



ISSN : 2347 - 2243

Indo - American Journal of Life Sciences and Biotechnology



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Probiotic Potential of Lactobacillus Strains Isolated From Traditional Fermented Rice Batter

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Received: April 2, 2015 Accepted: July 15, 2015 Published: December 5, 2015

DOI: [10.62644/iajlb.2015.v12.i4.pp9-18](https://doi.org/10.62644/iajlb.2015.v12.i4.pp9-18)

ABSTRACT

Traditional fermented rice batters, of the kind used for steamed cakes and griddle breads across South Asia, are often described as a ready source of probiotic lactobacilli. This narrative review asks how much weight that description can bear. It draws on published work on the microbiology of cereal and pulse fermentations, on the definition and selection of probiotic strains, and on the safety and regulatory literature, and it reports no new isolates, assays or measurements. Fermented batters host a changing community in which lactic acid bacteria dominate, but a species found in a food is not the same thing as a probiotic strain: the term applies to a defined strain with a demonstrated benefit, and benefits do not transfer between strains or species. The usual laboratory screen of acid tolerance, bile tolerance, adhesion and antagonism of pathogens is useful for ranking isolates but predicts health effects only loosely, and screens are seldom run in a food matrix. Safety checks, notably identification to strain level, antibiotic susceptibility and absence of transferable resistance, are less often reported than survival assays. The review concludes that isolates from fermented rice batters are reasonable candidates for study rather than established probiotics, and it sets out the evidence a convincing claim would need.

Keywords: Probiotics; Lactobacillus; Fermented rice batter; Lactic acid bacteria; Strain selection; Food safety; Narrative review

Citation: Oberdorfer, Kesselring and Arrieta [2015]. Probiotic Potential of Lactobacillus Strains Isolated From Traditional Fermented Rice Batter. *Indo-Am. J. Life Sci. Biotechnol.* 12(4):9-18. DOI: [10.62644/iajlb.2015.v12.i4.pp9-18](https://doi.org/10.62644/iajlb.2015.v12.i4.pp9-18)

Article Class: Narrative Review

1. Introduction

Walk through a South Asian kitchen early in the morning and there is a fair chance of finding a vessel of pale, bubbling batter on the counter. Ground rice, usually combined with a pulse, is left overnight to sour, and

by morning it has risen, smells faintly acidic and is ready to be steamed or fried. The transformation is microbial, and it has been exploited by households for generations without anyone needing to name the organisms responsible (1, 2). It is



natural that microbiologists have asked whether some of those organisms might be useful beyond the kitchen.

Lactic acid bacteria dominate many cereal and pulse fermentations, and lactobacilli are among the groups most often proposed as sources of probiotic strains (3, 4). Fermented foods of Asia, from vegetables to fruit to cereal batters, are regularly described as a promising reservoir of such bacteria (5, 6). The step from that description to a probiotic product, however, is longer than it first appears. A bacterium that lives happily in batter is not a probiotic simply because it is a *Lactobacillus*, and it is not necessarily harmless simply because people have eaten the batter for centuries.

This article is a narrative review of the published literature on the probiotic potential of lactobacilli from traditional fermented rice batters. The title speaks of strains isolated from batter, which suggests a laboratory study; none is reported here. No isolates were collected, no assays were run and no local figures are presented. What follows is an account of what is known about the habitat, what is required of a probiotic, how candidate strains are usually screened and where those screens fall short. The aim is to separate what a strain can do in a dish from what it can be shown to do in a person.

2. Literature Review

2.1 Fermented Rice Batters as a Microbial Habitat

Fermentation of cereals and pulses is among the oldest forms of food processing, and it is practised in some form on every inhabited continent (1). Reviews of cereal-based fermented foods describe a consistent pattern: raw materials carry a mixed microbial load, fermentation selects for organisms tolerant of acid and of the available sugars, and the final product

reflects both the recipe and the environment in which it was made (2, 3). Rice batters follow the same logic. Starch is slowly broken down, the pH falls, gas is produced, and the batter becomes a habitat dominated by lactic acid bacteria with yeasts alongside.

Work on the batter used for steamed fermented cakes has focused on selecting starter cultures that give consistent souring and leavening, and it illustrates how varied the community can be from batch to batch (7). Studies of other traditional fermented foods of South Asia show that the dominant lactic acid bacteria differ between products, between households and even between seasons (4, 8). For a microbiologist hoping to isolate a probiotic, this variability cuts both ways. It means that a rich diversity of isolates may be available, and it also means that a strain isolated from one batch may tell us little about batter in general, still less about the many regional variants of the recipe. Sampling several batches, households and seasons is the only way to learn which organisms are habitual and which are chance arrivals. Table 1 summarises the features of the habitat that matter for such claims.

A further point is easily missed. The microbes in a batter come from the grain, the grinding stones or machines, the water, the vessel and the remains of earlier batches. Which of them are stable residents of the batter, and which are passing through, is seldom established, and a single sample describes one batch on one day. Moreover, batter is usually cooked before it is eaten, so the live bacteria that interest the probiotic researcher may not reach the consumer at all (9). A food can be an excellent source of strains and a poor delivery vehicle for them, and the two roles should be kept apart. This is one reason the same genus can look promising



in one report and unremarkable in the next.

Table 1. Features of fermented rice batters relevant to probiotic claims.

Feature	What is generally reported	Why it matters
Substrate	Rice, often with a pulse, ground and left to ferment (1, 2)	Starch and protein support growth of lactic acid bacteria
Community	Lactic acid bacteria with yeasts, changing over time (3, 7)	A species seen once may be transient
Origin of microbes	Grain, equipment, water and previous batches	Hard to say which are resident
Consumption	Usually cooked before eating	Heat may remove live cells (9)
Variability	Differs between households and seasons (8)	Isolates cannot be assumed typical

Note: Qualitative summary. Batter communities differ with recipe, climate and season, so no counts are given.

2.2 What Makes a Bacterium a Probiotic

The working definition, endorsed by international expert panels and revisited in a consensus statement, describes probiotics as live microorganisms that, when administered in adequate amounts, confer a health benefit on the host (10, 11). Each clause carries weight. The organism must be alive, the dose must be adequate, and the benefit must be shown, not assumed. The history of the idea, from early speculation about fermented milk and longevity to modern trials, shows how often enthusiasm has run ahead of evidence (12, 13).

Two consequences follow. The first is that the term belongs to a defined strain, not to a genus or species, because effects documented for one strain do not transfer to another (10, 14). A claim about *Lactobacillus* in general is therefore a

claim about nothing in particular. The second is that benefit must be demonstrated in the host species for which it is claimed, normally through controlled human studies. Reviews of clinical use describe real but selective benefits for particular conditions and particular strains (15, 16), and a meta-analysis of trials in gastrointestinal disease found that the size of the effect depended heavily on the strain or mixture used and on the condition studied (17). A reader who meets a strain name on a label deserves to know whether safety testing or clinical evidence stands behind it.

2.3 Lactobacilli: Naming, Diversity and Identification

The genus *Lactobacillus* is large and diverse. Phylogenomic comparison shows that it spans a degree of genetic distance more typical of several genera, and that its present classification is a historical convenience rather than a tidy reflection of relatedness (18). Species names in this genus are therefore a coarse label. Species such as *L. plantarum*, whose complete genome revealed a large and versatile set of genes for sugar use and for interaction with the environment, can differ considerably between strains of the same name (19, 20).

Identification in the laboratory has moved from phenotype to sequence. Amplification and sequencing of the 16S ribosomal gene gave microbiologists a common method for placing isolates on the bacterial tree (21), and it remains a routine first step in studies of fermented foods (8). Its limits are well known: closely related lactobacilli can share nearly identical 16S sequences, so a name given on this basis is often a species-level suggestion. Strain-level identity, which is what a probiotic claim requires, calls for more discriminating methods or for genome data.



Ecology adds a final complication. Lactobacilli recovered from the human gut are a mixed collection, and many of them are probably transients from food, not permanent residents (22). A lactobacillus that is recovered from stool after a person eats a fermented food has survived passage, which is useful to know, but it has not necessarily colonised the gut. Colonisation is a stronger claim and is rarely tested.

2.4 Surviving the Digestive Tract

An ingested strain meets acid in the stomach, bile salts and digestive enzymes in the small intestine, and a crowded microbial community lower down (Figure 1). Early work showed that survival of lactic acid bacteria in the human stomach varied from strain to strain and was influenced by what the bacteria were given with (23). Lactic acid bacteria defend themselves against low pH by regulating their internal pH, a process that depends on energy supply and that eventually fails if the external acid is severe enough (24). Notably, the presence of a fermentable sugar can improve the survival of lactobacilli in acidic conditions, which means that the composition of a test medium can change the result (25).

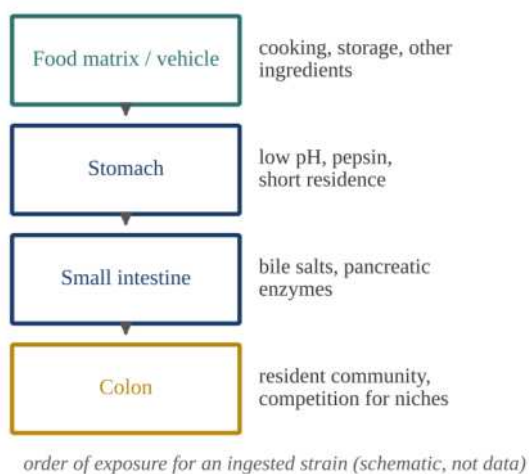


Figure 1. Stresses met by an ingested strain along the digestive tract (schematic, not data).

Bile is a second barrier. Tolerance of bile was recognised early as a desirable property for a strain intended to act in the intestine (26), and the interaction between bacteria and bile involves membrane effects, enzymatic modification of bile salts and stress responses that differ between species (27, 28). Because bile resistance rests on several mechanisms, a single yes-or-no test hides much of what is going on. Simulated gastrointestinal models that combine acid, enzymes and bile in sequence attempt to mimic transit more faithfully, though they remain artificial (29).

2.5 Adhesion, Antagonism and Host Interaction

Adhesion to the intestinal surface is often treated as a marker of probiotic potential, on the reasoning that a strain which binds may persist longer and interact more with the host. Studies using cultured cell lines have shown that adhesion varies markedly between strains, including strains of one species (30, 31). The molecular side of this has been mapped in some detail: surface proteins, polysaccharides and other cell envelope components mediate contact with the host and with mucus, and they differ between probiotic strains, commensals and pathogens (32, 33).

Lactobacilli also act against other microbes. They acidify their surroundings, produce hydrogen peroxide in some conditions, compete for adhesion sites and make antimicrobial peptides (34). The bacteriocins in particular have attracted interest as natural preservatives and as agents of competition in the gut (35). Inhibition seen on an agar plate, however, shows that a strain can make something that stops a pathogen under those conditions. It does not show that the same thing happens in the intestine, where nutrients, pH and the surrounding community are quite different.



3. Materials and Methods

3.1 Scope and Question

The review asks one question in two parts. How strong is the case that lactobacilli from traditional fermented rice batters are probiotic candidates, and what evidence would be needed to turn a candidate into a probiotic? The question was broken into the stages a study would have to pass: the habitat, the identity of the strain, survival through the digestive tract, adhesion and antagonism, safety, and demonstration of benefit. None of these steps is exotic, but each is easy to skip.

3.2 Literature Assembly

The review draws on peer-reviewed publications in four areas: the microbiology of fermented cereal and pulse foods; the definition, selection and clinical evaluation of probiotics; the physiology and molecular biology of lactobacilli; and the safety and regulatory literature. Sources were chosen for relevance, standing in the field and clarity of methods, and all of them were published in or before 2015. Work on other fermented foods is used for what it teaches about methods and pitfalls, not as evidence about rice batters.

We did not carry out a formal systematic search, and we do not claim to have done so. This is a narrative synthesis and the choice of sources reflects the authors' judgement. One consequence is that the review is a better guide to what a sound study should contain than to the exact performance of any particular isolate, and for that reason we do not quote performance figures from individual isolation studies.

3.3 Appraisal Framework

To judge how far a report supports a probiotic claim, we asked four questions. Is the isolate identified to strain level, or only named by species? Were the in vitro

screens chosen for relevance to the intended use and run under conditions resembling it (36, 37)? Was safety examined, including antibiotic susceptibility and the possibility of transferable resistance (38, 39)? And was any health benefit shown in the target host, with the dose and the vehicle described? Table 2 lists the common screens that the first two questions refer to.

Table 2. Common in vitro screens for candidate probiotic isolates and their main caveats.

Screen	What it tests	Main caveat
Acid tolerance	Survival at low pH for a set time (24, 25)	Medium and sugars change the outcome
Bile tolerance	Growth or survival with bile salts (26, 27)	Bile used is often not human bile
Adhesion	Binding to mucus or cultured cells (30, 31)	Cell lines are not the gut
Antagonism	Inhibition of pathogens (34, 35)	Often tested in agar, not in food
Transit model	Combined stress in a simulated gut (29)	Still an artificial system

Note: Caveats are those discussed in the cited methodological literature, not attributed to any single study.

4. Results

4.1 What the Habitat Can and Cannot Offer

The route from batter to claim is a long one (Figure 2). An isolate must be purified, identified, screened, characterised for safety, tested in a suitable vehicle and finally evaluated in people. Most laboratory reports cover the first few steps. In a typical report the later steps are described as future work, and the conclusion nonetheless refers to the isolate as having probiotic potential. The phrase is defensible if it is read as an invitation to further study. It becomes misleading when



it is read as a finding. Small differences at this stage can decide which isolate is carried forward.

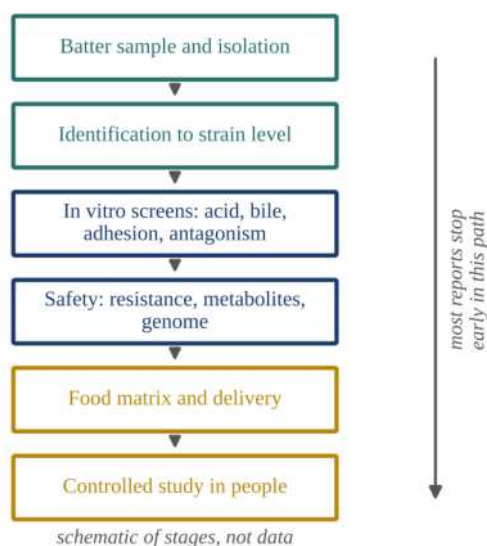


Figure 2. From batter to claim: stages between isolation and a health statement (schematic, not data).

4.2 What In Vitro Screens Tell Us

Screening for acid tolerance, bile tolerance, adhesion and antagonism is the usual first filter, and the idea of selecting strains by such criteria has been argued from the mid-1990s onward (36, 37). These screens are useful because they are cheap, quick and capable of discarding poor candidates. Their weakness lies in prediction. The correlation between in vitro properties and in vivo findings has been examined, and it is imperfect (37). A strain that tolerates acid in broth may fail in a food matrix, and one that adheres to a cell line may not adhere in a gut (25, 30). A strain tested in a realistic food matrix often behaves differently from the same strain in broth. Read in this way, a negative in vitro result is informative, while a positive one is only an invitation to test further.

Methods also differ from one laboratory to another, and that makes reports hard to compare. The pH used, the exposure time,

the source and concentration of bile, the medium and the way viable cells are counted all vary, and each can change the outcome (24, 27). A table of strains ranked by survival is therefore meaningful only within one study. Figure 1 shows the stresses an ingested strain meets; a screen that tests one of these in isolation tells us about that one stress only (Figure 3). The problem lies less in any one study than in how easily a laboratory result is read as a clinical one.

4.3 Safety and Resistance

Safety is where reports are thinnest. Food-grade status of a species, based on a long history of use, is sometimes treated as a safety assessment of every strain in it. Reviews on demonstrating the safety of probiotics argue for explicit testing, including attention to the possibility of toxic metabolites and the behaviour of the strain in vulnerable hosts (38, 39). Clinical reviews of risk note that probiotic use is generally well tolerated but that cases of infection have been described in people who are seriously ill or have compromised defences (40).

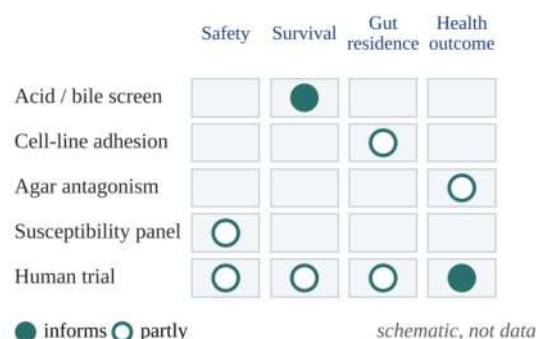


Figure 3. What each type of laboratory test can inform (qualitative matrix, not data).

Antibiotic resistance is a separate matter. Lactic acid bacteria are often intrinsically resistant to some antibiotics, and this is generally not a concern. The worry is



resistance that sits on mobile genetic elements and could pass to other bacteria in the gut (41, 42). Reviews of resistance in probiotic bacteria emphasise that the distinction between intrinsic and transferable resistance matters and that susceptibility testing should follow standard breakpoints where these exist (43). Many isolation studies test only a handful of antibiotics and do not look for transferable determinants at all (Table 3). Habit, more than difficulty, keeps these checks out of many reports.

4.4 Technological Suitability and the Matter of Delivery

A strain that is healthy in the laboratory must also survive processing and storage in a food if it is to deliver anything. Technological properties such as growth in the food, stability during storage and effect on flavour are part of the functional characterisation of a strain (39, 44). Non-dairy foods raise their own difficulties because viability is affected by acidity, water activity and the other components of the matrix (9).

Table 3. Safety and identification checks that should accompany a probiotic claim.

Check	Reason	Frequent gap
Strain identity	Effects belong to strains (10, 11)	Species-level naming only
Antibiotic susceptibility	Resistance genes can be mobile (41, 42)	Limited agents tested
Transferable resistance	Matters more than intrinsic resistance (43)	Rarely sought
Toxic metabolites	Safety of the strain and its products (38, 40)	Seldom reported
Genome information	Predicts traits and risks (19, 20)	Not yet routine

Note: The last column gives the authors' reading of the cited reviews, not a count of studies.

For rice batters the problem is plain. The product is typically cooked, and cooking

kills vegetative bacteria. A probiotic effect would require either a modified product that is eaten without heat, or a purified culture delivered by another route. Both are possible, and both are different from the claim implied by the title, which concerns the batter. This does not weaken the case for studying the strains. It means that the strains and the food should be evaluated as separate questions. That is a modest position, but it is the one the literature will currently carry.

5. Discussion

5.1 Interpretation and Practical Reading

The main finding of this review is that the case for lactobacilli from fermented rice batters is a case for further study. The habitat is plausible, the genus is relevant and the screens exist. None of that, taken alone, makes an isolate a probiotic. What is missing is not exotic, namely strain-level identity, safety data and a demonstrated benefit, and its absence is the usual reason a promising isolate stays promising for years (10, 11). Nothing here argues against studying fermented foods; it argues for describing exactly what was studied.

5.2 Limitations

This is a narrative review and shares the limitations of the form. The sources reflect judgement, no formal search or scoring of quality was carried out, and the review does not report numerical results from individual isolation studies because these could not be checked against the primary reports for this article. A reader who needs the performance of a particular strain should consult the original paper and apply the appraisal questions above. These cautions apply with equal force to any food-derived candidate, not only to rice batters.

The review also relies on evidence from other foods and from other species of



lactobacilli, which are imperfect proxies for rice batters, and on laboratory models that are imperfect proxies for the gut. We have used them to frame questions and to identify pitfalls, and the conclusions should be read in that light. Reviews are more useful when they say where the evidence stops than when they smooth it over.

5.3 Directions for Future Work

Three needs stand out. The first is better reporting: isolates identified to strain level with a stated method, screens described in enough detail to repeat, and failures reported alongside successes. The second is routine safety work, including a wider panel of antibiotics and a search for transferable resistance, with genome sequencing where possible (20, 43). The third is a move from broth to food, testing candidates in the vehicle in which they would be delivered and, ultimately, in controlled studies in people (9, 15). A candidate that passes these stages would have earned the name probiotic. One that has passed only the first has earned a second look.

6. Conclusion

Traditional fermented rice batters are a plausible source of lactobacilli that merit study as probiotic candidates. The published evidence does not show that any batter-derived strain has been established as a probiotic, and the usual laboratory screens, though valuable, cannot by themselves carry a health claim. What the literature does show is what a convincing claim would require: a strain identified with care, screened under realistic conditions, checked for safety and resistance, and tested for benefit in the intended host. Readers should treat the phrase probiotic potential as a statement about a research direction, not a result.

7. Acknowledgements

The authors thank colleagues who commented on earlier drafts of this review.

8. Funding

This work received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

9. Conflict of Interest

The authors declare no conflict of interest.

10. Author Contributions

M.O. conceived the review and wrote the sections on fermented foods and strain selection. M.K. wrote the sections on safety and antibiotic resistance. M.A. wrote the sections on digestive-tract survival and host interaction. All authors revised the manuscript and approved the final version.

11. Ethics Statement

This is a review of published literature. No human participants or animals were involved and no ethical approval was required.

12. Data Availability

No new data were generated. All sources are cited in the reference list.

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