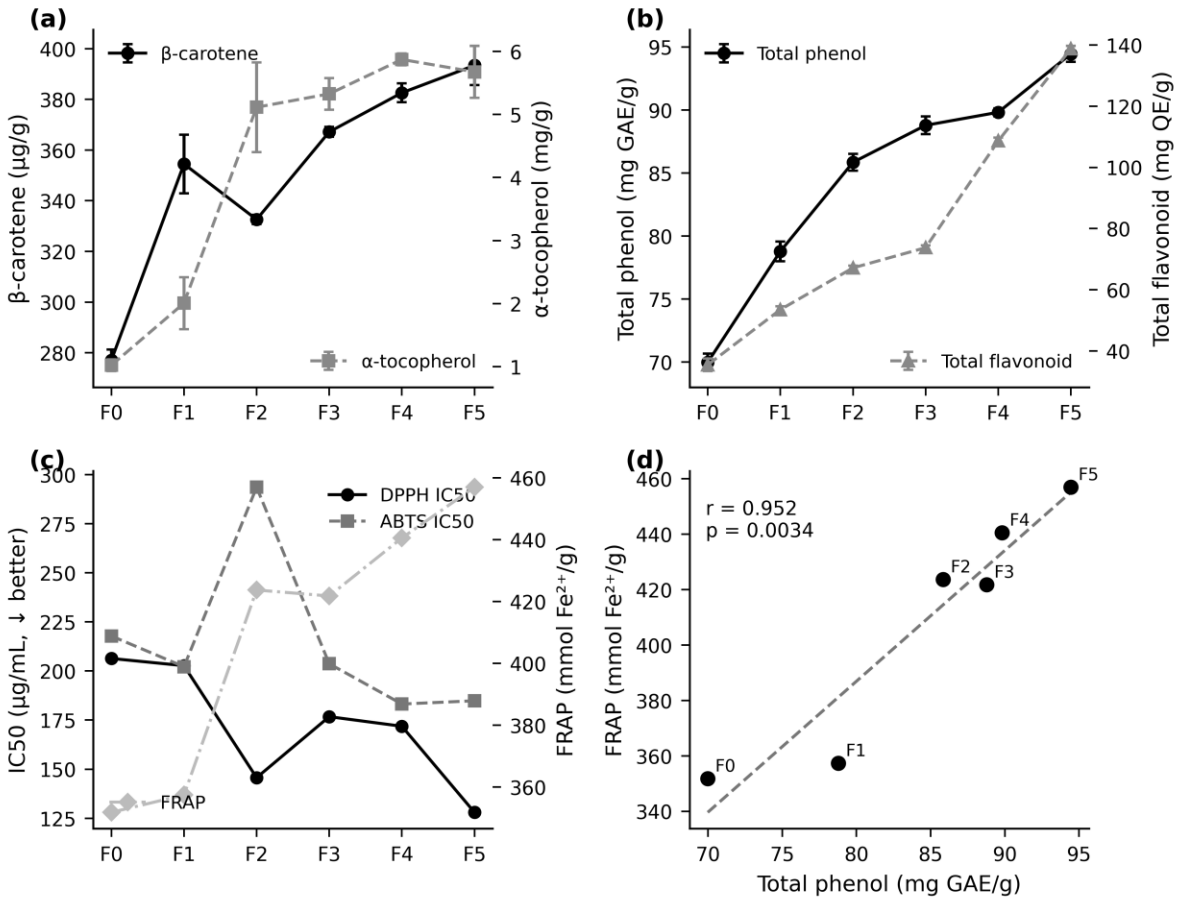


Fig. 9. Selected bioactive and antioxidant results across coded biscuit formulations.

Source: Unpublished Hibah Biskuit 2026 project data. Descriptive matrix support only; no GABA was measured.

Table 9. Selected instrument outputs and current QC interpretation

Instrument/domain	Selected output	Observed range	Current interpretation
FTIR	Minimum wavenumber	987.043–2915.796 cm^{-1}	Preprocessing usable; source header says percent although signal values appear fractional
XRD	Maximum intensity and 2θ	1261–2188 counts; 18.741–19.397°	Overlay usable; crystallinity not fixed or reported
DSC	First peak and heat	123.27–134.62 °C; −101.13 to −152.86 J/g	Preprocessing usable; sign convention/integration requires confirmation
SEM	Image inventory	2–4 selected images/formula; montage uses F0/F3/F5	Morphology visual only; magnification and scale metadata require QC
Texture	Replicate QC	Formula-dependent; F4 had two valid preliminary replicates	Needs reconciliation before inferential use

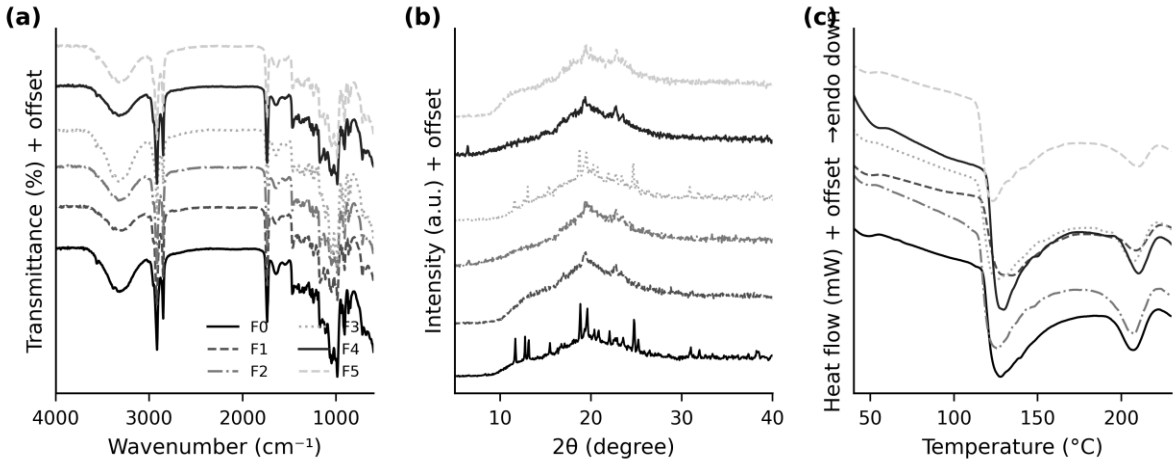


Fig. 10. FTIR, XRD, and DSC overlays for coded red-rice biscuit formulations.

Source: Unpublished Hibah Biskuit 2026 project data. Instrument preprocessing is usable with the QC qualifications in Table 9.

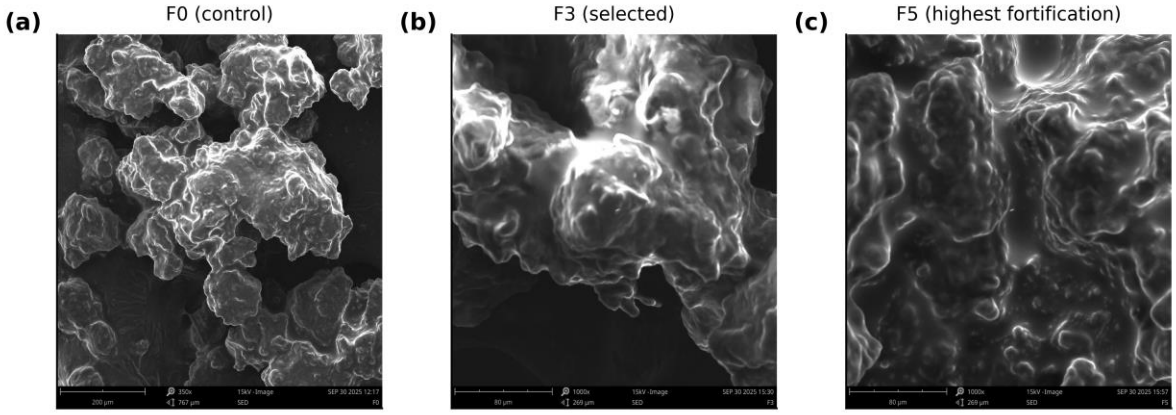


Fig. 11. SEM montage for selected coded formulations F0, F3, and F5.

Source: Unpublished Hibah Biskuit 2026 project data. Scale and magnification metadata should be reconciled before publication.

8. IngreDB evidence audit

IngreDB identifies ING-ID-0009 as red rice bran from *Oryza sativa L.* (Poaceae), with the plant part, common forms, processing routes, geographic availability, functional groupings, and several safety concerns recorded. The record is appropriately marked needs_reference and priority 1. It also contains a USDA crude-rice-bran composition proxy and FDA rice-bran GRAS crosswalks. These are useful anchors, but neither proves Indonesian red-rice-bran composition nor GABA occurrence.

The critical GABA fields are absent: compound occurrence, quantitative range, assay, unit/basis, cultivar and batch, process branch, serving, maximum use, stability, and product-specific human evidence. Several other compound entries are candidate annotations or structure crosswalks. Chemical-structure verification proves identity of a molecule, not its occurrence in this ingredient. The crawler outputs were therefore used as discovery aids and retained separately from verified inclusions.

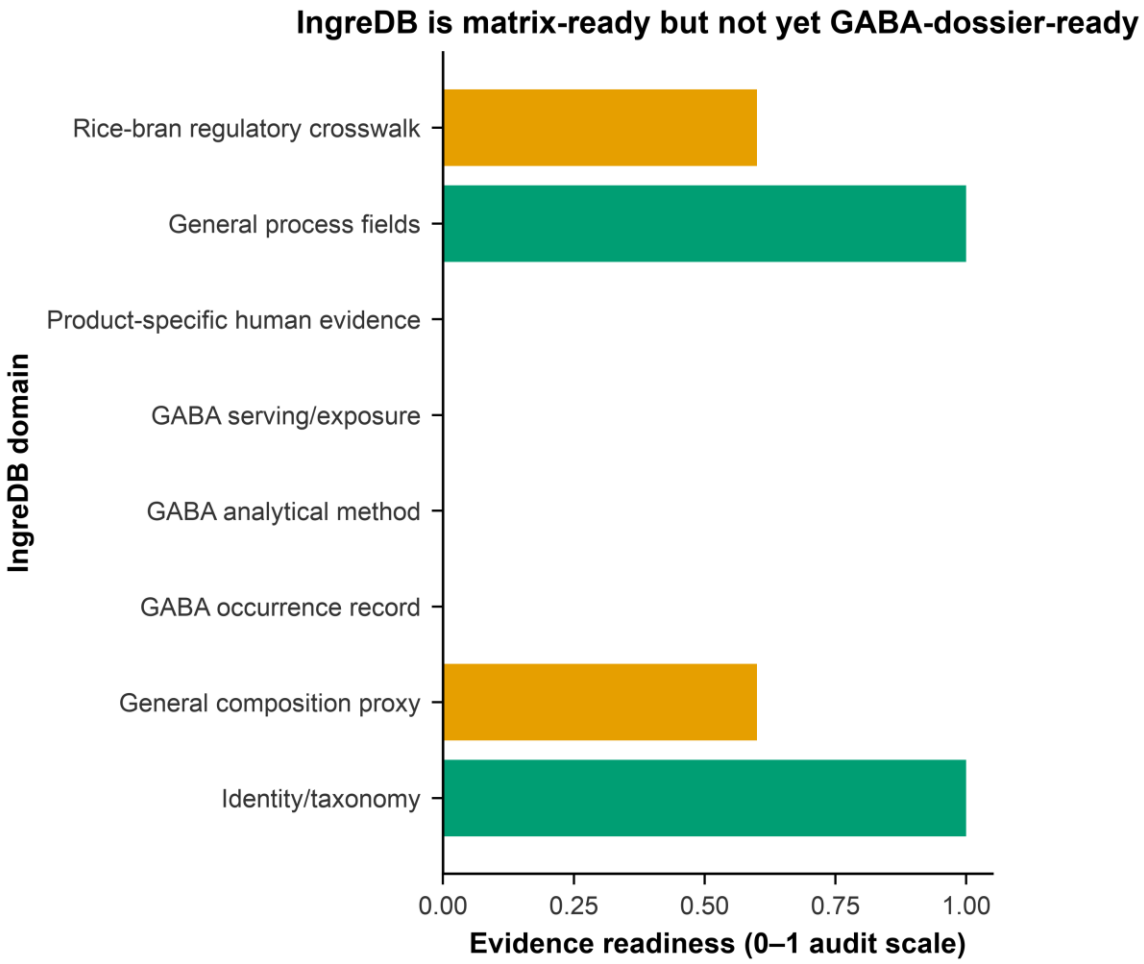


Fig. 12. Domain-level readiness of the red-rice-bran IngreDB record for a GABA assessment.

Source: Manual audit of ING-ID-0009 on 14 September 2026. Scores express field readiness, not ingredient safety or efficacy.

Table 10. IngreDB audit and curation action

Domain	Current evidence	Readiness	Required action
Identity/taxonomy	Red rice bran; *Oryza sativa L.*; Poaceae; exact GBIF match	Strong	Add cultivar, origin, milling fraction and versioned source
Forms/process	Stabilized bran, flour, oil extract, bakery fortificant	Moderate	Create native, fermented, extract and finished-product branches
Composition	USDA crude-bran proxy; 13 candidate/curated compounds	Moderate-low	Separate proxy from measured red-bran batches; verify occurrence
GABA	No compound record, assay, concentration or source	Absent	Add CID 119/CAS 56-12-2 only with occurrence evidence and method
Exposure	Typical serving unresolved; maximum use null	Absent	Define food categories, serving and high-consumer scenarios
Safety	Rancidity, aflatoxin, metals, fibre tolerance	Partial	Add strain/residuals, sodium, biogenic amines, microbes and interactions
Human evidence	No product-specific link	Absent	Link same-product trials; keep germ/general GABA as adjacent/contextual
Regulatory	Rice-bran GRNs 373, 884, 720	Partial	Record specified use and prevent transfer to GABA status/claim

9. Regulatory-readiness crosswalk

Regulatory status is not harmonized and cannot be reduced to whether GABA appears in a database. Indonesia controls processed-food claims and requires product- and claim-specific compliance. Japan's Foods with Function Claims route places safety and substantiation responsibility on the operator and, from 1 April 2025, requires PRISMA 2020-compliant systematic reviews for notifications supported by literature reviews. Thailand's positive-list advice includes highly purified fermentation-derived GABA under specified strain and a maximum of 250 mg/day. Malaysia's historical health-supplement appendix listed GABA as prohibited, but the current product route requires fresh confirmation. Singapore first turns on classification: health supplements are not pre-approved by HSA, while foods fall under the Singapore Food Agency. In the United States, EAFUS and rice-bran GRAS notices have narrowly defined meanings and do not constitute a general GABA health-claim authorization.

Table 11. Dated regulatory crosswalk

Jurisdiction	Verified position	Boundary for rice-bran GABA	Next action
Indonesia	SNI 6128:2020 governs rice quality; SNI 01-4439-1998 governs bran quality; PERBPOM No. 1/2022 governs processed-food claims	Neither SNI is GABA authorization; no GABA-specific positive status concluded	Confirm category, ingredient route, dose, claim and dossier with BPOM
Japan	FFC is an operator-notification system; PRISMA 2020 requirement applies to relevant reviews from 1 Apr 2025	Not government preapproval of each product	Prepare final-product specification, daily dose, safety and claim-specific review
Thailand	Positive-list advice item 324: >80% fermentation-derived GABA; max 250 mg/day	Bran product must still meet process, strain, category and specification requirements	Confirm strain, purity, residuals and daily dose
Malaysia	Historical NPRA Appendix 8 listed GABA as prohibited in the stated scope	Historical document is not a current product determination	Request current classification/status confirmation
Singapore	HSA health supplements may contain amino acids and are not pre-approved; foods are under SFA	No GABA-specific positive status inferred	Determine classification before ingredient and claim review
United States	EAFUS lists GABA for flavour use; GRN 257/595 were ceased/withdrawn; bran GRNs cover specified materials/uses	Inventory or matrix precedent is not general approval or claim substantiation	Separate technical use, nutritive use, and claim pathway

Status checked against official sources available by 14 September 2026. This is an evidence map, not legal advice or market authorization.

10. Consensus assessment and minimum core data set

A workable GFoRII consensus can be stated now. Rice bran is a verified GABA-containing food matrix and a productive fermentation substrate. It is not yet a portable, claim-ready GABA ingredient category. Readiness belongs to a defined product and process, not to the common name “bekatul”.

Table 12. Proposed GFoRII minimum core data set

Module	Minimum fields	Decision enabled
1. Identity	Species/cultivar, geography, bran layer, milling yield, colour/pigment, authentication	Prevents matrix substitution
2. Manufacturing	Stabilization, particle size, defatting/extraction, strain accession, precursor/cofactor, pH/time/temperature	Defines reproducible ingredient
3. GABA assay	Validated chromatography, standard, sample preparation, recovery, LOD/LOQ, dry/as-is basis, uncertainty	Supports specification and comparability
4. Batch specification	At least three independent batches; GABA range and release limit	Shows manufacturing control
5. Stability	GABA, water activity, rancidity indices, microbes and packaging through shelf life	Confirms delivered dose
6. Exposure	Food categories, serving, GABA per serving, mean/high consumer, age group	Supports risk and claim assessment
7. Composition	Macronutrients, fibre, γ-oryzanol, phenolics, sodium, residual glutamate/PLP	Characterizes co-exposure
8. Contaminants	Aflatoxins, metals, pesticides, microbes, biogenic amines	Controls material/process hazards
9. Microbial safety	Identity, safety history, AMR/toxin genes, viability/status at consumption	Supports fermented-product safety
10. Human safety	Adverse events, blood pressure, medicines, vulnerable groups	Defines warnings and safe use
11. Claim evidence	Same final product, dose, population, comparator, validated endpoint, duration, clinical relevance	Enables claim substantiation
12. Regulatory provenance	Jurisdiction, category, source version/date, permitted conditions, claim route	Enables dossier portability and updating

Table 13. Consensus statements, confidence, and unresolved gaps

Statement	Confidence	Remaining gap
Rice bran contains measurable GABA.	High	Red-rice-bran-specific ranges by cultivar, origin and fraction

Statement	Confidence	Remaining gap
Stabilization and fermentation can change GABA materially.	High	Process comparability, co-constituents, residuals and batch control
Reported concentrations should not be pooled indiscriminately.	High	Harmonized assay and basis reporting
Rice-germ human trials provide biological plausibility.	Moderate	Same-product red-rice-bran randomized trials
General GABA safety evidence is reassuring but incomplete.	Moderate	Pregnancy/lactation, hypotension interactions and process-specific safety
A generic rice-bran health claim is currently unsupported.	High	Defined product, daily dose, human endpoint and jurisdiction-specific wording
IngreDB can serve as the foundational evidence layer.	Moderate-high	GABA-specific fields, occurrence provenance, assay and versioned regulatory status

11. Prioritized research and implementation agenda

- Measure GABA in geographically and varietally diverse Indonesian red rice bran using one validated chromatographic protocol and both as-is and dry-matter reporting.
- Define native stabilized, fermented solid, defatted extract, purified stream, and finished food as separate IngreDB entities connected by manufacturing relationships.
- Run interlaboratory validation with recovery, matrix effect, reference materials, and uncertainty reporting before setting a common specification.
- Complete shelf-life work that jointly measures GABA, water activity, rancidity, microbial status, and packaging performance.
- Build intended-use and high-consumer exposure scenarios, including GABA, sodium, residual glutamate, fibre, and co-active compounds.
- Use the same final standardized red-rice-bran product in a preregistered randomized trial; choose one primary endpoint and clinically meaningful effect threshold.
- Maintain a dated regulatory evidence table in IngreDB rather than a binary permitted/prohibited flag.
- Treat crawler candidates as unverified until matrix, analyte, method, outcome, full text, and license have been manually checked.

12. Conclusions

The open-access literature supports rice bran as a scientifically credible GABA matrix, but it does not support a generic “GABA-rich red rice bran” or health-effect claim. Processing can increase GABA from modest native values to percentage-level concentrations, yet those products differ in cultivar, fraction, microbial strain, added precursor, unit basis, assay, purity, and delivered serving. The same heterogeneity that makes bran an interesting innovation platform also makes evidence transfer hazardous.

For GFoRII and GFoRSS, the strongest near-term contribution is not a universal claim. It is a common evidence architecture: product-specific identity, traceable manufacturing, validated GABA measurement, batch and shelf-life specifications, exposure and contaminant assessment, same-product human evidence, and dated regulatory provenance. IngreDB already provides the right foundation for identity and matrix context. Completing the missing GABA fields would turn red rice bran from a promising database record into a test case for interoperable regulatory science.

Declarations

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Competing interests: To be completed individually by all authors before submission.

Author contributions: CRediT roles should be confirmed by all authors; no role allocation has been inferred in this draft.

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Institutional disclaimer: The interpretations in this working draft are those of the authors and do not necessarily represent official positions of BPOM, GFoRII/GFoRSS, or the authors’ institutions and associations.

Data availability: The extracted evidence matrix, crawler audit, figure source manifests, and SQalytics chart specifications accompany the manuscript. Primary project data remain subject to project governance and should not be made public without the project owners’ authorization.

Glossary

Table 14. Controlled vocabulary used in this review

Term	Operational definition
GABA	γ-Aminobutyric acid (4-aminobutanoic acid), treated here as a measured analyte rather than a claim category.
Rice bran / bekatul	The milling fraction derived mainly from outer grain layers; distinct from rice germ, whole grain, oil and wax.
Red rice bran	Bran from a red-pigmented rice grain; evidence is not assumed to transfer from generic bran without identity data.
Direct evidence	Evidence generated on a defined rice-bran or bran-derived matrix.
Adjacent evidence	Evidence from rice germ, whole grain or germinated rice used only for plausibility or dose context.
Same-product bridge	A human study in which the tested ingredient matches the claimed final product in identity, process, composition and dose.
As-is basis	Concentration reported for the sample at its measured moisture content.
Dry basis	Concentration normalized to dry matter using measured moisture.
Evidence readiness	Completeness of fields needed for assessment; it is not a score of safety or efficacy.

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Appendix A. Evidence-package inventory

Table A1. Files supplied with the review

Artifact	Contents	Use
Bekatul_GABA_evidence_matrix.xlsx	OA corpus, quantitative evidence, clinical/safety, IngreDB audit, primary data, regulation, gaps, search log and charts	Auditable extraction and update surface
fig00 conceptual diagram	Indonesia-centred red rice–bran–GABA binding logic	Graphical abstract and scope control
fig01–fig08 and fig12 .png/.svg/.pdf	SQalytics Publication Graph Studio exports and source manifests	Publication graphics and reproducibility
fig09–fig11 .png	Primary project bioactive, FTIR/XRD/DSC, and SEM composites	Qualified matrix-characterization support
openalex/europepmc candidate JSON	Crawler discovery output	Candidate audit; not automatically verified evidence
component-fill audit	Database-wide completeness diagnostic	System context only; not an ING-ID-0009 score