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Investigating the Role of Grains, Pulses, Thermal Time, and Lipids in preparing the Nutritionally Complete and Perfect Khichdi

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Abstract: -

For a structurally sophisticated dish such as khichdi, we have done it a great disfavour by equating it to comfort food or food to be served to convalescing individuals. Sometimes khichdi also gets relegated to the role of being considered a culinary minimalist creation. In the arguments put forward through this article, the author intends to demonstrate that despite the general nonchalance afforded to khichdi, it will be very evident after examining all the data available at hand that a khichdi is actually a complex, nutritionally engineered product that uses various interdependent variables that are set within the framework of a coherent food system. These variables are and are not limited to the demonstration of an amalgamation of grains, pulses, spice architecture, a lipid medium, and thermal duration function as a coalescing unit for interdependent variables within what is technically an extremely coherent food system. The endurance of khichdi as a beloved food of the masses, a fact that skips the typical roadblocks of class and in the Indian context, the class system points to a culinary dish that should not be viewed as a simple combination of ingredients but as a symbol of empirical precision that is built into and embedded within essential culinary practice. The fascination with khichdi is enhanced by a simple and logical look at its longevity at being at the centre of research. A basic khichdi is composed of very few ingredients and yet it has remained relevant both culturally and physically across varying contexts. It has remained constant despite changes in culinary trends and fashions, shifts in nutritional paradigms and beyond the evolution of agricultural systems. The khichdi has also traversed and stayed consistent within the frameworks of modern nutritional discourses and stretching way back to Vedic period ritual economies via route of British colonial reimagination, and Mughal royal kitchens. This is easily demonstrated by the fact that the variables themselves ensure that the decision to work out as to what could be a 'perfect' khichdi could be arrived at more from a contextual lens rather than one that is universal. Because, to these variables, we can also add individual digestive states and capacities, sociocultural framing, and specific metabolic demand of individuals. From the ancient texts that have focused on glycaemic modulation, complementarity of the cereal and pulses and their ratios, and a bioavailability of phytochemicals that appear to be lipid-mediated, to the latter-day dismissal by British historians as a 'humble porridge', Indo-Persian records

and contemporary nutritional science that believes it to be a superfood, the multi-faceted complexities of a khichdi need to be unravelled in a phased manner. This research paper aims to work on one such specific aspect.

Introduction: The Focus on Culinary Minimalism: -

Historical persistence and the demonstration of physiological efficacy and to a great measure, psychological appeal, a khichdi has ensured that it is perceived as structured food and not merely an economical fallback. It is amongst the tiny minority of dishes that keep being routinely underestimated. Although it is composed of modest ingredients that are primarily a combination of pulses and grains, then additions of measured quantities of water and spices, salt, and fat that are supplementary but with utmost restraint, it packs a nutritional punch that far outweighs the simplicity in appearance (Diwekar, 2009).

There are over two millennia of textual references in the case of khichdi. These references may appear under the name khichdi or similar cognate words (Pant, 2024). Khichdi has also been the bridge between comforting the physical as well as the spiritual (Gupta, 2026). The appeal of khichdi lies in its stable and reproducible form that has been through the centuries embedded in domestic, ritual, and courtly contexts (Verma, 2025). Khichdi has also been linked to centuries of traditional pilgrimage kitchens that are located between waypoints of Hindu religious pilgrimage spots (Bharati, 1963). The universal appeal also being in the manner of how a khichdi's mild spice profile, soft texture, and simple composition allow it to be a universally acceptable food to both young and older pilgrims equally (Ghosh A. , 2022). Because the ingredients of the khichdi can be customised to ensure that they follow the traditional Hindu Sattvic dietary principles which are vital for a pilgrimage, it has cemented its position as the universally accepted food to be served to pilgrims and to those seeking enlightenment (Narayan, 2020).

Every claim this article makes about khichdi's sophistication rests on a smaller and more basic one: that cooking is not a neutral act of assembly but a controlled transformation, governed by heat, hydration, and time, whose specific parameters decide a dish's overall quality. This could include whether it is safe to eat, texturally sound, flavourful, and nutritionally available once eaten. This is what the article means by culinary thermodynamics, and each of these four outcomes follows a distinct mechanism. Safety is secured as sustained heat and moisture denature anti-nutritional compounds and inhibit microbial activity within the cooking medium.

Texture is set by the gelatinisation of starch granules and the coagulation of plant proteins, the process by which a hard, resistant grain becomes a soft and digestible one. Flavour develops chiefly at the tempering stage, where spices are heated briefly in fat to volatilise their aromatic oils, which the cooking liquid then carries through the grain and pulse. Nutritional value is the least straightforward of the four outcomes: heat can destroy certain micronutrients even as it unlocks others, by breaking down the plant cell walls and antinutritional factors that would otherwise limit their absorption. Recent scholarship in physics and food science has increasingly treated these thermally governed transformations as legitimate objects of rigorous study in their own right (Mathijssen, Lisicki, Prakash, & Mossige, 2023), which is the disciplinary ground on which this article's own use of the term rests.

This is not a claim that khichdi is engineered with laboratory precision; the evidence available does not support that, and the sections that follow are explicit about the difference. It is a narrower claim, and one better described through the lens of culinary science than of pure science: that khichdi's preparation follows a coherent, empirically discovered logic of grain, pulse, lipid, spice, and heat, arrived at and re-confirmed through an unusually long practical record rather than through controlled experiment. A specific gap separates that record from contemporary scholarship. Ayurvedic and historical literature has documented khichdi's reputation for digestibility and restorative value in rich qualitative detail for over two millennia (Pant, 2024) (Charaka & Drdhabala, 1) (Sushruta & Bishagratna, 1907) while food science has, independently, produced a substantial and growing body of work on the composition and digestibility of legume and cereal proteins (Zhang, Boateng, Xu, & Zhang, 2024) and on the processing behaviour, digestibility, and antinutritional properties of the millets used across several of khichdi's regional variants (Fu, Gao, & Li, 2023) (Balyatanda, et al., 2024). What is largely missing is a sustained attempt to read these two literatures against each other around a single dish. It is this gap, and not a gap in khichdi's cultural documentation, that the present article addresses.

Two research questions organise the analysis that follows. First: through what specific thermal, hydration, and lipid-mediated mechanisms does the preparation of khichdi convert raw grain and pulse into a dish that independent textual traditions, separated by centuries and by purpose, consistently describe as unusually digestible and restorative? Second: when khichdi's grain, pulse, lipid, and spice components are substituted for reasons of climate, geography, or economic necessity such as the regional and poverty-history sections of this article go on to

document or show and how does the underlying nutritional architecture identified in response to the first question hold, degrade in proportion to the substitution, or fail outright? Both questions are pursued through literature synthesis and historical-textual analysis rather than through original laboratory work, a methodological choice made explicit here so that the claims which follow are read as an interpretive model built from existing evidence, and not as new empirical findings.

Three objectives follow accordingly. A) To synthesise the food-science literature on starch gelatinisation, protein complementarity, lipid-mediated bioavailability, and spice-driven digestive modulation specifically as it bears on khichdi's grain-pulse matrix, connecting mechanisms already established in that literature to a dish that has rarely been its explicit subject. B) To examine, through historical, ethnographic, and socioeconomic material, how khichdi's regional and poverty-driven adaptations test the resilience of this architecture, and what their outcomes suggest about its underlying structure. C) To propose, from this synthesis, a provisional and literature-derived model of khichdi's compositional logic, offered here as a hypothesis for future empirical testing — through primary data collection, sensory evaluation, and laboratory analysis — rather than as a validated finding; its limitations in this respect are addressed explicitly in the discussion of methodology below.

The intentional design of a khichdi also reveals an advanced culinary intelligence that uses carminative spices and fat to modulate digestion, balances amino acids through the perfect complementarity of cereals and pulses, and ensures the transformation of starch and protein through a mechanism of ensuring controlling over both hydration and heat (Han, Moughan, Li, Stroebinger, & Pang, 2021) (ND & Gonuguntla BNS, 2024) (Platel & Srinivasan, 2024) (Dhingra & Jood, 2002). Through this article, the author would like to advance three propositions that would prove that unlike the popular misconception of a khichdi being culinary nostalgia, it is in fact a case of culinary architectural precision. The three propositions are:

A) The adaptability of khichdi whether prepared with rice or millets, whether sparse or enriched, outwardly demonstrates a system capable of responding to environmental and physiological variations.
B) Sensory bioavailability and metabolic activity are enhanced through the lipid and spice architecture.
C) Optimum digestibility and protein complementarity is ensured through a consciously stabilised pulse-cereal matrix.

Ethnographic Vignette:-

Khichdi has traditionally not been a celebratory meal. In South Asia and particularly in India, it appears on the menu at moments of recalibration. Surprisingly, these moments are not few and far between. They include the conclusion of ritual fasts, during the monsoon season or the harshest winter days, when illness strikes and a recuperative is required, or when distance needs to be fixed with comfort food. This was served to deliver ease and increase appetite.

Khichdi did not really become famous because of the complementarity of the amino acids or the glycaemic load. It retains the spot that it has because science has explained only much later what the body recognised earlier on.

Global Tableau: -

Cereal and legume dishes are prevalent around the world in almost every local cuisine and this is a culinary family with which a khichdi is associated. Mujaddara is a Middle Eastern dish composed of rice and lentils, the Portuguese Moros Y Cristianos, and Latin American traditional rice and beans are all based on a similar nutrition balancing policy. A Southeast Asian congee is also known to often incorporate beans or legumes.

What distinguishes a khichdi however is the repeated appearance within the gamut of medical discourse and its integration a part of medical advice.

The appearance of khichdi in Sanskrit texts is largely looked at as therapeutic food and less as sustenance.

Methodology: - A framework focusing on culinary system analysis. There are three analytical frameworks that have been employed in this approach in assessing khichdi from a critical perspective. Culinary thermodynamics, nutritional modelling and analysis of historical texts have been employed to arrive at our conclusions.

The focus is simply to justify through a series of well-demonstrated rationales that enduring appeal of khichdi is not continuation of folklore but as being a functional nutritional matrix.

The three core subjects chosen for our approach is due to the following:

A focus on culinary thermodynamics will explain how a grain and pulse mixture is transformed through cooking. Digestibility and sensory qualities are both determined through a look at hydration, starch gelatinisation, lipid volatility, and denaturation of protein.

In nutritional modelling, food composition databases have been drawn upon to analyse both macronutrient and micronutrient compositions in the typical khichdi formulations. In addition, we have also assessed fibre contribution, glycaemic modulation, and acid complementarity.

For historical texts, our focus has been particularly on Indian origin texts and texts that have focused on the South Asian diet. These have included and are not limited to Vedic period and traditional medical texts rooted in the Sanskrit tradition, court chronicles documenting the Indo-Persian period, and travel literature from the colonial era. No recipes have been gleaned from these texts since none are provided in the modern sense. The texts however focus extensively on dietary reasoning which on foods being components in balanced diets, digestible, or restorative.

Digestibility and Design laid in our original Sanskrit foundations: -

Mudgah laghuh salis sa sresthah annanam (Charaka & Drdhabala, 1) the epic lines from Charaka Samhita that describe the lentil commonly referred to as mung beans (*mudgah*) to be considered easy or light to digest (*laghuh*) while expressly mentioning the *Sali* strain of rice to be the best choice to ensure a digestive balance.

This is not however the first time that there has been a reference to khichdi in ancient texts. Sanskrit literature has several references to *khiccha* which has been explained as a product that has been created by cooking rice and lentils together. The earlier Vedic hymns reference dishes like khichdi without explicitly naming the same but the medical texts and ritual treatises mention a grain and pulse preparation to be a standard dietary formula especially in the case of palliative care of patients especially those recovering from febrile illnesses (Sushruta & Bishagratna, 1907).

This is also not an arbitrary pairing. Ayurvedic taxonomic system operates from the perspective of qualities of foods and their post-digestive effects. These are respectively referred to as gunas and vipaka (Lad, 2004) (Gautam, Srivastava, Urmaliya, Hardeniya, & Gupta, 2025) (Suni, Pillai, & Nair, 2021).

Given that ayurveda operates on the principle of *anubhava* which translates into experiential validation to adhere to or declare ingredients as beneficial (Singh, 2007) (Manohar, 2015). This means that the system of ayurveda works on constant observation to ensure validation. Using the human body as the primary testing ground and tracking digestive ease to ensure suitability

for the human body, the sustained endurance of khichdi as a constantly referred food or meal component, is in itself an iterative confirmation over centuries of use and the practice of Ayurveda and a testament to the efficacy of the utilisation of khichdi in treatment.

Early modern transformations preceded by medieval times: -

Fourteenth century texts especially travel literature are replete with references to khichdi albeit some may not have named it as such but had instead preferred to refer to it as simply as a dish containing rice and lentils. The famed Moroccan born traveller, explorer of north Africa, and Arabic scholar Ibn Battuta had visited India in 1334 AD at the time of the Delhi Sultanate. In his recorded diary later published under the original title *Tuhfat al-anzar fi gharaaib al-amsar wa ajaaib al-asfar* (A gift to those that contemplate the wonders of cities and the marvels of travelling) (Battutah, 2003) mentions '*kishri*' with an elaborate description of the rice and lentil dish cooked with clarified butter that he notices a large section of the population eating rather frequently. He later on alludes to this being the inspiration to the Egyptian national dish called 'Kushari' which includes rice and lentils amongst other ingredients that are cooked separately and then tossed together. Ancient India and ancient Egypt shared a very special trade bond that facilitated numerous exchanges. Primary amongst the exchanges is a well-known anthropological event that India received the lentils that are locally known as *masoor dal* which are called red lentils in English. The lentils received their name as a nod to their place of origin since the traditional name for Egypt in India is *Misr*. The 16th century courtly documents published as Ain-i-Akbari detail khichdi as a recipe and as a dish served at court without much change with respect to the description earlier laid out by ibn Battuta well over two centuries earlier (Blochmann, 2010) (Seth, 2025). The mere addition of a few spices and ghee displays what can be best termed as a courtly elaboration by the Mughals and without the structural rupture that one may expect with the passage of time.

The Mughal court then moved on to add more spices like cinnamon, clove, and mace which allowed for khichdi to be elevated socially and yet retain the architecture that makes it a nutritional powerhouse.

In the documentation maintained about life and the diet under British colonial rule, the khichdi evolves into a kedgeree. It retains the cereal and pulse core but now it has an addition of fish and eggs focusing on protein emphasis (Yule & Burnell, 1886). This represents resilience and flexibility and not dilution. This elasticity is in fact what underscores the core hypothesis of

this paper. Resilient structural ratios in the preparation of a khichdi are what ensure the possibility of variations.

Starch behaviour and glycaemic implications within grain architecture: -

In convalescent khichdi traditions, rice remains a dominant ingredient. Oryza Sativa or rice as it is commonly called is primarily composed of starch. This starch is made up of amylose and amylopectin. Rice grain strains that are amylose rich, gelatinise easily and produce cohesive textures if they are prepared in an excess of water (Juliano, 1993).

The carbohydrate content of polished white rice ranges approximately between 78 to 80% carbohydrate, 6 to 7% protein, with minimal fat and fibre that is considered negligible. Brown rice has the bran retained which is a great source of dietary fibre. Apart from the bran, micronutrients are retained. The retained bran however moderates glycaemic response which is a great thing but also helps the grain to resist uniform gelatinisation (USDA FoodData Central, 2026).

The millet family which includes pearl millets (Pennisetum Glaucum) and finger millet (Eleusine Coracana) contain a higher mineral density and higher fibre and are observed to often demonstrate lower glycaemic indices when used in comparison with polished white rice (Saleh A. S., Zhang, Chen, & Shen, 2013).

Finger millets have been observed to be calcium rich and a hundred-gram measure of the raw grain has been observed to exceed 300 mg of calcium content (Puranik, et al., 2017) (Anitha, et al., 2021). Thus, if one is to create a proper khichdi, one may choose to use rice if one wants to optimise on the digestibility and softness aspect. The use of millets would optimise metabolic moderation and mineral density.

Protein quality and pulse complementarity: -

Cereals happen to be deficient in lysine and have adequate reserves of methionine. Pulses on the other hand have this same distribution but in reverse. Consuming them together helps the attainment of the adult adequacy of amino acids (Young & Pellett, 1994).Vigna radiata also known commonly as the mung bean contains approximately 24% of raw protein and in comparison to other legumes, it also displays relatively lower levels of oligosaccharides that would go on to induce flatulence (Reddy, Pierson, Sathe, & Salunkhe, 1985) (Reddy N. , 1985). Thermal processing enhances digestibility and denatures factors that are anti-nutritional. This

is because trypsin inhibitors are denatured by thermal processes which improve digestibility (Avilés-Gaxiola, et al., 2018) (Avilés-Gaxiola, Chuck-Hernández, & Saldívar, Inactivation Methods of Trypsin Inhibitor in Legumes: A Review, 2017).

Maillard reactions caused by excessive heat can reduce available lysine (Kelly R. Robbins, 1980). The moderate and water-rich cooking environment of a khichdi ensures softness but simultaneously preserves protein quality.

Lipid Mediation: -

The inclusion of fats in khichdi is important for various factors. Primarily, gastric emptying slows down; there is an enhanced absorption of fat-soluble nutrients and the aromatic compounds that are released from spices are dissolved by lipids (Collier, McLean, & O'Dea, 1984) (Shapira, 2019).

Curcumin present in turmeric is an antioxidant powerhouse and is being trialled as an alternative treatment to cancer. The absorption of curcumin increases dramatically when combined with piperine which is a compound in pepper (Shoba, et al., 1998) (Heidari, et al., 2023) (Kakarala, et al., 2009) (Platel & Srinivasan, 2024). The consistent observance of the benefits of these biochemical reactions is a key factor in the use of spice tempering as a practice in the Indian culinary scenario.

Coconut oil, sesame oil, mustard oil, and ghee may each have very distinct and different aroma and extremely distinct fatty acid profiles, yet they all have similar functional roles within the confines of a dish of khichdi.

Spice Thermodynamics: -

The spices that are used in khichdi have been frequently observed to possess digestive properties. Pancreatic enzyme secretion is stimulated by cumin, gastric motility is enhanced by ginger, and turmeric displays anti-inflammatory properties (Platel & Srinivasan, 2024).

The process of tempering which essentially is a brief heating of spices in fat before ensuring that they are incorporated in the dish. The process releases volatile oils while preventing degradation. Timing is a therefore a structural variable which is if used well can enhance the flavour profile and nutritional value of the dish.

Thermal Transformation: -

The process of cooking a khichdi involves the simultaneous hydration of grains and pulses. Enzymatic accessibility of the rice grains is increased when the rice starch gelatinises between approximately 68^0C to 78^0C (Juliano, 1993). Excessive cooking of a khichdi leads to starch breakdown and glue-like textures. Insufficient cooking leaves the pulses hard or firm and difficult to digest. The optimal texture and consistency of a khichdi lie in the narrow balance between structural integrity and optimum hydration.

Nutritional Data: -

Rice-Mung Khichdi (250g Serving)

Energy	320 kcal
Protein	11 g
Carbohydrate	48 g
Fat	9 g
Fibre	4.5 g

Millet-Mung Khichdi (250g Serving)

Energy	340 kcal
Protein	12 g
Carbohydrate	44 g
Fat	10 g
Fibre	7 g

A model of optimal khichdi composition: -

Incorporating our learnings of nutritional modelling, we have tried to create a composition that has approximated the most balanced khichdi structure. This is primarily an approximate composition and not really a recipe aimed at nutritional equilibrium. The dry ingredient ratio should ideally be 60% grain, 30% mung dal, and 10% vegetables. The fat inclusion should ideally be between 5% and 7% of the cooked weight. The ideal hydration ratio should be four parts of water to one part of a grain and pulse mixture. The cooking time should ideally be about thirty minutes of simmering.

The nutritional value of the completed dish would be as follows:

Energy	360 kcal
Protein	14 g
Fibre	6 g

There is amino acid complementarity due to the cereal and pulse ratio with fat and fibre moderating glycaemic response.

Nutritional Modernity and Sustainability: -

There is a renewed relevance of khichdi in these modern times of metabolic disease and climate instability. As global diets move towards incorporating more sustainable practices, khichdi's architecture becomes even more valuable. Seeing that a modern world is leaning towards cruelty free, vegetarian, and vegan options, the khichdi ticks all those boxes and more.

The cultivation of millets requires comparatively less water when one pits it against irrigated rice fields and also supports agricultural resilience (CT, S, V, & RK, 2021) (Wilson & VanBuren, 2022) (B, et al., 2025).

Regional Variations: Climate, Ecology, and the Geography of the Perfect Khichdi

The proposition that a khichdi possesses a stable and universal architecture becomes considerably more interesting when examined against the grain of its regional expressions. Across the Indian subcontinent, the basic structural logic of the dish, which is grain, pulse, lipid and spice tempering, remains intact. What changes with a consistency that is not arbitrary but responsive are the specific choices made within each structure category. These choices, read carefully, are not aesthetic preferences. They are nutritional and ecological adaptations. These are quiet negotiations between the dish and its environment, worked out over generations of observation and refined by the same empirical pragmatism that the Ayurvedic tradition formalized as *Anubhava*.

In the coastal regions of Karnataka and Kerala, the grain of choice is frequently parboiled red rice. It is a variety that retains a proportion of its brand layer and therefore delivers the B-vitamins and fibre that a polished white rice does not. The lipid medium shifts correspondingly to coconut oil, whose saturated medium chain triglycerides are rapidly metabolized and whose

smoke point accommodates the mustard seeds, curry leaves and dried red chillies of the coastal tempering tradition. The relevance here is not merely culinary. Coastal populations operating in high humidity, high heat environments exhibit historically elevated requirements for rapidly available energy and electrolyte balance. The medium chain fatty acids of coconut oil and the potassium rich curry leaves address both requirements within the architecture of a single dish (Dayrit, 2014).The inclusion of split red lentils, known as masoor dal, rather than the mung bean characteristic of northern formulations reflects the local agricultural abundance of the region and the lentils comparative speed of cooking, an advantage in households where fuel economy was historically a genuine constraint (Gopalan, Sastri, & Balasubramanian, 2004) (Gurusamy, Vidhya, Kasherao, & Shanmugam, 2022) (Kamboj & Nanda, 2017).

The Gujarati and Rajasthani khichdi traditions occupy the opposite pole of the climatic spectrum, and the ditch reflects this with corresponding precision. In the semi-arid northwest, where water scarcity has historically shaped agricultural possibility, bajra, which is pearl millet, replaces rice as the primary grain. This substitution is not a compromise. Bajra possesses a mineral density that white rice cannot approach with iron and zinc, concentrations that are particularly significant in populations historically dependent on limited animal protein (Saleh A. S., Zhang, Chen, & Shen, 2013). Its high fibre content slows starch digestion, producing the sustained satiety that is a practical advantage in environments of unpredictable food supply. The lipid medium in this region shifts to ghee in quantities more generous than the coastal tradition employs, a choice explicable not only through the availability of dairy culture in the cattle rearing northwest, but through the caloric imperatives of a population sustaining itself in extreme heat or cold across an agricultural cycle of considerable physical demand (Bhavsar & Bhatt, 2014).

The spice architecture deepens accordingly. There are dried ginger, asafoetida, and black pepper that appear in concentrations that would be unusual in the coastal preparation, each serving the carminative function that a high fibre, pulse dense diet in a digestively taxing climate requires (Platel & Srinivasan, 2024). The northeastern states of India present a third distinct adaptation. In Assam and Bengal, where the climate is humid and the river basin produces a distinctive agricultural ecology, the khichdi tradition incorporates mustard oil as the primary lipid medium. This is a choice with deep cultural roots, but also with nutritional logic. Mustard oil's high erucic acid contains aside, its alpha-linolenic acid component provides the Omega-3 fatty acids that a predominantly fresh water fish supplemented diet in this region has

historically supported (Ghafoorunissa, 1994) (Ghafoorunissa, Fats in indian diets and their nutritional and health implications, 1996) (Manchanda & Passi, 2016).

The grain here returns to rice, but frequently to shorter-grain aromatic varieties like Gobindobhog, Kataribhog, Tulaipanji, whose starch gelatinization profile differs drastically from the basmati or sona masoori of the north and south respectively, producing a dish of softer, more cohesive texture that reflects both agricultural availability and the cultural preference for a particular consistency in the Bengali culinary tradition (Ghosh, B. Das, Mahata, & Ghose, 2018) (McGee, 2004).The Deccan Plateau region encompassing parts of Maharashtra, Telangana and Karnataka's interior, presents perhaps the most clinically interesting regional adaptation. Here sorghum, jowar and the various indigenous varieties of tur dal, which are split pigeon peas, form the base of a khichdi preparation that is nutritionally distinct from its coastal and northern counterparts. Sorghum is notably gluten free, making the Deccani khichdi tradition of particular relevance to populations with gluten sensitivity; a condition of unclear historic prevalence but clear contemporary significance (Taylor, Schober, & Bean, 2006). Tur dal contributes a protein profile complementary to sorghum's with isoflavone compounds that have been associated with cardiovascular protective effects in epidemiological literature (Messina, 1999).

The tempering in this region frequently incorporates curry leaves in quantity whose presence is not merely as aromatic. The antioxidant alkaloids and carbazole compounds in Murraya koenigii have been studied for the glycaemic-modulatory properties. A fact that the Deccani tradition seems to have intuited centuries before the relevant biochemistry was formalized (Iyer & Mani, 1990). The mountain regions of Uttarakhand and Himachal Pradesh offer a final, climatically extreme case study in regional adaptation. At altitude where the growing season is short, the agricultural palette is constrained, and the metabolic demands of cold environments are substantially elevated, the khichdi tradition here incorporates mandua, which is finger millets, as its grain base. As noted in the grain architecture section of this paper, finger millet contains calcium concentration that exceeds 300 milligrams per 100 grams of raw grain. These are figures that are particularly significant for population with limited access to dairy and whose skeletal health in cold, physically demanding environments is a genuine nutritional priority (Anitha, et al., 2021). The generous use of sesame seeds and sesame oil in this regional tradition provides additional calcium alongside zinc and the lignans associated with antioxidant activity. The resulting dish is, by caloric density, significantly richer than its coastal or plains

equivalent. This is a reflection not of reference but of physiological necessity in an environment whose winters demand that the body sustain itself against cold on the available agricultural surplus (Puranik, et al., 2017).

What this survey of regional variation reveals, is not the absence of a universal khichdi, but the presence of a universal principle expressed through local intelligence. The structural logic of the dish, which is balanced protein complementarity, lipid-mediated bioavailability, thermally transformed digestibility, spice-modulated motility remains constant. What varies is the specific instantiation of the logic in response to what climate provides, what the body requires and what the agricultural system can support. And the khichdi does not merely tolerate this variation; it actively enables it. And in doing so it just demonstrates not the humility of a simple dish, but the sophistication of a system designed to be adapted.

The economics of necessity: How poverty transformed the khichdi, and what it reveals about the dish

There is a version of this paper that could treat the khichdi's nutritional architecture as the product of deliberate design. We could speak about Ayurvedic physicians and court cooks operating from a position of abundance, selecting optimal ingredients and refining optimal ratios. That version would be partially true, but it would omit the other great engine of culinary evolution, which is scarcity. The khichdi that sustained the working poor of Indian cities, the famine struck village household, the migrant labourer between paydays and the students surviving on the thinnest of margins of a shared urban kitchen was not always the mung bean and basmati preparation of Charaka Samhita. It was whatever the dish needed to become in order to remain possible at all. And what it became across these conditions of necessity revealed something about its essential architecture that no affluent formulation could demonstrate. That the structural logic of the khichdi is robust enough to survive substitution of almost every ingredient it nominally requires and still deliver within narrowed margins the nutritional function it was designed to provide.

The most fundamental substitution that economic necessity imposed upon the khichdi was in the pulse category. Mung beans, the Charaka Samhita's recommended dal, endorsed for the digestibility and low flatulence potential, are, by the standards of the households operating under genuine food insecurity, a relative luxury. What replaced them in the kitchens of the poor across most of the subcontinent were the cheapest available legumes, which is like broken

chana dal, coarse masoor or in the deepest reaches of scarcity, the various split and dried legumes that remain on a grain merchant's shelf when more expensive options were exhausted. The nutritional consequences of the substitution were not trivial. Chana Dal and masoor, both carry anti-nutritional factors. These are tannins, phytic acid, and in the case of masoor, elevated trypsin inhibitor activity that reduce protein digestibility relative to the ideal of fully prepared mung bean. But the extended cooking that poverty kitchen khichdi typically underwent which was longer cooking at lower heat, often in covered earthen vessels that retained steam, effectively mitigated these factors through thermal denaturing, arriving at the digestibility outcome closer to the intended formulation than the ingredient substitution alone would have produced (Avilés-Gaxiola, Chuck-Hernández, & Saldívar, 2017).

The grain substitutions that poverty imposed were equally instructive. In periods of rice scarcity or where rice was beyond the household means, the khichdi absorbed whatever grain was available. Broken wheat known as dalia which provided a higher protein and fibre than polished rice, and a cooking time that, when combined with dal in a single vessel, produces a preparation of comparable texture and superior fibre content. Sorghum and pearl millet, discussed in the regional variation section for the climatic adaptation, served double duty as poverty grains, both because they grew in conditions too harsh for rice and because their lower market value, made them accessible to houses for whom rice represented an aspirational purchase rather than a daily staple. The nutritional outcome of these substitutions was in several respects superior to the rice-based formulation that they replaced. There was higher mineral density, higher fibre, lower glycaemic index. The irony that nutritional science now actively advocates for many of the dietary choices that economic necessity once imposed upon the poor is not lost on the food historian, and the khichdi's trajectory here encapsulates it with particular sharpness (Mal, Padulosi, & Ravi, 2010).

The lipid dimension of the poverty khichdi is perhaps the most analytically poignant. Ghee, is clarified butter, and it was and remains the aspirational fat of the subcontinent's culinary imagination. Its Ayurvedic credentials, its ceremonial associations, its role in the tempering of spices in court and temple kitchens made it theoretically the ideal lipid medium for a khichdi prepared according to classical principles. In the poverty kitchen, ghee was replaced in rough sequence of decreasing affordability by cold pressed mustard oil, crude coconut oil, the hydrogenated vegetable fats that the 20th century's industrialization of the oil sector made cheaply available, and in the most extreme cases by the residual fat from previously cooked

preparations or by no fat at all. Each of these substitutions degraded the dish's lipid-mediated bioavailability function to a degree. Fat soluble micronutrients, the beta carotene from turmeric, the fat-soluble vitamins present in the spice matrix were less efficiently absorbed. The aromatic volatiles of the spice tempering were less completely dissolved. But the dish did not collapse. It contracted to a reduced version of its optimal function rather than failing entirely, sustaining the populations who depended on it, within a narrowed but still meaningful nutritional envelope (Srinivasan, 2005).

The expansion of the khichdi through the addition of vegetables deserves particular examination as a poverty innovation rather than a culinary elaboration. In the classical and Mughal-era formulation, vegetables appear sparingly or not at all. The dish in its prestigious form is primarily grain and pulse. In the household operating at the margins of food sufficiency, the khichdi becomes a vehicle for whatever the kitchen garden, the market's cheapest stall, or the seasonal abundance of a given week could provide. Pumpkins and its seeds, which added carotenoids and zinc; raw banana, which contributed resistant starch and potassium; drumstick leaves, whose extraordinary micronutrient density, notably iron, calcium and vitamin C, transformed a preparation of modest nutritional reach into something approaching a complete meal (Fuglie, 2001).

The integration of green leafy vegetables like spinach, fenugreek, amaranth leaves, into a khichdi was both a response to poverty and a nutritional improvement over the prescription. The folate, the non-haem iron and the ascorbic acid they contributed addressed deficiencies that the classical grain and pulse formulation, however well executed, do not specifically target.

The colonial period produced a specific variant of the poverty inflected khichdi that merits independent discussion. This is the institutional khichdi of the colonial famine relief operation. During the famines that struck India with devastating periodicity in the 18th and 19th centuries, particularly the Great Bengal Famine of 1770, the Madras Famine of 1876-78, and the Bihar and Odisha famines of 1873-74 relief kitchens operated by colonial administrators and subsequently by Indian and missionary charities, produced a khichadi adapted for mass preparation and maximum calorie efficiency under conditions of extreme resource constraints (Davis, 2001).

The grain ratio in these preparations was typically shifted heavily towards cheaper grain at the expense of the pulse. This was a reversal of the classical balance that reduced protein quality

but extended the reach of a fixed quantitative ingredients to more mouths. The spice content was reduced to turmeric and salt alone, sufficient to inhibit microbial growth in a moist, warm preparation, but insufficient to provide the carminative support that the population, already weakened by malnutrition required. These institutionalized reductions were not nutritional decisions but administrative ones, and the consequences were measurable. Yet even in this stripped form, the khichdi's core function, the rapid delivery of digestible energy and some protein to a body in physiological crisis was preserved. It remained, as it has been in Charaka Samhita's convalescent prescription, the food one turns to when the body has very little left to work with.

The 20th century produced one final poverty inflected transformation worth noting. The kerosene-stove khichdi of the urban slum and the migrant workers' hostel. This variant was shaped not by the absence of ingredients, but by the absence of cooking time and fuel. In the single room household operating on a kerosene burner of limited output where the working day left no time for the extended simmering that optimal khichdi preparation requires, the dish was adapted through pre-soaking of both grain and pulse. This practice reduced required cooking time by 30% to 40% while simultaneously reducing the phytic acid content of the pulse through enzymatic activation during the soaking period (Lestienne, Icard-Vernière, Mouquet, Picq, & Trèche, 2005).

The result was the preparation of inferior texture but comparable nutritional reach cooked in a fraction of the optimal time on a fraction of the optimal fuel. It was not the kitchen of the Ain-i-Akbari. It was the khichdi of a city absorbing, in every decade of the 20th century, millions of people whose relationship with food security was precarious and whose need for a dish that could be prepared quickly, cheaply and in a single vessel was acute.

But all of these poverty adaptations reveal, taken together, is a dish that progresses what engineers could call graceful degradation. This is the capacity to lose components without losing function, to contract under constraint without collapsing, to continue providing its essential service across a remarkably wide range of ingredient substitutions and preparation compromises. This is not a coincidental feature. It is the emergent property of a system designed, whether consciously or through iterative empirical refinement, around redundancy and flexibility. The khichdi's multiple routes to protein complementarity, its various lipid media, its interchangeable grain bases, and its tolerance for a wide range of pulse varieties are not culinary pluralism for its own sake. They are the structural features of a food system built

over millennia to feed people across the full range of conditions that the subcontinent produces. From the Mughal courts to the colonial famine camp, from the Himalayan winter kitchen to the urban migrant's single burner stove. A dish capable of all of that is not humble, it is extraordinary!

Conclusion: -

Far from the prevailing sentiment of a khichdi being a humble and simple dish, there appears to be a precise system through which a khichdi has been constructed. The sophistication of the system lies in embodying a culinary intelligence and a structural complexity that has been refined through centuries of empirical observation. Amino acids are balanced with a pairing of grain and pulse. Bioavailability and digestion are enhanced through the addition of fat and spice. Resistant plant tissues are transformed into digestible nourishment through hydration and heat. Far from being simple, a khichdi is actually precise.

The regional survey undertaken in this paper extends and deepens that conclusion. From the coconut oil and parboiled red rice of the Karnataka coast to the finger millet and sesame preparation of the Uttarakhand mountains, the khichdi's structural logic holds constant, while its specific expression responds, with ecological precision to what the climate provides and what the body requires. But this dish does not merely accommodate regional variation. It appears designed to accommodate its interchangeable grain bases, lipid media, and pulse varieties functioning as a system of nutritional redundancy built for a subcontinent of extraordinary climatic and agricultural diversity.

The observation that contemporary nutritional science now advocates for many of the ingredient choices that geography and agricultural ecology imposed upon regional traditions is not a coincidence. It's a confirmation that the empirical refinement encoded in those traditions was tracking something real.

The poverty economics analysis as a dimension that the classical and courtly literature could not supply. The evidence that the khichdi's architecture is robust under conditions of ingredient deprivation as well as ingredient abundance. The substitution sequences documented, from mung bean to broken chana dal, from basmati rice to bajra, from ghee to crude vegetable fat, from a spice tempering to turmeric and salt alone, constitute an unintentional stress test of the dish's structural redundancy and the khichdi passes it. In each case, the core function, the rapid delivery of digestible energy and complementary protein to a body under physiological demand

is preserved within a narrow but still meaningful nutritional envelope. This is not accidental resilience. It is the emergent property of a system whose multiple pathways to the same nutritional outcome were refined through millennia of daily use across the full social spectrum of the subcontinent, to withstand the exact pressures that the poor and hungry, brought to bear upon it.

This paper suggests that the underestimation of khichdi is not merely a cultural oversight but an analytical one. This is a dish that has fed the Vedic patient, the Mughal emperor, the colonial famine survivor, the Himalayan smallholder, the Deccani subsistence farmer, and the 20th century urban migrant. And that has done so in each case by adapting its specific instantiation to the constraints and requirements of that context, while presuming its essential nutritional logic, is not demonstrating culinary simplicity.

It is demonstrating culinary intelligence of the most enduring kind. The intelligence of a system that knows what it is for. And that has built into itself, over centuries of empirical refinement, everything it needs to keep being that across the full range of conditions that human life on the subcontinent produces. A khichdi is not humble. It is extraordinary. And it is precisely so.

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