Received: 12 July 2026	Revised: 16 Aug 2026	Accepted: 15 Sept 2026

Review Article

AJDP
Nature has the Power to Heal

ISSN: 3048-5614

"VIPAKA AND GUT MICROBIAL BIOTRANSFORMATION OF PHYTOCONSTITUENTS: A CONCEPTUAL REVIEW AND EVIDENCE-BASED HYPOTHESES FOR TESTING THE POST-DIGESTIVE EFFECT OF AYURVEDIC DRUGS"

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FUNDING INFORMATION:
Not Applicable

How to cite this article:
Tushar Tapadiya, "Vipaka and gut microbial biotransformation of phytoconstituents: a conceptual review and evidence-based hypotheses for testing the post-digestive effect of Ayurvedic drugs" Asian Journal of Dravyaguna and Pharmacology. 2026;3(3):5-8.
Sri. 2026.1006.ajdp.03.02

ABSTRACT
Vipaka is the Ayurvedic concept of the post-digestive transformation of a substance. It is the change that occurs after the action of digestive fire, which determines the substance's later effects on the dosha, tissues and excreta. Charaka recognises three vipaka, madhura (sweet), amla (sour) and katu (pungent), which generally follow taste but with important exceptions, such as ginger, which is pungent in taste but sweet in vipaka. It has been difficult to study because it is inferred from outcomes. This review proposes that gut microbial biotransformation of phytoconstituents provides a framework for making vipaka testable. Gut microbes metabolise a wide range of plant compounds, including glycosides, polyphenols and alkaloids, into metabolites that may be more or less active than the parent compounds. The ellagitannins abundant in Triphala, for example, are converted by gut bacteria into urolithins. The capacity to produce them varies between people, and an analysis of urolithin metabotypes found that it depends mainly on age. In fermentation studies with human faeces, Triphala, liquorice and slippery elm each produced distinct microbial communities and increased short-chain fatty acid producers. In a colon simulation model, Triphala increased *Akkermansia muciniphila*, reduced *Bifidobacterium* and altered microbial metabolites. These findings parallel classical descriptions of vipaka in three ways: transformation after digestion, dependence on the individual's digestive capacity, and effects that differ from those predicted by taste. We formulate specific hypotheses and propose study designs to test whether classical vipaka predicts microbial metabolite profiles and their physiological effects.

KEYWORDS: Vipaka, gut microbiota, biotransformation, urolithins, Triphala, Agni, post-digestive effect, Dravyaguna

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INTRODUCTION

Classical Dravyaguna recognises that a drug does not act only by the properties it has when swallowed. After the action of the digestive fire (jatharagni), the drug undergoes a further transformation, vipaka, and its later effects on the dosha, tissues and excreta depend on the result.[1,2] Charaka describes three vipaka. Sweet and salty substances usually become madhura vipaka, sour substances amla vipaka, and pungent, bitter and astringent substances katu vipaka.[1] Madhura vipaka is said to promote kapha and semen and ease excretion; amla vipaka promotes pitta; katu vipaka promotes vata, reduces semen and obstructs excretion.[1] There are notable exceptions: dry ginger is pungent in taste but sweet in vipaka, and the texts explain such exceptions as arising from the unique composition of the drug.[1]

Vipaka has been one of the hardest Dravyaguna concepts to study, because it is inferred from the effects of a drug after digestion rather than observed directly.[1] Modern research on the gut microbiota offers a new way to think about it. The human gut contains a vast community of microbes that chemically transform many ingested compounds, including drugs and plant constituents, into metabolites with different properties.[3] This review examines whether microbial biotransformation provides a useful framework for vipaka, summarises relevant evidence for Ayurvedic drugs, and proposes testable hypotheses.

METHODS

This is a conceptual review. We drew on classical descriptions of vipaka and on literature concerning gut microbial metabolism of phytoconstituents, with emphasis on studies of Ayurvedic drugs and their constituents. The aim is to generate hypotheses rather than to synthesise evidence exhaustively.

GUT MICROBIAL BIOTRANSFORMATION OF PLANT COMPOUNDS

Gut microbes carry out reactions that human enzymes cannot, including removal of sugar groups from glycosides, reduction, dehydroxylation, ring cleavage and demethylation.[3] Many plant constituents are poorly absorbed in the small intestine and reach the colon, where these reactions convert them into smaller, often more absorbable metabolites. The result can be activation of a pro-drug, inactivation of an active compound, or formation of a metabolite with new activity.[3] Because microbial communities differ between people, the same drug can yield different metabolites in different individuals.

Ellagitannins provide a well-studied example directly relevant to Ayurveda. They are abundant in Amalaki, Haritaki and Bibhitaki, the three fruits of Triphala. In the gut they release ellagic acid, which bacteria convert into urolithins, compounds absorbed much more readily than the parent tannins. People differ in their ability to produce urolithins and can be grouped into metabotypes; an analysis of these metabotypes found that the human metabolism of ellagic acid depends mainly on age.[4] A Triphala dose could therefore produce different post-digestive metabolites in a child, an adult and an older person, even with identical intake.

AYURVEDIC DRUGS AND THE GUT MICROBIOTA

Table 1 summarises studies of Ayurvedic drugs and gut microbial communities.

Table 1. Studies of Ayurvedic drugs and human gut microbiota.

Study	Drug and model	Main finding
Peterson et al., 2018[5]	Triphala, liquorice, slippery elm; anaerobic faecal cultures from 12 adults	Distinct community for each herb; increased *Bifidobacterium*, *Lactobacillus* and short-chain fatty acid producers; reduced potential pathogens
Goya-Jorge et al., 2025[6]	Triphala; colon simulation with faeces from mildly constipated donors	Increased *Akkermansia muciniphila*; reduced *Bifidobacterium*; reduced branched-chain fatty acids and ammonia; increased tryptamine; improved epithelial barrier in cell model
Cortés-Martín et al., 2018[4]	Ellagic acid (constituent of Triphala fruits); human metabotypes	Conversion to urolithins depends mainly on age

Two features of these studies are relevant to vipaka. First, each herb produced a distinct microbial community and set of metabolites,[5] which is consistent with the idea that drugs differ in their post-digestive transformation. Second, the effects were not uniformly beneficial: in the colon simulation,

Triphala reduced *Bifidobacterium* while increasing *Akkermansia* and lowering potentially harmful metabolites.[6] Post-digestive effects can therefore be complex and context-dependent, as classical texts imply when they relate the effects of vipaka to the person's condition.

PARALLELS BETWEEN VIPAKA AND MICROBIAL BIOTRANSFORMATION

Three parallels suggest that microbial biotransformation is a useful, though partial, model for vipaka (Table 2).

Table 2. Parallels between classical vipaka and gut microbial biotransformation.

Classical feature	Microbial counterpart	Example
Transformation after digestion determines later action	Colonic metabolism of unabsorbed constituents yields active metabolites[3]	Ellagitannins to urolithins[4]
Outcome depends on the individual's agni	Outcome depends on the individual's microbiota and age[4]	Urolithin metabotypes
Vipaka may differ from rasa	Metabolite activity may differ from parent compound activity[3]	Bitter, astringent tannins yielding absorbable metabolites with different effects

The parallels should not be overstated. Classical vipaka is a theory of the whole digestive process, including small-intestinal digestion and tissue metabolism, not only the colon. It is also defined by its effects on dosha, tissues and excreta rather than by specific chemicals.[1] Microbial biotransformation is one mechanism that could contribute to vipaka, not a complete translation of it.

TESTABLE HYPOTHESES

- Hypothesis 1: drugs of the same classical vipaka produce more similar microbial metabolite profiles in standardised faecal fermentation than drugs of different vipaka.
- Hypothesis 2: exceptional drugs whose vipaka differs from their rasa, such as dry ginger, produce metabolite profiles closer to their vipaka group than to their rasa group.
- Hypothesis 3: drugs of madhura vipaka increase short-chain fatty acid production and ease bowel transit, whereas drugs of katu vipaka reduce them, consistent with the classical effects on excretion.[1,5]
- Hypothesis 4: the post-digestive effects of a drug vary between individuals according to their microbial metabotype, which may correspond to classical assessments of agni.[4]

These hypotheses can be tested with in vitro fermentation using standardised faecal inocula, followed by human studies that measure plasma and urinary metabolites, microbial composition and classical outcomes such as bowel habit after controlled administration of drugs of different vipaka. Plant material must be authenticated and chemically characterised.[7] Ginger is a useful test case, since its classical sweet vipaka contrasts with its pungent taste, and it did not raise energy expenditure in a three-month trial.[8]

LIMITATIONS

This is a conceptual review, and the evidence linking specific Ayurvedic drugs to microbial metabolism is limited and largely in vitro. Isolated compounds such as curcumin have complicated metabolic fates and may give misleading results in assays.[9] Classical vipaka is broader than microbial metabolism, and any mapping between them is provisional.

CONCLUSION

Vipaka describes a transformation after digestion that shapes the later action of a drug and depends on the individual. Gut microbial biotransformation of plant constituents has exactly these features, and studies of Triphala and other Ayurvedic drugs show that they produce distinct, individual-dependent microbial and metabolic effects. Framing vipaka in terms of microbial metabolism yields testable hypotheses that could, for the first time, put this elusive Dravyaguna concept on an experimental footing.

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